Governing energy in Nicaragua: the practices and experiences of off-grid solar energy technologies

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CERTIFICATE OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this thesis, that the original work is my own except as specified in acknowledgments or in footnotes, and that neither the thesis nor the original work contained therein has been submitted to this or any other institution for a degree.

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Abstract

The global energy trilemma has brought attention to the importance of energy access, in particular to the 1.3 billion people worldwide without access to electricity. Vital for addressing poverty, improving people's quality of lives and meeting the Millennium Development Goals, small scale solar energy technologies are espoused as a solution to household energy needs in off-grid areas of the developing world. This thesis contributes to this critical research area through an investigation of energy governance issues in Nicaragua; specifically it focuses on the practices and experiences of off-grid solar energy technologies. The lived realities, voices and aspirations of energy users are largely absent in scholarly accounts of energy poverty, as such this thesis considers the implications of solar energy technologies from the perspective of those ultimately adopting, using, maintaining (and abandoning) them.

Contributing to the burgeoning field of geographical and social science studies of energy, this thesis draws on ten months of field research in Nicaragua, which encompassed more than seventy qualitative interviews with stakeholders at multiple spatial scales. This included actors from international development agencies, national government, non-governmental organisations, the private sector, civil society, as well as households participating in three solar energy programmes. This was complemented by a large household survey of participants from one solar energy programme. Incorporating perspectives from the micro, meso and macro scales, this study presents a highly nuanced picture of the Nicaraguan energy landscape.

The study concludes that interaction between global energy paradigm shifts and the domestic political economic context produced an electricity sector that was – until recently - characterised by low distributional equity, deep consumer mistrust and dominated by fossil fuel-based electricity generation. The recent prioritisation of energy as a key developmental concern is demonstrated not only in strong government intervention, but also through growing international interest in solving Nicaragua's 'energy problem'. A raft of programmes to green the electricity generating matrix, strengthen distribution activities and expand electricity access have emerged. Despite these encouraging developments, this research concludes that issues related to transparency, vested interests and the politicisation of electricity access appear to remain unresolved.

The study traces the development of the off-grid solar energy market segment, revealing a complex architecture of institutions and actors working to promote and deploy solar energy technologies at scale. While this market initially developed in response to gaps in remote electrification plans, the research finds that recent grid expansion activities mean that the longer-term scope for small scale solar energy technologies is limited. However, solar energy remains an important feature of energy development assistance in Nicaragua, with further evidence in this study highlighting the amenability of solar energy to multiple institutional objectives and mandates – whether climate change-related or poverty focused. The thesis concludes that the positions and expectations of key solar actors are often misaligned with the needs, wants and aspirations of off-grid energy users.

Engagement with the narratives of people living in remote, off-grid areas reveals that the implications of solar energy programmes are not guaranteed, static, or necessarily captured by all households – or indeed, all members of households. Users perceive that small scale solar energy technologies provide important 'soft benefits' including increased levels of comfort, security, wellbeing and connectivity. However, the benefits are only captured for as long as the technology continues to 'work' – whether in organisational, financial, technical or social terms. The research concludes that there are numerous challenges facing solar energy interventions in Nicaragua, with some barriers connected to the situation of the user household, for instance, their continued ability to absorb the financial commitments associated with technology use. Other challenges link to the broader political economic context, where the highly complex, fragmented and politicised nature of (solar) electricity access has the potential to undermine interventions.

This thesis argues that it is vital to examine solar energy interventions as embedded within broader political economic frameworks, but also to account for the intricacies of inter and intra-household dynamics. The study contributes new insights and empirical findings to debates on global energy governance, energy poverty, and the practices, politics and experiences of off-grid solar energy technologies in the Global South.

Key words: Energy governance; Energy poverty; Nicaragua; Central America; Solar Home Systems; Solar PV; Political Economy

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Chapter One. Introduction

This thesis is an investigation into the practices, politics and experiences of off-grid solar energy in the Global South. Specifically, it analyses the emergence and evolution of the use of solar energy technologies in Nicaragua. The thesis operates at multiple levels to examine the proliferation of solar energy technologies in Nicaragua as a phenomenon which is deeply embedded within the complexities of Nicaraguan energy governance and broader global energy shifts. This chapter begins by underscoring the urgency of this research, and why Central America and more specifically Nicaragua were selected as a focus for examining these debates in more detail. The research approach, overall aim and research questions are then introduced. The chapter concludes by outlining the structure of this thesis.

1.1 Global energy challenges: an urgent research agenda

> 'The world's energy system is at a crossroads. Current global trends in energy supply and consumption are patently unsustainable – environmentally, economically, socially. But that can - and must - be altered; there's still time to change the road we're on' (IEA, 2008:37)

The global energy system is facing a set of unprecedented and seemingly contradictory challenges; the convergence of energy security, climate change and energy poverty dilemmas. The so-called 'energy trilemma' (Scott, 2012; Gunningham, 2013) - increasingly dominates debates in global political and development arenas. How such challenges are to be governed is one of the key academic and policy questions of our time (see Florini and Dubash, 2011; Goldthau, 2012). This thesis focuses on the energy poverty dimension of this trilemma, but as the analysis in the chapters which follow suggests, this cannot be disentangled from the security and climate components. The IEA (2011) World Energy Outlook recently drew our attention to the 1.3 billion people without access to electricity and the 2.7 billion people without clean cooking facilities. While this shocking reality has been recognised as a key issue facing developing countries over several decades, as a policy issue, it has frequently been overlooked or couched within broader objectives (Birol, 2007; Dubash and Florini, 2011; Sovacool et al., 2012). Questions of 'energy for development' and dealing with 'energy poverty' in developing nations has gained significant traction over recent years. Facilitating access to modern energy services for the several billion people currently without such access has become a key arena for international governance, culminating most recently with the launch of the United Nations' 'Sustainable Energy for All' (SE4All) initiative in 2011. High profile commitments made to this initiative at the UN Conference on Sustainable Development (Rio+20) and the UN General Assembly's recent recommendation to designate an 'International Decade of Sustainable Energy for All' highlight the urgency and increasing momentum of this agenda (UN, 2012a). Although energy for all refers to several types of energies, this thesis specifically explores electricity access, through the deployment of decentralised solar energy technologies.

1.2 Off-grid solar energy technologies: the solution?

The Intergovernmental Panel on Climate Change (IPCC) (2011) state that renewable energies are an affordable and economically viable option for addressing the electricity needs of people in developing countries. Small scale renewable energy technologies (RETs) are often the only means of supplying electricity to rural areas where it may be expensive and unfeasible to extend the national electricity grid system (IEA, 2010); importantly, RETs may also offer additional environmental benefits (Gullberg et al., 2005; Zerriffi and Wilson, 2010). Described as a 'vital' technology in international efforts to address energy poverty (Sovacool et al., 2011: 1534), small scale solar energy technologies such as the solar home system (SHS) are frequently deployed to expand electricity to households in remote areas of developing countries. The faith that the international community places in this technology is evident through the increasing prevalence of programmes supporting solar-based electrification in the developing world (see Sovacool and Drupady, 2012). Given the rapid acceleration in deployment of this technology, it has never been more urgent to examine the key political economy questions of 'who benefits, who loses, how and why?' within the context of this specific technology (Newell and Mulvaney, 2013:133). This thesis stresses the crucial importance of embedding analysis of solar energy within the broader political-economic frameworks within which they are promoted, used and maintained. As the following sections explore, this research is grounded within the regional and national contexts of Central America, and specifically, Nicaragua.

1.3 Why Central America? Why Nicaragua?

The Central American region has periodically risen to prominence in international agendas, particularly in relation to its troubled twentieth century - a period characterised by revolution, counter-revolution and severe natural disasters (Booth et al., 2006). However, it has so far been largely overlooked in debates on energy. Central America is an important region that warrants our attention. The six nations that make up the region possess hugely important natural resources which are increasingly threatened by climate change (see Hill et al., forthcoming; Harmeling and

Eckstein, 2012). These small nations located in the 'waist of the Americas' have also long been implementation spaces for global policy priorities, where macro-level processes have been translated differentially into national political economies. Within a small land area, we see a rich tapestry of experience. As Robinson (2003:3) argues, the region provides an important entry point for 'understanding of the dynamics of change elsewhere'.

From the perspective of the global energy trilemma, the Central American region provides a fascinating case study. Focusing on the energy security facet of the trilemma, the region's energy sectors have over recent decades undergone a transition away from renewable (largely hydropower derived) electricity generation towards dependence on fossil fuel based generation, in some cases leading to dire consequences for macroeconomic stability. This is surprising since the countries of Central America are endowed with significant renewable energy resource potential, but are also highly vulnerable to climate change (CEPAL, 2009). More recently, however, Central American economies have been increasingly heralded as key sites for private investment in renewable energy (IDB, 2012; 2013), making this an interesting context for examining the potential contribution of RETs to energy for development. Examining the energy poverty aspect of the trilemma in particular, Central America faces a formidable challenge. Over six million people in the region lack access to electricity, and approximately twenty million people rely on firewood to satisfy their most basic energy needs (CEPAL et al., 2010; CEPAL, 2011). The Central American 'energy challenge' (Eguizábal, 2011) is receiving increased attention from state, private sector and civil society actors as well as international financial institutions, seeking to achieve a more sustainable energy future (see Dolezal et al., 2013). However, as Chapter Three of this thesis later identifies, despite this rapidly shifting panorama, there is a dearth of academic work that considers the contemporary dynamics of Central America's energy landscape.

Within this regional context, Nicaragua emerged as a particularly fascinating site within which to pursue empirical research. The paradox of Nicaragua – its possession of the best renewable energy potential in the Central American region, the greatest amount of land and the smallest, youngest population, yet at the same time being the most 'energy poor' country (Miranda-Urbina, 2006) – made this the ideal site for this research. Indeed, the International Energy Agency's 'Energy Development Index'[1] places Nicaragua in fortieth place out of sixty four of the least energy

[1] The Energy Development Index (EDI) was developed by the International Energy Agency to mirror the UNDP's Human Development Index and ranks countries according to progress made on indicators such as the use of modern fuels or increased electricity access. The EDI is composed of four indicators: commercial energy consumption (indicating overall economic development); per capita electricity consumption (indicating reliability and consumer's ability to pay for electricity services); share of modern fuels in total residential sector

developed countries in the world, with indices comparable to Sri Lanka and Gabon (IEA, 2011). A country where over 60% of the rural population does not have access to grid electricity, and 86% of households without electricity are classified as poor (CEPAL et al., 2010; MEM, 2011), Nicaragua demonstrates one of the lowest levels of 'energy development' in Latin America.

Nicaragua also offered a fascinating context because of the striking shifts experienced over recent years – not only in energy terms, but also in political economic domains. Just a few years ago, the Nicaraguan electricity sector was in crisis; rolling blackouts plagued the country for approximately eighteen months, which had severe macroeconomic consequences (Herrera-Montoya, 2005a; McGuigan, 2007; Cupples, 2011). Within just five years however, Nicaragua's electricity sector had seemingly transitioned from crisis to being hailed as a key site of renewable energy investment and 'renewable energy revolution' (Rogers, 2012: n.p.). During this period a government that was committed to intervening in many aspects of the country's development was re-elected (Staten, 2010). Since re-election, the *Frente Sandinista de Liberación Nacional* (the Sandinista National Liberation Front, FSLN) have prioritised Nicaragua's 'energy problem', dedicating significant resources to tackling different aspects of the energy trilemma. This period also witnessed the emergence of a policy environment supportive of the large scale deployment of off-grid solar energy technologies. This rapidly changing context offered a fascinating breadth of governance issues to explore.

Finally, Nicaragua was selected due to strong Loughborough University connections and contacts with a range of Nicaraguan universities, NGOs, private sector actors and local government, which were established through a European Union funded research project.[2] These were vital for setting up the research, but also provided essential support throughout the study. These practical considerations, coupled with reasons cited above made Nicaragua an ideal location to situate this study.

1.4 Research aim and questions

An aim and set of research questions have been formulated for this research, informed by the wider literature and conceptual framework. The conceptual underpinning of this thesis is *energy governance*, which refers to 'the actors, institutions and processes that shape how decisions are

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energy use (indicating levels of access to clean cooking facilities) and share of population with access to electricity (IEA, 2010).

[2] 'Strengthening Municipal Action on Renewable Energy in Central America' (ENERGYCENTRAL) was a multi-disciplinary project aimed at supporting the promotion of renewable energy in Central America, co-delivered by Loughborough University.

made about how to provide energy services' (Bazilian et al. 2014: 219). Energy governance involves actors from governments, NGOs, civil society, donors, corporations, citizens, as well as the rules and regulations which determine decisions and agenda setting in the energy sphere (Cherp et al., 2011; Newell, 2011; Van de Graaf, 2012; Bazilian et al., 2014). As such, energy governance is not confined to the activities of the state, but involves a multi-actor process, played out across multiple scales, from the local to national, regional and global scales (Bazilian et al, 2014; see also Brody, 2009).

Adopting an energy governance lens enables the political-economic power structures that shape energy realities and energy inequalities to be examined in depth. Key questions relevant to this approach include: which technology and policy options are favoured over others and why?, and as a result of a specific technology or policy option, who wins, who loses and why? (cf. Büscher, 2009; Moe, 2010; Newell and Mulvaney, 2013; Newell, Phillips and Pueyo, 2014). The energy governance lens also enables multiple levels – and their interconnections - to be examined; Büscher (2009) argues that global and local energy dynamics are frequently investigated separately, however there is a need to better understand the linkages, which it is argued strongly influence national energy policies and the realities of energy inequality (see also Bazilian et al., 2014).

Informed by debates around energy governance, this thesis aims **'to explore the multiple practices and experiences of off-grid solar energy within the broader Nicaraguan political economic context'**. The research questions emerging from this aim encompass different scales of analysis, and necessitate interaction with a broad range of stakeholders. The research questions that will be addressed throughout the thesis include:

1. How has Nicaragua's electricity sector been shaped by global energy paradigms and changes in the domestic political economic context?
2. Who are the key stakeholders involved in the promotion and deployment of off-grid solar energy technologies in Nicaragua, and what are their positions, motivations and expectations?
3. From the perspective of users, what are the implications of solar energy technologies?
4. What are the challenges facing solar energy interventions in Nicaragua?

The research questions relate to specific gaps identified in the literature. **Research question one** responds to the dearth of academic work on the historical and contemporary dynamics of electricity production, consumption and distribution in Nicaragua. Within this broader context, **research**

questions two, three and four address the scarcity of critical literature on the emergence and growth of Nicaragua's off-grid solar energy market. Few studies have situated the growth of off-grid PV markets within their broader historical and political-economic contexts (see Jacobson, 2007; Bawakyillenuo, 2012; Ondraczek, 2013 for exceptions). **Research questions two, three and four** enable an examination of solar energy deployment and use through multiple lenses – including the complex agendas of international development agencies, government actors, NGOs, as well as the dynamics of user households and communities. This approach connects with this thesis' commitment to analyse multiple levels, and is specifically inspired by Jacobson (2007), who emphasises the importance of examining the significance of solar energy both 'inside and beyond' the household. **Research question three's** emphasis on the end user, addresses a dearth of literature that takes into account the perspective of solar energy technology users and their daily lived experiences (first highlighted by Nieuwenhout et al., 2001), and seeks to give a voice to those users. Importantly these questions (specifically **research question four**) also tackle concerns raised by various scholars regarding the lack of neutral scholarship on programmes promoting the use of off-grid RETs (Schäfer et al., 2011; Sovacool and Drupady, 2012; Brass et al., 2012; Watson et al., 2012). Together, the research approach and questions contribute to an increasing body of studies that apply social science approaches to the topic of energy (e.g. Sovacool, 2014).

1.5 Thesis structure

This thesis consists of eight chapters in total, the remainder is structured as follows: **Chapter Two** begins by detailing the complexities of the current global energy era, and the challenges this poses for energy governance at multiple scales. The recent evolution of the 'energy poverty' challenge is singled out for particular attention; its discursive journey is traced which suggests that this policy issue has gained increasing momentum over the past decade. As one of the keystone technologies in the push for 'sustainable energy for all', decentralised applications of solar energy, such as the SHS, are then introduced as the focus of this thesis. Close examination of the history and practice of solar energy interventions in the Global South suggests that it is necessary to examine their deployment within multiple levels and arenas, such as the complex agendas of international 'energy development' agencies, IFIs, politicians, NGOs and end-users.

Chapter Three establishes the geographical frame of this thesis. It begins with an introduction to twenty-first century Central America, providing information on socio-economic development indicators and energy challenges. Addressing key gaps in the literature, Chapter Three provides analysis of historical and contemporary developments in Central American power sectors. It concludes that governance arrangements have shifted significantly over the past three decades from state to market-led but have been characterised most recently by an interventionist turn. In reviewing the energy systems of the six Central American countries, Nicaragua emerges as an interesting and exceptional case in which to pursue empirical research.

Chapter Four describes the research methodology. This chapter begins by discussing the 'research journey', and examines the ways in which the realities and practicalities of the field ultimately shaped this thesis. The research questions are then re-introduced, before the qualitative, multiple method approach is outlined. Each of the methods is discussed in detail before reflecting on the challenges presented by this research, which include: the ethical dilemmas of 'development' research, issues relating to access and gatekeepers and finally, the complexities of representing voices from the field.

Addressing research question one, **Chapter Five** presents a detailed examination of Nicaraguan energy governance. It focuses on how Nicaragua's energy pathway has been influenced by the interaction of evolving global energy paradigms and national political-economic processes. By tracing the complex evolution of the electricity sector, it becomes clear how until recently, Nicaragua possessed Central America's most vulnerable electricity sector – one characterised by high dependency on hydrocarbons for electricity generation and with the lowest coverage levels. A detailed examination of this national context prepares the ground for profiling the emergence and growth of the off-grid solar energy market.

Chapter Six examines the rise of solar energy in Nicaragua. Addressing research question two, the positions of key actors central to the promotion and implementation of solar energy technologies, are analysed. Their positions, motivations and expectations are interrogated to unravel the complex practices and politics of solar energy technology promotion and deployment. Perspectives on the challenges facing solar interventions in this context are then examined to address research question four. The chapter highlights how programmes are shaped through a complex interplay of domestic and global political economies, but also the fragmented, uncoordinated and politicised nature of (solar) electricity access in Nicaragua.

Chapter Seven adds the final level of analysis to the broader global to local framework adopted by this thesis. Addressing research questions three and four, the chapter presents detailed analysis of three solar energy programmes, all 'project organised' in nature, with different delivery mechanisms, implementing organisations and target populations. The 'energy realities' of off-grid households prior to their participation in solar programmes are then discussed. A detailed examination of user experiences in the post-adoption period follows, including whether user expectations of solar energy were met, the perceived impacts and benefits wrought; in addition to the challenges facing users as solar energy technologies are incorporated into their everyday lives. It concludes that while technologies such as the SHS may deliver significant 'non-monetary lifestyle benefits', dissatisfaction with limited output, relatively high costs and the promise of grid electricity may ultimately result in its abandonment.

Finally, **Chapter Eight** draws together the main ideas and findings of the thesis and in doing so, illustrates how the thesis has addressed the research questions set out above. The contribution of this thesis to investigating the practices and experiences of off-grid solar energy in Nicaragua is examined, together with the broader conceptual and empirical contributions and possible directions for future research.

Chapter Two. Setting the context: Global Energy Governance, Energy Poverty and Distributed Solar Energy Technologies

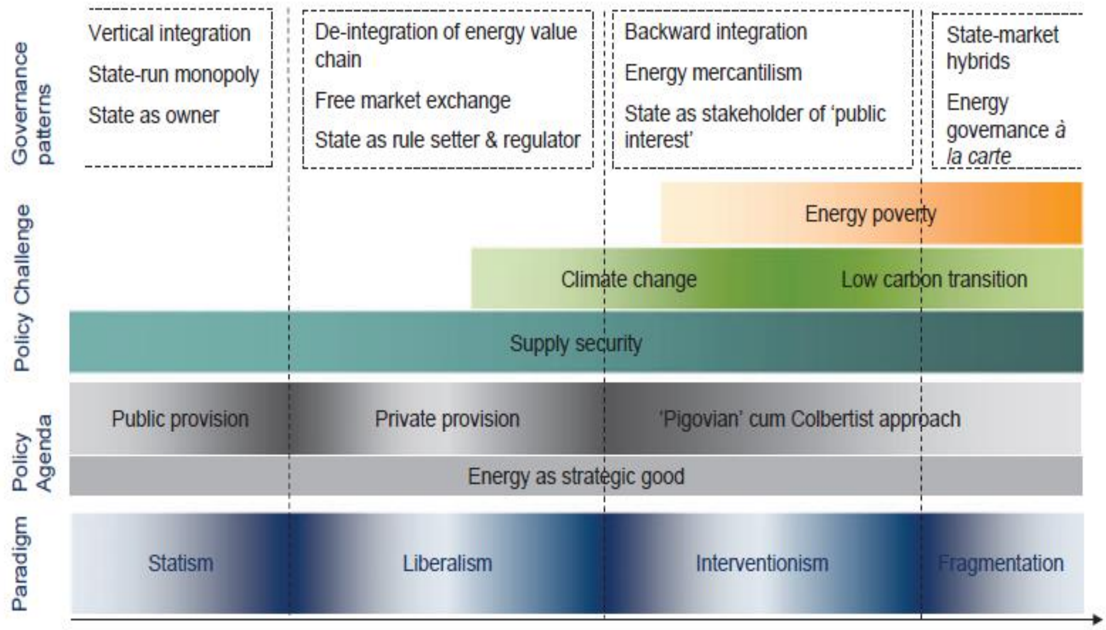
Having introduced the study and the research questions, this chapter provides a detailed analysis of several key bodies of literature. Debates on global energy governance, energy poverty and electricity access through distributed solar energy technologies are analysed and linked together. The drawing together of these literatures represents one of this thesis' novel contributions as few studies have attempted to link the three largely disparate areas of energy scholarship. Both this review and the wider thesis add to an emergent geographical frontier – the so-called 'new geographies of energy' that 'cascade across a variety of scales and types of landscapes' (Zimerrer, 2011: 705). Geographical perspectives – particularly perspectives from Human Geography - are crucial for engaging with issues connected to the so-called 'global energy dilemma' (Bradshaw, 2010). Foundational concepts of the discipline, including uneven development, scale, spatial embeddedness, landscape and territoriality have much to offer the study of energy transitions (Bridge et al., 2013), and are all themes that this thesis speaks to. As outlined in Chapter One, this research examines the influences from multiple scales that serve to shape Nicaraguan energy realities, including global processes, regional geopolitics and domestic politics.

The chapter begins by highlighting a useful framework for examining historical trends in global energy governance - Andreas Goldthau's (2012) energy paradigm theory. Through a governance lens, section 2.1 highlights the complexities of the current energy era – via use of the so-called 'energy trilemma' – a perspective which suggests that contemporary energy 'governors' need to respond to a set of unprecedented and often contradictory challenges. Section 2.2 focuses on a governance arena increasingly unavoidable in international political debate, that of 'energy for development'. The evolution of this agenda is traced, and discussion turns to examine how 'energy poverty' in particular has emerged as a key policy concern during the past decade. Discussion of the recently launched United Nations 'Sustainable Energy for All' initiative reveals the momentum behind addressing the needs of the several billion people experiencing energy poverty and its growing significance within the current international development landscape. Section 2.3 critically engages with literature on the definitions of energy poverty and energy access, focusing on the Global South. Section 2.4 specifically focuses on one particular technology that has emerged as vital in the efforts of the international community to provide electricity for all - decentralised applications of solar energy in the Global South. This section focuses particularly on solar home system (SHS) technologies, and aims to highlight the costs, benefits and research gaps. After initially describing the mechanics of SHS technology, the environmental, social and economic ‘promises’ offered by SHS at multiple scales are then discussed. The rise of SHS to a prominent position in achieving ‘energy for all’ and its linkages to emerging discourses of ‘international development’ and ‘development assistance’ are then examined. The history of SHS is also traced beginning with early experiments in West African field laboratories through to technological maturity and global roll out, highlighting some of the questionable motives behind its deployment. The final section examines the practice of SHS in the Global South, in particular, issues pertaining to its delivery and governance, local level implications, and some of the challenges that face both users and implementers of SHS. The final section summarises key knowledge gaps and draws some conclusions.

2.1 Energy paradigms

Over the last century, the way in which societies and policy makers have framed energy has shifted. This has shaped the way in which energy has been governed. Goldthau (2012) employs the concept of ‘energy paradigms’ to characterise and examine these shifts in global energy governance over time, as illustrated in Figure.1. The concept of an energy paradigm provides a useful framework for this thesis, which analyses shifts in Nicaraguan energy policy agendas and governance patterns.

Figure 1. Energy paradigm framework



Source: Goldthau (2012)

Goldthau (2012) argues that shifts in energy paradigms have reflected wider economic paradigm changes. Cherp et al. (2011) also employ the concept of paradigm shifts to identify emerging energy governance arenas which have evolved to respond to distinct policy challenges, which as illustrated in Figure 1 constitute energy security, climate change and energy poverty. These shifts are closely tied to changing perspectives on the appropriate role of the state versus the market in delivering goods and services, such as energy. While states continue to be key drivers of energy policy, the role of the state in energy issues has been continually questioned throughout the decades (Batlle et al., 2010; Nakhooda, 2011).

The first paradigm identified by Goldthau (2012), the 'statist' paradigm, was dominant until the 1980s. This paradigm was rooted in a post-World War Two reconstruction policy agenda and geared towards the state-led provision of public goods and services, including energy. However, the election of Ronald Reagan and Margaret Thatcher in the late 1970s and early 1980s led to an abrupt shift in economic paradigm from state-led to market-led. This paradigm shift was also reflected in energy governance (Goldthau 2012). The emergence of a new ideology, Neoliberalism, led to an increasing reliance upon market forces, coupled with a reduction in state intervention (Fine, 2001). This was based on the assumption that private ownership would deliver more effectively on the provision of goods and services than public ownership (Bayliss and Cramer, 2001). The policy implications of this shift were the privatisation and liberalisation of state-owned electricity utilities, and a shift in the state's role, from 'owner' to 'enabler'. In many cases, international financial institutions (IFIs), such as the World Bank, acted as 'substantial vectors' for the promulgation of these policy prescriptions, particularly in developing countries (Dubash, 2011: 70; see also Thomas, 2004; Bayliss and Fine, 2007). This paradigm change was the most polemical in the case of the Global South, where levels of success and the implications of reform were hotly debated with often highly polarised opinions (McKenzie and Mookherjee, 2003). The issue of energy access provides one example; while some reform processes emphasised the objective of increasing energy access for the poor, this was often subordinate to the larger objective of neoliberal reform - in other words the prioritisation of cost recovery and enhanced operational efficiency (Dubash and Florini, 2011; Sokona et al., 2012). During the 1990s, the push to privatise electricity generation and distribution activities in developing countries exacerbated the problem of reaching unserved populations. As the World Bank (2008) now acknowledges, private utilities, often driven by bottom-line considerations (i.e. profits), had little incentive to deliver energy to the most isolated populations, while public utilities had few resources to do so in an anti-interventionist funding climate (see also Karekezi and Kimani, 2002). The 'failure' of privatisation to deliver normative energy goals gradually led to the call for increased government intervention in activities such as electrification (Wamukonya, 2003).

From the turn of the Millennium onwards, Goldthau (2012) notes increasing unease with market-led governance in energy sectors, which has led to a gradual shift towards a new period he terms 'interventionist'. Under this new paradigm, energy is viewed as having strategic qualities in several policy fields. Interventionism has emerged in response to recognition that the market alone cannot deliver normative energy goals. This new period witnesses the state's role shift from 'enabler' to 'stakeholder of public interest' (Goldthau, 2012: 204), to address not only energy security issues (e.g. through key re-nationalisations of energy companies), but also the climate change agenda, and most recently, the energy poverty agenda (see also Bhattacharyya, 2012). The confluence of these global energy challenges has been framed as an 'energy trilemma' (Scott, 2012; Gunningham, 2013). This is the quandary posed by the potentially conflicting goals of needing to simultaneously secure energy supplies, while also promoting environmental protection and providing universal energy access (World Energy Council, 2011). Looking forward, Goldthau (2012) suggests that a new energy paradigm that supersedes 'interventionism' may be in the making, a paradigm he terms 'fragmentation' (see Figure 1). Although it is important to examine the potential for subsequent paradigm shifts, this discussion focuses on statism, liberalism and interventionism.

2.1.2 Governing the global energy trilemma

Addressing the energy trilemma is inherently difficult due to the complex and unique nature of energy issues in the contemporary era. Goldthau and Sovacool (2012) for instance, argue that as well as underpinning the global economy and human existence, energy is deeply embedded in other sectoral and policy contexts; for instance, Florini and Sovacool (2009) emphasise its incursion into military interests (e.g. securing sea lanes for oil shipments), but also environmental interests (e.g. managing oil spills or human rights issues connected with resource extraction) and finally, human development interests (e.g. extending access to modern energy services) (see also Sovacool, 2012a). The vital importance of energy to global and national economies may result therefore in certain trade-offs; for example energy may be secured at the expense of environmental or developmental concerns. Goldthau and Sovacool (2012) therefore conclude that energy is among one of the most complex, path dependent, and embedded international policy fields (see also Unruh, 2000; Unruh and Carillo-Hermosilla, 2006). Cherp et al. (2011) also note that any transformation of the global energy system will need to overcome systemic inertia, ensure temporal and scalar coordination across energy sectors, engage with non-energy sectors and also mobilise unprecedented resources (see also Bradshaw, 2010). This is no easy challenge.

Those governing energy are therefore required to deliver on a much more complex set of issues than before (Goldthau, 2012); how global energy challenges are to be governed is a key academic and policy question of our time (see Florini and Dubash, 2011 and special issue). Indeed, as Newell (2011) notes:

> 'Governance is critical to ensuring that energy is directed towards those who need it most in an affordable and accessible way (energy poverty); that it can be supplied in a regular and predictable manner (energy security); and that it can be done in a way that minimises environmental externalities (sustainability)' (p. 94; see also Sovacool, 2011).

Furthermore, noting the tendency that energy has been susceptible to a high degree of corruption and rent-seeking, Dubash and Florini (2011) identify domestic good governance as a key issue for global energy governance (see also Lemaire, 2013).

Energy governance operates at multiple and interconnected scales, encompassing the household, community, local and national government and global institutions (Brody, 2009). Energy governance scholars recognise a complex and diverse range of institutions, 'governors' and governance mechanisms, which include intergovernmental organisations and summit processes (involving organisations such as the OECD, IEA, OPEC, G8 and G20), individual nation states, IFIs, private actors and civil society organisations (Cherp et al., 2011; Van de Graaf, 2012). However, many have also argued that the existing forms of global governance do not adequately match or cope with the nature and scope of the global energy trilemma (Florini and Sovacool, 2009; De Jong, 2011; Dubash and Florini, 2011; Florini and Dubash, 2011; Goldthau and Sovacool, 2012).

Despite shifting paradigms, which have envisaged a lesser or greater role for national governments, they have played a central role in this complex structure of energy governance. However, there are distinctions between nation states: whilst some have shaped the global energy arena – the so-called 'rule makers' (i.e. OECD (Organisation of Economic Cooperation and Development) countries) – others have been shaped by it, the so-called 'rule takers' (e.g. La Viña et al., 2011). Yet shifting power dynamics in the global political economy have witnessed the emergence of 'rising powers' – particularly the BRICS (Brazil, India, China, South Africa), which are increasingly shaping global energy governance (see Dubash, 2011; Kong, 2011; Goldthau, 2012; Johnson and Power, 2012; Baker et al., 2013). As outlined in Chapter One, the empirical focus of this research is Nicaragua; a rule taker whose energy system has been and continues to be conditioned by its position in the global political economy (Baker et al., 2013). As a 'rule taker' it is necessary to reflect on global and regional processes, as well as on the shifting global energy paradigms that influence the direction of Nicaragua's energy system and its ability to negotiate the complexities of the energy trilemma – examining so-called 'energy governance from above' (Newell et al., 2009; Phillips and Newell, 2013). Equally important, however, is the influence of 'governance from below' - the processes at work within nations that interact with global processes to shape energy policies and energy realities. Indeed, Büscher (2009) and Moe (2010) emphasise the importance of examining the political-economic power relations of domestic energy sectors. These global to local linkages strongly influence national energy policies and impinge on multiple scales, for instance, shaping the realities of energy access at the local level (Büscher, 2009). However, Büscher (ibid) argues that energy research frequently examines the 'local' and 'global' in isolation from one another and urges for scholars to engage with multiple and nested scales of analysis. Further, such research should be embedded within a consideration of the wider social and political-economic frameworks (see also Meadowcroft, 2011; Goldthau and Sovacool, 2012; Newell and Mulvaney, 2013). This thesis responds to these calls, through an investigation of the multiple scales and processes that influence energy realities in the Nicaraguan context.

This section has explored debates on global energy governance and the challenges posed by the contemporary energy era, characterised by the global energy trilemma. The following section now turns to examine the framing of energy challenges faced by countries of the Global South. While these challenges have been recognised over several decades, crucial issues, particularly energy poverty, have been frequently overlooked or set within broader objectives (Birol, 2007; Dubash and Florini, 2011; Sovacool et al., 2012). Questions of 'energy for development' and 'energy poverty' in developing nations rose to global prominence relatively recently, with the 2002 World Summit on Sustainable Development (WSSD) in Johannesburg forming a key milestone. These issues have since become key objectives for international energy governance, culminating most recently in the launch of the United Nations' 'Sustainable Energy for All' (SE4All) initiative. The following section examines the discursive journey of the 'energy for development' issue at the global level. In particular, it examines the actors, institutions, events and summit processes that have served to prioritise this agenda.

2.2 Energy challenges in the Global South: a fluctuating policy concern

Since the 1960s, there has been an increasing awareness that certain approaches to energy production, transportation and consumption are unsustainable (Matthews and Siddiqi, 1981). This matter rose to the top of political agendas, particularly for industrialised countries, in the wake of the 1970s OPEC (Organisation of the Petroleum Exporting Countries) oil crises. As a result, many countries adopted policies to diversify their energy matrices. Writing after the crises, Smil and Knowland (1980: 5) argued that 'the energy problems of the industrialised nations… pale in comparison to those facing most of the world's developing countries'. Others pointed to the 'unseen energy crisis' that was afflicting many areas of the developing world at this time (Hoffman and Johnson, 1979; Eckholm, 1980). The emerging 'Fourth World' - the poorer, oil importing developing countries - found the increased price of imported oil a growing constraint on economic development (Bailey, 1977; see also Goldemberg et al., 1987). Around this time, recognition grew of the 'real energy crisis' facing rural sectors of developing countries, namely the fuelwood crisis. It was estimated that one third of the world's population was engaged in a daily battle to secure scarce wood resources in order to satisfy their basic cooking needs (Eckholm, 1980). The oil and fuelwood crises constituted a dual burden for many developing countries, and energy more broadly became framed as a source of both environmental and macroeconomic stress (Rehman and Cleveland, 1980; Hayes, 1981; Najam and Cleveland, 2004). Foley (1992), referring back to this period, argues that as international awareness of energy issues rose during the 1970s, energy was transformed from a 'relatively obscure technical issue' to a matter of 'high public and political concern' (p. 355).

This sea change influenced the growth of 'energy development' assistance policies of the developed world and provided an impetus for renewable energy technologies (ibid; Matthews and Siddiqi, 1981; Byrne et al., 2011). Energy development assistance was a key theme of the Bonn Economic summit of 1979, which Hoffman and Johnson (1979) suggest was stimulated by a combination of factors which included: pressures from environmental and anti-nuclear lobby groups; concern over monetary instability caused by Third World debts; commitment to humanitarian foreign aid programmes; and increased support for industrialised nations' renewable energy technology industries. For instance, in the case of the US solar technology industry, companies sought to compete in developing world markets, which had been typically dominated by French exporters (ibid) (this is a theme which is returned to in section 2.4). Countries of the Global South were therefore simultaneously framed as potential threats (in environmental and economic terms), as well as victims and market opportunities in alternative readings of the energy problems afflicting the developing world. This had profound impacts on the ways in which the energy challenges facing the Global South were to be framed. Just as is the case today, development assistance policies at the time focused on providing substitutes for oil, and significant attention was devoted to renewable energy technologies (Foley, 1992). The transfer of renewable energy technologies from the Global North was primed as a key solution, and financing was framed as the key barrier to this; developing countries 'needed' technology and the industrialised countries loaned the money through 'aid' to finance it (Byrne et al., 2011). Energy development assistance therefore focused on fixed capital assets and transferring new technologies as 'experiments' to the developing world; however, Sovacool (2012b) observes that little support was dedicated to improving local capacity or self-sufficiency. This focus on technology illustrates what Shah (2009) describes as the traditional 'uncritical optimism' about the role of science and technology in solving issues of underdevelopment (p.7) (see also Sesan et al., 2012). Indeed, there is a history of expectations about the power of technology in providing 'solutions' to development challenges (see Sachs, 1992; Leach and Scoones, 2006; Smith, 2009; Byrne et al., 2012).

The role of renewable energy (technologies) in the economic and social development of countries in the Global South was recognised as an international priority at the 1981 UN Conference on New and Renewable Sources of Energy in Nairobi (Kozoloff, 1995). A programme of action was agreed that included measures for energy assessment and planning; research, development, and demonstration; transfer, adaptation and application of mature technologies; information flows; and education and training[3]. However, developing countries were suspicious of the motivations of the international

[3] See: http://www.un.org/documents/ga/res/36/a36r193.htm

community. The measures were interpreted as ways to check the power of OPEC countries, contain nuclear capabilities and provide heavy export-promotion orientated aid programmes, in addition to the widespread scepticism that renewable technologies were not economically competitive or technically mature (Foley, 1992; Byrne et al., 2011). Confrontation between developed and developing countries arose over the means to develop new and renewable sources of energy; while industrialised nations emphasised the role of the private sector, developing countries stressed their need to access technology on reasonable and equitable terms (Byrne et al., 2011). While funds disbursed for energy development assistance peaked at approximately the time of the Nairobi conference, Michaelowa and Michaelowa (2011) argue this was linked to the second oil crisis. Subsequent oil gluts and falling energy prices weakened political resolve to commit funds and implement the plans made at the Nairobi conference (Kozoloff, 1995).

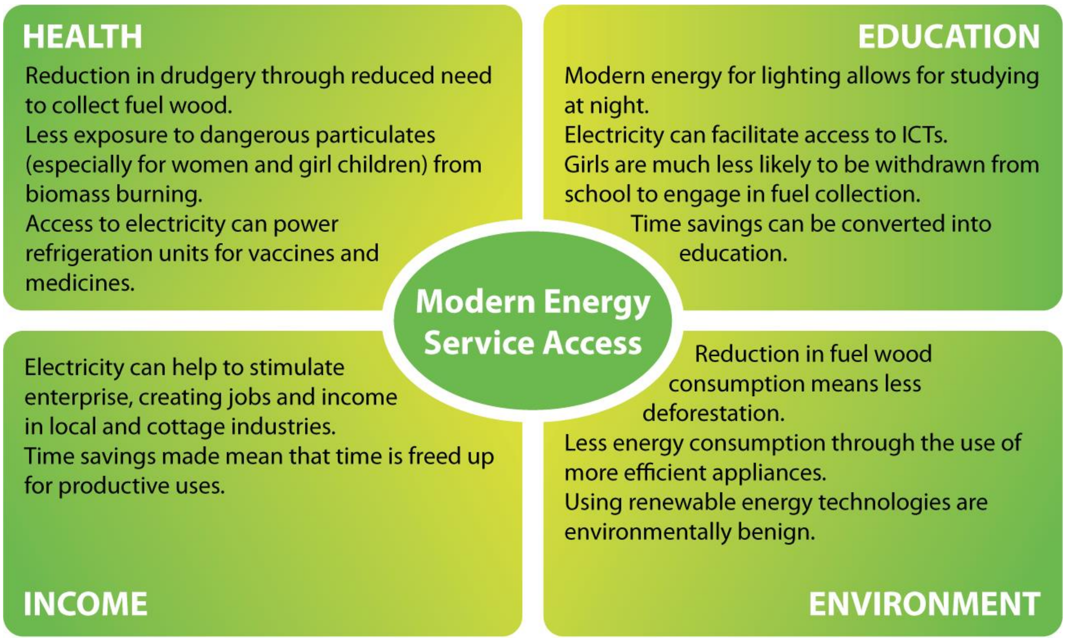
By the time of the 1992 Rio Earth Summit, the prominence of the global 'energy issue' was reinforced, this time as a source of environmental stress. While 'energy' was not directly discussed at Rio, it was implicit in key discussions; for instance, within those relating to the protection of the atmosphere or promoting sustainable consumption (Najam and Cleveland, 2004; Spalding-Fecher et al., 2005). According to Hodas (2010), the omission of energy at Rio was not an oversight, but rather indicative of the disputes between oil exporting and oil importing nations. As a result no specific energy chapter was published in the Agenda 21 outcome document. In terms of energy assistance, Michaelowa and Michaelowa (2011) argue that the Rio summit had little impact on trends in flows of energy development assistance. Indeed, the landscape for development assistance shifted significantly during the 1990s, and an overall decline in bilateral and multilateral aid was witnessed. This was stimulated by two factors. Firstly, the 'Helsinki package' came into force in 1992 which saw the end of so-called 'tied aid' for commercially viable projects (Piebalgs, 2012). Secondly, a broader shift in ideological currents (described in section 2.1), saw donors reduce their support for large scale energy projects. Instead, donors focused on restructuring initiatives to promote private investment, activities which generally required smaller amounts of aid (OECD-DAC, 2010; Nakhooda, 2011). Broader trends in the development community were heavily influenced by the so-called 'Washington Consensus' (see Bayliss and Cramer, 2001), however as indicated in section 2.1, the emphasis on macroeconomic orthodoxy did not always deliver the expected benefits, for instance, increased levels of energy access (see Yumkella, 2012).

This section has briefly examined the ways in which the energy challenges facing countries of the Global South were framed during the 1960s through to the 1990s. It is evident that the relative prioritisation of these issues has fluctuated on the international agenda, influenced by a wide range of factors, including international oil prices, broader shifts in economic paradigms, and Northern interests, namely export markets. The following section focuses on energy challenges facing the Global South since the turn of the Millennium. In particular, it explores how energy has come to be framed as the linchpin of achieving twenty first century international development agendas.

2.2.1 Energy: the missing MDG?

Moving towards the fifth development decade, the most well-known international development agenda was the United Nations Millennium Development Goals (MDGs), which were ratified in September 2000. The eight MDGs – which range from halving extreme poverty rates to halting the spread of HIV/AIDS and providing universal primary education, by the target date of 2015 – form a blueprint agreed to by all countries and leading development institutions[4]. While the MDGs do not explicitly refer to energy, it is widely recognised that improving access to modern energy services is a fundamental input for achieving each objective (Modi et al., 2005). Energy has been described as the 'missing MDG' (Modi, 2004; Brew-Hammond, 2012); indeed, it came as a surprise to some commentators that an energy goal was not included in the Millennium Declaration, especially given its links with social and economic development (Najam and Cleveland, 2004; Töpfer, 2013). Figure 2 depicts the relationship between access to modern energy services and social, economic and environmental objectives.

Figure 2. The relationships between modern energy service access and poverty reduction



Source: adapted from Kanagawa and Nakata (2008)

[4] See: http://www.un.org/millenniumgoals/

Spalding-Fecher et al. (2005) provide a discussion of some of the key initiatives that attempted to improve global understanding of the need for international cooperation on energy and development. They describe the ninth session of the UN Commission on Sustainable Development (CSD-9), which was held in New York in 2000 and 2001 with the UN Development Programme, World Energy Council, EU, and G8. They argue that the CSD-9 represented the first time that energy had been addressed in an 'integrated way' by the UN system; as a result it formed a significant element of the groundwork for the World Summit on Sustainable Development (WSSD), which in 2002 would serve as a key catalyst in the proliferation of the contemporary debate on energy poverty. As in previous summit processes, CSD-9 revealed the highly contentious nature of what exactly various protagonists understood 'energy for development' to encompass and what the most appropriate means of promoting it were. For example, there was a clear North-South divide present in the definitional debate with the idea of 'sustainable energy' favoured by the EU and 'energy for sustainable development' favoured by countries of the South (Spalding-Fecher et al., 2005).

The WSSD, which was held in Johannesburg in 2002, represented a turning point in the discursive journey of energy for development. Rather than just constituting a subsector of 'environment' talks (as it had done at Rio a decade earlier), energy - specifically energy services - became a central issue in its own right in Johannesburg (Clancy et al., 2007), marking significant progress in the advance of the sustainable energy agenda (Karlsson and Oparaocha, 2003). It was at this meeting where it became more widely accepted that energy, whilst not being a basic human need itself, was critical to the fulfilment of all basic needs (WSSD, 2002). Although the WSSD did not achieve any binding targets on energy access (Spalding-Fecher et al., 2005), it did generate significant (non-binding) partnerships in these areas (Peake, 2002) and is credited with incorporating social and human development dimensions (in addition to the environmental and economic dimensions emphasised at previous environmental summits) into international discussions on energy (Najam and Cleveland, 2004). Pielbags (2012) argues that the most recent explosion of international interest in and action on energy directly stems from the WSSD. Since this milestone, energy has become more firmly mainstreamed in the fight against global poverty (Goldthau, 2012). Moving forwards from the WSSD, Table 1 highlights the key milestones in the relatively recent prioritisation of 'energy for development' in the global development agenda.

Table 1. Key milestones in the recent prioritisation of energy in the global development agenda

Key milestones	Year	Overview
World Summit on Sustainable Development, Johannesburg	2002	International recognition that energy is critical to the fulfilment of all basic needs. Acknowledgement that poverty reduction, access to energy, energy security and climate change mitigation are interlinked issues requiring a coordinated response from the development community.
Publication of 'Energy services for the poor' (Modi)	2004	Commissioned for the Millennium Project Task Force; recognises that energy services are a ‘missing MDG’ and outlines vision for 2015 comprising a set of energy services that could provide a way forward towards meeting the MDGs.
Creation of UN-Energy	2005	Mechanism for UN inter-agency collaboration in the field of energy established.
Publication of 'Energy services for the Millennium Development Goals' (Modi et al.)	2006	Report shows linkages between all of the MDGs and energy and argues that much greater quality and quantity of energy services will be required to meet the MDGs.
Creation of the UN Secretary General’s Advisory Group on Energy and Climate Change (AGECC)	2009	AGECC was established to advise the Secretary General on energy-related dimensions of the climate change negotiations. AGECC is an example of a multi-stakeholder partnership bringing together the UN system, including the World Bank, with the private sector and research institutions.
Publication of AGECC’s 'Energy for a Sustainable Future'	2010	AGECC call for commitment and concerted action on two ambitious goals: universal access to modern energy services and improved energy efficiency. The report recommends the launch of a global campaign in support of ‘energy for sustainable development’. The report recommended that the UN system should make ‘energy for sustainable development’ a major institutional priority. Specifies potential minimum energy access level targets.
Launch of 'Sustainable Energy for All' (SE4All) initiative	2011	SE4All is launched to tackle three highly ambitious and interlinked objectives by 2030: 1) to provide universal energy access; 2) to double the global rate of improvement in energy efficiency; 3) to double the share of renewable energy in the global energy mix (UN, 2011).
Designation of 2012 as International Year of Sustainable Energy for All	2011	General Assembly (GA) resolution 65/151 encouraged all Member States to take advantage of the International Year of Sustainable Energy for All to increase awareness of the importance of addressing energy issues for the achievement of development goals (MDGs), sustainable development and the protection of the global climate (UN, 2011).
Rio +20 United Nations Conference on Sustainable Development	2012	Despite being merely ‘noted’ by the GA, SE4All's three goals attracted commitments equating to over $320 billion in direct investment – approximately 10% is earmarked specifically for energy access programmes (the least investment of the three goals) (IEA, 2012a)
Designation of 2014 to 2024 as International Decade for Sustainable Energy for All	2012	GA resolution 67/257 calls upon Member States to galvanise efforts to make universal access to sustainable modern energy services a priority. It also highlighted the importance of improving energy efficiency, increasing the share of renewable energy and cleaner and energy-efficient technologies (UN, 2012a)

United Nations Global Energy Consultation	2013	Global consultation underway on how energy is to be incorporated into the UN's post-2015 development agenda.

Since 2002, the 'energy for development' agenda has gained significant traction and is increasingly emphasised within the UN international development apparatus. The escalating prioritisation of this agenda has led to new forms of governance in this arena, for instance, the creation of the multi stakeholder bodies UN-energy and the UN Secretary General's Advisory Group on Energy and Climate Change (AGECC). Emerging from these collaborations is the highest profile of all recent initiatives, SE4All, which was launched in 2011. This initiative represents a creative governance arrangement that has been developed outside of traditional intergovernmental negotiations (Evans and Steven, 2012). Hailed as 'the greatest public-private partnership of all time' (Guardian Environment Network, 2012: n.p.), SE4All has brought together national governments, private sector actors, researchers and civil society to address energy issues in both the developing and developed world. SE4All is also unique amongst international initiatives in that its three objectives reflect the breadth of the challenges of the global energy trilemma discussed in section 2.1.2 (Scott, 2012). SE4All aims to provide universal energy access, to double the global rate of improvement in energy efficiency, and to double the share of renewable energy in the global energy mix.

The UN Rio+20 summit in July 2012 was envisioned as a platform for collecting commitments for SE4All; stakeholders were invited to announce their commitments in line with SE4All's Global Action Agenda (UN, 2012b). The outcome of Rio +20 was disappointing however as there was no over-arching international recognition or adoption of SE4All. While the Rio+20 outcome document recognises the critical role that modern energy services play in development and commits 'to facilitate support for access to these services' (United Nations, 2012c pp. 24-25), the launch of SE4All was merely 'noted' by delegates (ibid). This means that no high level UN commitment was made to the initiative. Critics argued that the Rio+20 outcomes lacked the 'urgency required to stimulate rapid acceleration of sustainable energy access in developing countries' (Christian Aid, 2012).

Despite disappointment with the lack of high level support for this initiative, SE4All has galvanised international efforts (and generated significant financial resources via voluntary commitments) to an implementation space already rife with energy access efforts from states, IFIs, aid agencies, Non Governmental Organisations (NGOs), UN agencies, and private-sector companies (as described by Bazilian et al., 2010b). Programmes that simultaneously confront two aspects of the energy trilemma - energy poverty and climate change - through the expansion of decentralised renewable energy technologies are increasingly popular amongst national and international development institutions (see Schäfer et al., 2011; Sovacool and Drupady, 2012).

While the current profile of energy poverty is unprecedented, the most recent Poor People's Energy Outlook cautions that commitments to clean, secure and affordable energy do not automatically translate into its delivery, especially for poor communities (Practical Action, 2013). Not only is there an apparent shortfall in investment required to achieve universal modern energy access by 2030 (see IEA, 2012a), but scholarly attention increasingly focuses on the barriers to alleviating energy poverty at various scales (see Bazilian et al.; 2010b; Sovacool et al., 2011; Bazilian et al., 2012; Sovacool et al., 2012). Sovacool (2012b) provides an overview of the challenges and political economies of increasing energy access to the poor; some of these will be discussed specifically in relation to the deployment of solar energy technologies in section 2.4. He argues that the energy poor typically 'fall between the cracks', where private sector actors have little incentive to expand service provision, and public sectors have limited capacity to do so under pressure to satisfy other urgent public needs (p. 278). Turning again to Sovacool (2012b), where energy access has been prioritised, it has typically been framed as a challenge of electricity provision, with urban areas predominantly benefitting through centralised grid extension (see also Rehman et al., 2012). Energy access initiatives have been described as short-lived, fragmented, framed under different assumptions and incommensurate with the magnitude of the problem (see Sagar, 2005; Bazilian et al., 2010b; Sovacool, 2012b). As we shall see in the empirical chapters of this thesis, many of these concerns are raised in relation to solar energy access initiatives in the Nicaraguan context. This section has described the way in which energy issues have risen to the top of the international development agenda. The chapter now turns to an analysis of the emerging debates on energy poverty in the Global South.

2.3 Conceptualising energy poverty

There is currently no internationally-accepted or adopted definition of 'energy poverty' or what basic level access to modern energy services should look like. The concept of 'poverty' alone is not a static or fixed state, but instead a multi-dimensional concept encompassing dimensions such as calorific intake, life expectancy, housing quality, literacy, access to energy, and a variety of other factors (see OHPI, 2013). Developing a robust set of indicators for measuring energy poverty is considered a necessary step to enable countries to set targets and monitor progress towards achieving modern energy access (Bazilian et al., 2010a; IEA, 2010; Nussbaumer et al., 2011). In the context of SE4All, commentators have called on the international community to clarify the ambiguity of achieving 'universal energy access', raising questions such as, what levels of access? What types of energy services? What types of technologies? And, what development benefits? (FOEI, 2012; Garside, 2012).

In both practitioner and academic literatures, several approaches have been developed to conceptualise energy poverty. The World Energy Outlook (IEA, 2010) identifies a lack of electricity and dependence on the traditional use of solid fuels for cooking as two key indicators of energy poverty. Other broader definitions have been posited, for instance, Barnes et al. (2010) state that 'energy poverty is the point at which people are using the bare minimum energy needed to sustain a healthy life, beyond this point, energy contributes to increased welfare and higher levels of economic well being' (p. 2). Reddy (2000) argues that energy poverty is 'related to the absence of choice in accessing adequate, affordable, high quality, safe and environmentally benign services to support human and economic development' (p.44). Differential framings of energy poverty illustrate the lack of consensus around its conceptualisation.

For Sovacool (2012b), the most common concept that is used to illustrate energy poverty involves the idea of 'energy ladders' for services such as heating and cooking. This involves households 'fuel switching' or becoming less 'energy poor', as household income increases. In practical terms, this means the replacement of the simplest, most traditional fuels and materials (e.g. candles, biomass) by more efficient, 'modern' energy sources (e.g. kerosene, LPG, electricity) (ibid; see also Pachauri, 2004; WHO, 2006). However, the transition to more 'modern' energy in the home is a dynamic process, and evidence suggests that the ladder concept is over simplistic because even with high per capita incomes, households may continue to use biomass alongside commercial fuels. Thus, households 'stack' fuels and devices rather than substituting them (e.g. Ruiz-Mercado et al., 2011; UN, 2013). Indeed, individual household 'energy baskets' may vary widely across age, gender, family priorities, income generating activities, country, climate and cultural preferences (Pachauri et al., 2004; Pereira et al., 2010). For instance, under unstable livelihood circumstances, households may alternate their fuel consumption habits to take advantage of 'free' biomass resources, or more 'flexible' fuels that can be purchased in smaller quantities (Corsair, 2009).

Hierarchies of 'basic need' have been linked to different levels of energy access and uses of electricity or cooking fuels (e.g. Krugman and Goldemberg, 1983; Yeager, 2001). This involves making assumptions regarding the type of energy conversion equipment, their sizes and efficiencies, but moreover, assumptions of what human needs constitute. The difficulties of measuring and defining the basic energy needs of humans are well documented in the literature (e.g. Krugman and

Goldemberg, 1983; Goldemberg et al., 1985; Goldemberg, 1990; see also Illich, 1992 and Sachs, 1992 for wider debates of human 'needs' in international development debates). The UN (2010) outlines three levels of 'needs' and the associated power requirements and kilograms of oil equivalent (see Table 2). How key actors in the energy poverty governance arena build consensus and operationalise definitions of energy poverty and energy access matters for how such challenges will ultimately be tackled.

Table 2. Incremental levels of access to energy services

Level (needs)	Electricity use	kWh per person per year	Solid fuel use	Mobility	Kilograms of oil equivalent (kgoe) per person per year
1- Basic human needs	Lighting, health, education, and communication	50–100	Cooking and heating	None, walking or bicycling	50–100
2- Productive uses	Agriculture, water pumping for irrigation, mechanized tilling, processing	500–1000	Minimal	Mass transit, motorcycle, or scooter	150
3- Modern society needs	Domestic appliances, cooling, heating	2000	Minimal	Private transportation	250–450

Source: adapted from UN (2010)

The emphasis on defining and operationalising basic minimum energy services led Pielke Jr. (2012: n.p.) to argue 'against modern energy access'. Based on the basic minimum access threshold in Table 2 (500kWh of electricity for a five person household), Pielke Jr. calculates that this accounts for access to 2.2% of electricity consumed by the average American. He highlights the inequities of global energy consumption; for key energy governors (e.g. IEA or UN), a successful conclusion to the energy poverty challenge would see energy poor populations attaining just a fraction of the energy that consumers in the Global North enjoy on a daily basis. This echoes Grimsby (2012) who argues that the global focus on energy poverty, rather than energy equity, conveniently evades the problem of the gap in energy consumption per capita in the developed and developing world (p. 6912).

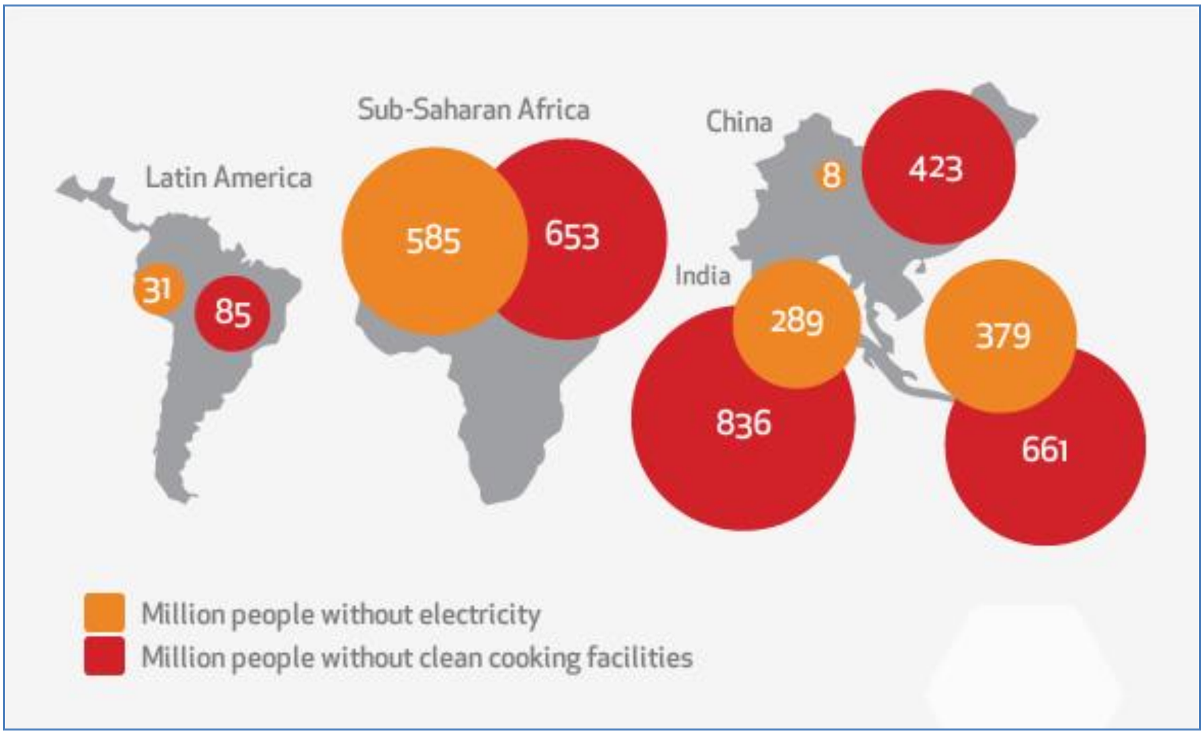
This exploration of the emerging debates on energy poverty reveal that there are clear conceptual and methodological challenges to defining what is meant by energy poverty and access. Energy poverty has been explored in a way that is over-simplistic and technical in nature (e.g. engineering approaches that incorporate kilowatt hours of electricity or kilograms of oil equivalent), which arguably lends itself to a technological, engineering-based fix (see also Makhabane, 2002). With the exception of the Poor People's Energy Outlook (see Practical Action, 2010; 2012; 2013), there are few scholarly accounts that incorporate the voices of the energy poor or examine how modern energy services are viewed by the people who live without them. Furthermore, there is a dearth of studies that consider how energy services contribute to the fulfilment of 'needs' as defined by individuals, households or communities. Moving beyond techno-economic framings of energy poverty is required to appreciate the diversity of populations living off the grid. For example, in energy poor households, evidence suggests that it is women who spend a disproportionate amount of daily time and human energy procuring energy services (WSSD, 2002; UNDP, 2004; Clancy et al., 2003; Clancy et al., 2007). While perhaps it is helpful to set a minimum access threshold (e.g. 100kgoe person/year), what does this tell us about the women and girls responsible for acquiring fuels? What does this say about who within a household has the right to use a particular fuel? Further conceptual work is required to recast energy poverty as a set of complex intra-household relations, which are closely tied to the gendered division of labour. These themes are returned to in Chapters Four and Seven.

2.3.1 Spatial dimensions of global energy poverty

Recent data suggest that while some developing areas have made remarkable progress in increasing their citizens' access to modern energy services (for instance China, see Bhattacharyya and Ohiare, 2012); others have yet to make significant progress. Current analyses show that unless efforts are scaled up significantly, by 2030 the number of people without electricity is likely to remain above 1 billion. The number of people who lack clean cooking facilities, which is currently estimated at 2.7 billion, will remain roughly the same (IEA, 2012b; Piebalgs, 2012; Yumkella, 2012). Some regions are projected to reach universal electricity access by 2030 and make significant progress in expanding modern cooking fuels (e.g. Latin America), for others however, particularly sub-Saharan Africa, the situation deteriorates (IEA, 2012b). Figure 3 illustrates the global distribution of populations living without access to electricity or clean cooking facilities in 2011.

Energy poverty is largely a Southern phenomenon, and within the Global South one that affects rural, peri-urban and urban areas. Together, developing Asia and sub-Saharan Africa account for more than 95% of those without modern energy access. Figure 3 masks some of the huge disparities within countries. For instance, in terms of electrification, the average global level of coverage is 76%; however, for urban areas this is approximately 92%, falling to 64% in rural areas (IEA, 2012b). The crude 'without electricity access' figures presented are, however, over-simplistic; for instance, the UN Foundation (2013) estimates that up to 1 billion people globally are grid connected, but with intermittent supply. The electricity access problem is therefore much greater than published statistics suggest.

Figure 3. Global distribution of energy poverty



Source: IEA (2011)

While this discussion focuses on energy access, quite often what is meant is electricity access. Indeed, analysis of the commitments made under the recent SE4All initiative indicate a bias towards facilitating access to electricity, rather than access to clean cooking fuels (Practical Action, 2013; see also IEA, 2012b). Focusing on electricity provision specifically, the IPCC (2011) recently stated that renewable energies are an affordable and economically viable option to react to the electricity needs of people in developing countries. Micro-scale renewable energy technologies (RETs) are sometimes the only means of supplying electricity to rural areas unable to be reached by the grid (IEA, 2010), but may also provide an environmentally benign source of electricity (Gullberg et al., 2005; Zerriffi and Wilson, 2010). Decentralised applications of solar photovoltaic (PV) energy technologies are a key example of small RETs, and emerge as a particularly popular technology choice in analysis of the SE4All commitments. Posited as a means to supply electricity to households in remote areas of developing countries - where it is often expensive and unfeasible to extend the national electricity grid system – technologies such as the solar home system (SHS) are considered 'vital' in international efforts to address energy poverty (Sovacool et al., 2011: 1534). As solar energy is the main focus of this thesis, the remainder of this chapter examines the evolving debates surrounding solar energy technologies in off-grid areas of the Global South.

2.4 Off-grid solar photovoltaic technologies in the Global South

In an effort to meet enormous electrification demand in an environmentally benign way, many have looked to solar PV energy (Acker and Kammen, 1996); solar PV arrays have been deployed across the developing world in the form of SHS, Solar Battery Charging Stations (SBCS) or Solar Pico Systems (SPS). SHS vary in their PV array size, from around 12-150Wp, and have the potential to run domestic lights and small entertainment appliances (such as television). SHS currently provide many off-grid areas of the developing world with power (REN21, 2012), having been widely used to assist with rural electrification schemes in particular (see Acker and Kammen,1996; Nieuwenhout et al., 2001; Urmee et al., 2009 for examples). They have been promoted and implemented by governments, donor agencies, NGOs and through private-sector initiatives. Bangladesh is one site where there has been an SHS explosion in recent years. It was recently announced that more than 2.1 million systems had been installed between 2009 and 2013, with a final target of 4 million installations set for 2015 (Chowdhury, 2013; REN21, 2013a). The SBCS is a variation on the SHS. While it can share the same potential capacity as SHS, it is a community-managed system where PV arrays are located centrally, and the power supply is shared between various users. Users bring batteries to the SBCS to be charged, and the battery is then plugged into home kits to provide electricity services (Green, 2004). A further variation is the SPS, which has seen significant growth over recent years. SPS has a smaller PV array than the SHS, typically with a lamp and facilities for mobile telephone charging. With the emergence of efficient end use equipment (e.g. LED lights), SPS can provide high quality lighting and are typically more portable and affordable than traditional SHS (REN21, 2012; IEA PVSP, 2013). There are increasingly innovative approaches to the delivery of SPS which enable it to be gradually scaled up, so that service levels reach that of a larger SHS[5].

There are signs that the current emphasis on the delivery of decentralised applications of solar energy technologies will continue for the foreseeable future. Indeed, the recently published 'Renewables Global Futures Report' (REN21, 2013b) examines future prospects for rural renewable energy and predicts continued momentum in off-grid solar PV applications (see also Devabhaktuni et al., 2013). The faith that the international community places in solar energy is evident in the prevalence of programmes supporting solar-based electrification in the developing world. Indeed, solar energy programmes are a significant feature of the 'energy development assistance' activities of IFIs and development agencies, and are also heavily promoted by national governments and

[5] For instance the Indigo product offers users an opportunity to climb the 'Energy Escalator'; users can scale up the capacity of their solar pico lighting system to enable the greater use of appliances (see: http://www.azuri-technologies.com/indigo/products/)

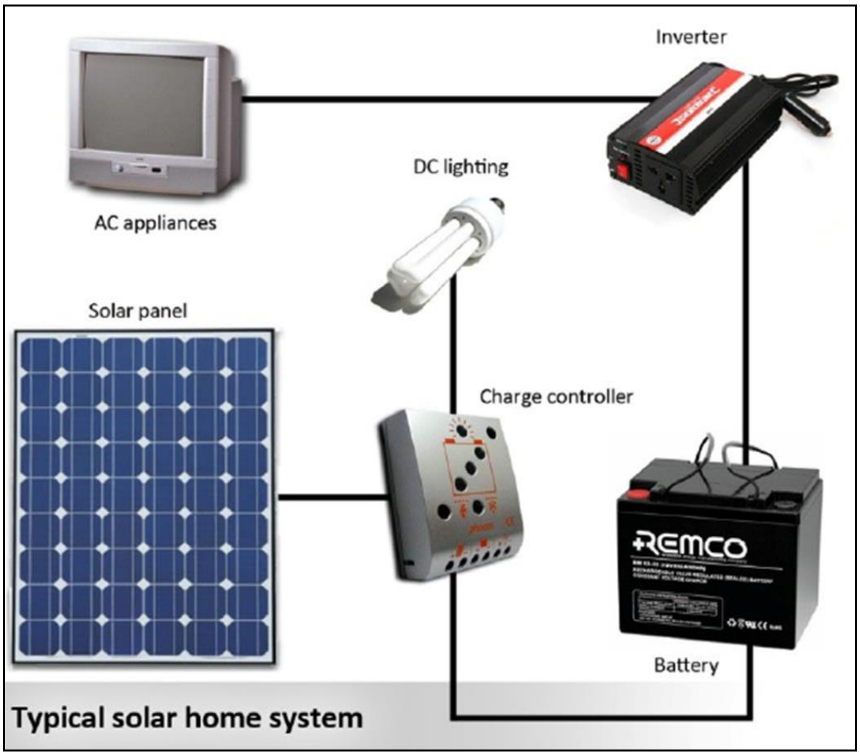
NGOs. The volume of solar energy-based commitments made to the SE4All initiative[6] illustrates just how critical technologies such as the SHS are perceived to be in tackling global energy poverty.

2.4.1 The technology

SHSs typically comprise a solar PV panel, battery, charge controller and inverter that can provide modest amounts of electricity to homes, usually in rural or remote regions that are not connected to the electricity grid (see Figure 4). Solar photovoltaic modules are mounted on a roof/pole and pointed in the direction of the Equator. The modules generate electricity from sunlight – photons of light that, upon hitting a solar module, displace electrons to create an electrical charge (Miller, 2010). This charge is then channelled and conducted from the solar modules through wires to the battery, charge controller and inverter – known as the balance-of-system (BOS) components - which are required to deliver electricity to an end use. While Foley (1995) states that the BOS components do not often attract the same attention as PV modules , they can constitute up to 50% of the cost of an installation. Furthermore many studies highlight the vital part that BOS components, particularly batteries, play in the long term functionality of the technology (e.g. Foley, 1992; 1995; Lysen, 1994; Gustavsson, 2007; Hajat et al., 2009). The most common solar PV systems found in rural areas of developing countries are SHSs with a capacity of between 30 and 100 Wp (IEA, 2010), the most common being 50 Wp (Foster et al., 2010). A typical 50 Wp SHS kit can operate three or four lamps, in addition to small appliances, such as a radio or small black and white television for limited periods. This will, however, depend on the availability of solar resource. A pervasive view of SHS is that they are ideally suited to the electricity needs of a typical rural household and can lead to increased quality of life in rural households (e.g. Oliver and Jackson, 1999; Kaufman et al., 2000; Martinot et al., 2002; Mala et al., 2009).

[6] See: http://sustainableenergyforall.org/actions-commitments/high-impact-opportunities

Figure 4. A typical solar home system configuration



Source: author's own illustration

However, as discussed in section 2.3.1, the notion of 'needs' is a deeply contentious issue, especially in debates on how to define 'energy poverty' and minimum energy access thresholds. While the sizing and design of systems is largely framed as a technical issue to overcome (e.g. Foster et al., 2010), in reality it is a process fraught with political challenges – for instance, IEA PVPS (2013) argues that sizing has to balance the conflicting viewpoints of various actors. Firstly, the perspective of the institution implementing or financing the technology may be oriented towards fulfilling 'basic needs' and hitting cost-benefit targets (i.e. small systems limited to lighting). Secondly, the end users, who, in addition to lighting, may prioritise the use of appliances, such as small televisions or radios (i.e. larger capacity systems that can power appliances). Finally, the opinion of engineers, who typically determine standardised need levels and system sizes (i.e. maximum technical performance and efficiency). The politics involved in the selection, design and implementation of solar PV technologies is a recurrent theme throughout the remainder of this section.

2.4.2 The promise of PV

The use of SHS is seen as one tool toward the alleviation of global energy poverty. While SHS cannot be used for cooking or heating – which is a key concern in energy poverty debates - the electricity produced does provide a clean lighting source. At the household level the use of SHS can eliminate or reduce the need for candles or kerosene. This has been linked by various authors to economic benefits, increased household safety and improved indoor air quality (Smith, 2000; Martinot et al., 2001; Obeng et al., 2008). In addition to increased living standards and levels of user convenience, Erickson and Chapman (1995: 1130) outline a series of justifications behind the global promotion of PV technologies in rural off-grid settings. These include: the large percentage of the global population without electrical services; the absence of reliable and efficient grid supplied electricity in many developing countries; oil price instability; the high solar resource available in many developing countries (see also Huacuz, 2003; Miller, 2010; SWERA[7]); and finally, that PV technologies are economically competitive, locally appropriate, and deliver environmental benefits. On a global level, the expansion of PV links to the increasing traction of 'green economy' thinking (see UNEP, 2011; Brown et al., forthcoming); Greenpeace and EPIA (2011) for instance estimate that the global PV industry could generate up to 3.6 million jobs by 2020 (see also Frankfurt School and UNEP, 2012). With this extensive array of benefits, it is hardly surprising that solar energy technologies have penetrated rural energy mixes globally, gaining momentum over recent years. To borrow a phrase from Hunsberger (2010: 959), PV can be posited as an 'agent of multiple objectives', one that spans multiple scales, simultaneously addressing various aspects of the energy trilemma discussed in section 2.2. Moreover, the environmental promise appeals to the climate agenda, while the 'small is beautiful' economically competitive and human development qualities make solar a particularly attractive response to the energy poverty challenge. Finally, the energy security facet is appeased through the potential reduction in fossil fuel use.

The idea that solar energy technologies can provide the 'silver bullet' to the policy challenges facing global energy governance is, however, contested. For instance, while frequently cited in programme justifications, the arguments that decentralised applications of PV are economically competitive with other remote power sources, are technologically appropriate, and can promote environmental benefits – are countered by scholars who question the applicability amongst energy poor populations in developing world contexts (see Foley, 1992; 1995; Erickson and Chapman, 1995; Drennen et al., 1996). Discussing the energy security angle of the global energy trilemma, Raman (2013) delves into the geopolitical and economic dimensions of rare earth materials of which RETs such as PV are constituted, raising important questions about the 'moral logic' of their deployment (p. 173; see also Powell-Turner, 2012). Further, examining the climate change mitigation rationale of technologies such as PV, Best (2010) argues that fossil-fuel based universal energy access would

[7] See: http://en.openei.org/apps/SWERA/

contribute less than 2% of global GHG emissions. She goes on to argue that IFIs and donors typically look to fund projects that target so-called 'sweet spots', i.e. ones that can simultaneously address multiple objectives (Best, 2010: n.p.).

In particular, IFI and donor institutions have been important actors in the promotion and dissemination of PV technologies, catalysing markets, stimulating demand and providing training. However, motivations for playing such active roles in the deployment of solar are not always clear. Echoing some of the questions raised in section 2.3, regarding the motivations of the international community in driving 'energy development' initiatives, Erickson and Chapman (1995) argue that historically PV has been promoted, not because of local consumer demand, but because 'Northern entrepreneurs' have worked in collaboration with 'Northern aid agencies' to find and establish markets (p. 1130) (see also Wamukonya, 2007). This highlights the importance of analysing the promotion and implementation of PV technologies within the multiple objectives, scales and political economies of actors that seek to promote them. Under such circumstances, the key political economy questions of 'who benefits, who loses, how and why?' (Newell and Mulvaney, 2013: 133) are raised. It is to these issues which we now turn in the next section of the chapter.

2.4.3 The politics and practice of PV in developing regions

Perlin (2002) provides an excellent historical account of the emergence and development of solar photovoltaic technologies. From Perlin's description, it is evident that PV emerged as a technology in search of applications. Cross (2012) argues that this search for applications became tied to an 'emerging discourse of international development' (n.p.). He describes how engineers and scientists embraced the idea of 'international development' and identified countries of the Global South as in 'need' of electricity, offering enormous potential market opportunities. By the mid-1970s, PV production costs were approaching economic feasibility and by the 1980s, a global PV market had been established (Acker and Kammen, 1996). From this period onwards, solar photovoltaic technologies began to be proactively introduced into many emerging markets, which Miller (2010) argues was done with much promise for the 'dawning of a new solar era' (p. 3).

Many early interventions in support of the establishment of solar programmes in the 1970s and 1980s were characterised by a 'supply push' rather than a 'demand pull' (Erickson and Chapman, 1995), with questionable motivations in some cases. For instance, Perlin (2002) connects the French government's pioneering of the dissemination of solar energy in Polynesia to improve its image during a period when it was conducting nuclear tests in the region. Electricity was delivered to keep local people 'happy' and PV appeared to be the most appropriate way to do so. Similarly Cross

(2012) examines early PV interventions in Mali. Here programmes were ostensibly aimed at improving quality of life and reducing dependence on fossil fuels. However, they were also designed to gain experience of using photovoltaics under harsh climatic conditions and in new social and economic contexts – West Africa was essentially used as a field laboratory. Initial dissemination of solar energy faced significant challenges, however, and early interventions were often beset with technical problems. For instance, Foley (1992) argues that as ecologically benign substitutes for petroleum, such interventions were exempt from 'normal engineering scrutiny' (p. 360). The programmes established at this time often focused heavily on technical aspects, and adopted a 'donor gift paradigm' (Sovacool and Drupady, 2012). Many of these projects are now considered as failures given their unsustainable and non-replicable nature. While end users received the hardware for free, this strategy underestimated problems of training and future maintenance and repair costs (Nieuwenhout et al., 2001; Palmas-Cajas and Foster, 2001; Martinot et al., 2002; Foster et al., 2010).

Despite the apparent failure of many early interventions, donor agencies played a key role in stimulating demand for solar products, and in catalysing solar markets (see Corsair and Ley, 2008). For instance, Acker and Kammen (1996) contend that in Kenya, the solar PV market was sparked by the activities of proactive donors and NGOs. Over time, the 'market creation paradigm' superseded the donor model and shifted emphasis from technology to markets (Martinot et al., 2002; Sovacool and Drupady, 2012). Seemingly successful PV market creation in Kenya and in other contexts (e.g. Dominican Republic, Honduras, Sri Lanka and Zimbabwe) enhanced the credibility of solar to lending institutions, such as the World Bank, which led to a renewed push for its promotion in the Global South (Acker and Kammen, 1996; Miller and Hope, 2000).

While Kenya is frequently referred to in the literature on solar PV as a 'successful' case of market growth, not all countries have achieved the same level of market development, or indeed, have been influenced by the same factors. Investigating examples from the African continent, Bawakyillenuo (2012) and Ondraczek (2013) find that PV market development and growth are shaped by multiple factors, primarily social and political-economic structures. Again in Kenya, Bawakyillenuo (2012) discusses growth in the PV market as intimately tied to the historical geopolitical-economic landscape. In the post-independence period, Kenya gained a reputation as a stable, pro-capitalist country, and key ally to the United Kingdom and United States in the Cold War era. These factors arguably resulted in high levels of foreign investment and donor assistance, which provided important enabling conditions for market establishment and growth (Jacobson, 2004). This example suggests that the development and growth of PV markets in the Global South are bound up in the political economies of domestic and international actors. Other examples are particularly instructive for highlighting this point. For instance, in the case of Laos, Smits and Bush (2010) argue that a market for off-grid solar PV was heavily promoted because of a combination of the World Bank's desire for a single rural electrification model as well as the government's desire for a 'command and control' policy environment (p. 120). As a result, Smits and Bush (2010) find that the heavy promotion of SHS crowded out other technological options for rural electrification and particularly pico-hydropower, which they argued has enormous technical potential. Similarly in the context of Sri Lanka, it was the strong solar lobby, combined with World Bank/Global Environment Facility (GEF) funding that resulted in a large programme to develop the PV market. Sovacool and Drupady (2012) however raise questions about who ultimately benefitted from this model – the burgeoning solar industry, or the relatively poor households purchasing the systems? The research presented in this thesis similarly investigates the winners and losers of the promotion and adoption of solar energy in Nicaragua.

A further factor shaping the emergence and trajectory of PV markets in different global contexts has been the expansion of grid-supplied electricity (Bawakyillenuo, 2012). For instance, in the absence of planned grid electricity expansion, the desirability of technologies such as the SHS may be enhanced, potentially driving a market for solar products. On the flipside of this argument, scholars have noted that the promise of grid-supplied electricity may deter consumers from adopting a renewable alternative (Sovacool and Drupady, 2012). Tensions between off-grid renewable electricity and grid-supplied electricity therefore exist (this complex relationship is explored in relation to the Nicaraguan context in Chapters Five, Six and Seven). It is also important to situate analysis of the emergence and trajectory of off-grid solar energy markets within the context of shifting energy paradigms. As discussed in section 2.1, the shift to neoliberal energy policies oversaw a decline in publicly financed grid expansion, and in many cases failed to address the challenge of low rural electrification levels (see also Karekezi and Kimani, 2002). It is in this context that Jacobson (2007) finds it unsurprising that individualised, market-compatible solar photovoltaic applications emerged as important tools for rural electrification.

Within the market paradigm, van der Vleuten et al. (2007) provide a comprehensive review of the types of delivery mechanisms for PV technologies. Dominant delivery mechanisms are identified in two broad categories, including 'self-organised' sales within a market framework, or externally organised within the framework of a project – so-called 'project organised' interventions (p. 1440). For 'self-organised' sales, end-users buy SHS from a supplier in cash (or in some cases with credit, if credit mechanisms exist locally) and the user can purchase equipment that varies in price and quality. Conversely, in the case of the 'project organised' model, dissemination is a planned effort, which comprises multiple actors (e.g. donors, governments, private sector suppliers, micro finance institutions) in a complex set-up. Systems may be donated (or subsidised), purchased through the extension of micro-credit, or offered on a fee-for-service basis (see also Nieuwenhout et al., 2001; World Bank, 2008). Users obtain the kits promoted by the project (usually high quality, standardised models) or none at all. In terms of operation and maintenance (O&M) structures, van der Vleuten et al. (2007) identify differences in each approach. While self-organised users may approach the initial supplier for O&M, in the case of project organised interventions, O&M structures are created (for instance, end users pay into a savings fund to cover future maintenance costs), however, few have created sustainable structures due to the limited life of projects (ibid). There is recent academic and practitioner research into more innovative, or pro-poor energy delivery models (see Wilson et al., 2012; Bellanca and Garside, 2013), however, this research – and many of the published case studies this chapter draws on – examines the 'self-organised' and 'project organised' categories discussed by van der Vleuten et al. (2007). Chapters Six and Seven explore the 'project organised' model in the market framework of the Nicaraguan context.

Despite PV appearing an obvious choice for electrification in developing countries due to its multiple 'promises' (discussed in section 2.4.2), its appearance in rural energy mixes is bound up in broader historical and political-economic processes. The Kenyan, Sri Lankan and Laos case studies discussed above all illustrate that the emergence of photovoltaic energy technology markets came about because of interacting global and national processes. This links to an earlier discussion within the chapter which emphasised the importance of examining the influence of energy governance processes 'from above' and 'from below' (section 2.1.2). Grappling with these processes is critical to understanding the constitution of PV markets, for interrogating the distribution of costs and benefits deriving from them, and for understanding their implications at the local level. Despite the importance of these debates, few studies have situated the growth of off-grid PV markets within their broader historical and political-economic contexts (see Jacobson, 2007; Bawakyillenuo, 2012; Ondraczek, 2013 for exceptions). These broader processes have implications at the local level. From the perspective of a household in the developing world, adopting a technology like PV is not an obvious or straightforward choice – even in the absence of 'modern' energy access alternatives. For instance, unserved populations 'fed on a diet' of political promises that grid electricity will reach their household or community, may reject stand-alone PV technologies as inferior (Rehman et al., 2012: 30; see also D'Agostino, 2011; Sovacool and Drupady, 2012). Similarly, the major credibility problems of early PV interventions (see Foley, 1995; Sovacool, 2012b), may serve to undermine confidence in the technology.

Multiple factors determine whether or not a household decides to adopt a PV technology; this includes factors such as household income, kerosene consumption, ownership of rechargeable batteries, mobile phones, or televisions, and cultural and behavioural aspects (Acker and Kammen, 1996; Green et al., 2001; Nieuwenhout et al., 2001; Komatsu et al., 2011b; Sovacool et al., 2011). Indeed, research illustrates complex motivational structures behind individual and household decisions to adopt solar energy technologies (Sonnberger, 2013); these are influenced by micro processes at the household level, but also wider political economic frameworks within which they are embedded (as discussed above). Chapter Seven specifically investigates these micro processes. Having discussed the issues related to the politics and practice of decentralised photovoltaic energy systems in the Global South, the following section examines experiences at the local level.

2.4.4 Experience with solar energy in the Global South: a review of cases

It is beyond the scope of this thesis to provide a comprehensive review of all donor-led, government, and private sector PV programmes completed or under way in the developing world, however, the following sections draw on a series of key case studies. Firstly, the current state of knowledge about the implications of PV deployment at the local level is reviewed. This is followed by a consideration of the challenges facing their use. It is important to sound a note of caution about the literature at this stage. Authors of a recent systematic review of articles discussing distributed electricity generation projects in the Global South (drawing heavily on studies of PV) note that published works are often written by experts affiliated with the programmes, which raises concerns about potential conflicts of interest (Brass et al., 2012; see also Sovacool and Drupady, 2012; Watson et al., 2012). It is important to bear this in mind in light of Schäfer et al's (2011) call for transparent discussions of programme results and outcomes in order to avoid practitioners and policymakers from falling into the same traps. A further observation to make about the literature is that many studies refer to programmes in the early stages of implementation (and others simply do not state how long systems have been in place) (Nieuwenhout et al., 2001). This makes it difficult to assess the long-term viability of interventions (see also Brass et al., 2012). A final observation is the dearth of studies that examine accounts of lived experiences of SHS users over periods of time (Nieuwenhout et al., 2001). Understanding the perspectives of end-users is of vital importance; for instance, Schillebeeckx et al. (2012) argue that a better understanding of users is likely to increase the long-term sustainability of rural electrification projects (see also Shyu, 2013). Despite the importance of user perspectives, their voices, aspirations and histories appear to be absent. Rather than simply assuming that the expected benefits of RETs such as SHS automatically materialise (Marawanyika 1997; van Alphen et al., 2008), Cherni (2008) argues that there is an urgent need for studies to examine user experiences to determine whether or not the practical energy needs and priorities of users are fulfilled. This thesis addresses this gap through an examination of user experiences of solar energy technologies in Nicaragua (Chapter Seven).

2.4.4.1 User experience

Common claims made about the 'development benefits' of solar electrification relate to educational benefits or income generation. According to Jacobson (2007), such 'basic needs' chime with key international development objectives and therefore justify international support for solar electrification programmes (see Cross, 2012; 2013; also Illich, 1992, who provides a broader discussion of 'needs discourses' in development). However, as the empirical work reviewed below suggests, the implications of solar energy interventions at the local level are not so clear cut.

Studies that examine the impact of solar interventions generally record improvement in user living conditions; such changes are termed 'non-monetary lifestyle benefits' (Komatsu et al., 2011a) or 'soft' benefits (Wamukonya, 2007). For instance, in the Bangladeshi context, Komatsu et al. (2011a) find that the introduction of SHS significantly reduced or eliminated kerosene consumption. Research in Ghana found that PV lighting led to a reduction in the use of kerosene, which resulted in less indoor smoke, with positive health implications for householders (Obeng et al., 2008). However, the flipside of this argument is that PV lighting simply serves to illuminate an unhealthy or 'smoky hearth', because off-grid households often continue to rely on traditional fuels for cooking (Mathur and Mathur, 2005).

Education related uses of solar electricity feature prominently as a key social benefit in many studies (e.g. Gustavsson and Ellegård, 2004; Mala et al., 2009). Jacobson (2007) however counters this argument. Drawing on empirical evidence from Kenya, he finds that while solar electricity is used for studying, the educational benefits are far from universal. Rather, intra-household dynamics are found to influence how limited amounts of electricity are allocated to different uses. Small amounts of power output were prioritised for powering televisions, rather than light bulbs, making it difficult for studying to take place.

Similarly, in the case of income generating or productive activities, Jacobson (2007) argues that solar electricity receives much attention from the international community. However, evidence on whether access to SHS technologies - that are limited in output - can deliver increased economic opportunities is uncertain (Green, 2004; Hajat et al., 2009; Brass et al., 2012). For instance in Sri Lanka, Laufer and Schäfer (2011) find that while the use of SHS led to increased quality of life benefits, household incomes were not directly improved. Similar findings were also reported by

Mala et al. in Kiribati (2009), and Mondal and Klein in Bangladesh (2011). PV is therefore conceptualised as a 'consumptive technology', rather than a 'productive investment' (Jacobson, 2007; Wong, 2012).

That PV is consumptive, rather than productive, and combined with the reality that its introduction likely implies increased costs for households, divides opinion amongst scholars about the balance of potential impacts for adopter households. For instance, Wijayatunga and Attalage (2005) highlight the Sri Lankan experience and contend that the additional US $3 cost per month to households is 'worth it' given the improved socio-economic conditions experienced. Similarly, in Bangladesh Komatsu et al. (2011a) conclude that the 'micro benefits' enjoyed by SHS users are commensurate with their higher costs. By contrast, Wamukonya (2007) argues that the contribution of PV to poverty alleviation is extremely limited, and points to empirical findings that highlight the limited impact of solar electrification on the nurturing, growth or diversification of income generating activities (see also Wamukonya and Davies, 2001). Wamukonya (2007) therefore questions the viability of the push for solar electrification in the African continent, given the relatively high costs it poses to both users and governments[8]. Corsair's (2009) research on energy poor households in Guatemala also casts light on the cost implications of SHS on users; she reports that even donated SHS placed an increased financial burden on families, despite the so-called 'soft benefits' it delivered.

Wamukonya (2007) further questions the extent to which PV technologies align with the practical energy needs of rural households. Her concerns are echoed by Clancy et al. (2003) who argue that cooking is rural households' greatest energy concern and that the limited quantities of electricity generated by a PV system cannot substitute cooking fuels. When examining the application of PV in off-grid contexts therefore, it is useful to consider the services that different forms of energy can provide. Empirical work suggests that tasks in rural communities predominantly require process heat and motive power, rather than electricity (Batliwala and Reddy, 2003).

These criticisms are linked to a literature examining the 'gender-energy-poverty nexus' (see Clancy et al., 2003). Indeed, where the gender implications of solar energy technologies have been examined, mixed outcomes are revealed. For instance, Wong (2009) examines the implications of a SHS intervention in Bangladesh. While it is claimed that women are often the main beneficiaries of

[8] Wamukonya (2007) argues that a common misconception of SHS projects is that they are entirely donor-funded; in the African context, 'donor-funded projects' actually derive the larger share of funding from the host country, e.g. of 8 Global Environment Facility (GEF) projects across Africa, only 23% of project costs are covered by GEF grants.

such interventions, he found that the introduction of evening-time lighting extended the working day of the female household member, burdening her 'already-tired' body (Wong, 2009: 120). In Wong's study, the introduction of evening time lighting fostered competition amongst females of the community, who felt it was their duty to pursue income-generating activities when prior to the arrival of solar lighting, they would have been sleeping (see also Cowan, 1983 and Wacjman, 1995 for a discussion of the broader gender implications of technology). Conversely, Clancy et al. (2004) found in the case of PV in Namibia that while women generally had longer days than men, it was because solar lighting enabled them to socialise in the evening, rather than work.

Another unintended consequence is the divisive and potentially exclusionary nature of solar energy technology programmes (Wong, 2012). Solar programmes often require households to dedicate part of their incomes in order to pay for electricity services, which may mean that not all households within the same community have the capacity to participate. Wong (2012) explored the role of PV in visibilising the 'haves' and 'have nots' within communities in Bangladesh. He found that mothers expressed feelings of guilt when unable to access solar electricity for their children (due to affordability issues), and concerns were raised regarding the widening of existing development gaps within communities.

Whether benefits (or disbenefits) are delivered to off-grid households through solar energy technologies depends on the way in which the technologies ultimately 'work' in a particular context. Literature on the social shaping of technology provides some useful insights, in particular the conceptualisation of a 'working' technology that constitutes more than technical functionality. Rather, 'working' technology is socially constructed, built in accordance with user realities and aspirations, appropriate to local contexts, and is able to gain the support of local participants to ensure its long term maintenance (see Akrich, 1992; de Laet and Mol, 2000; Dusek, 2006). Akrich (1992) provides a particularly instructive example of the complicated nature of a 'working' PV lighting programme. Well intentioned design choices (taken in France), such as using shorter wires in between components to enhance efficiency, ultimately produced 'non users' of the technology (in rural Senegal), as it meant that light switches were positioned in out of reach places (ibid). As Mol and de Laet (2000) contend, enormous difficulty exists in 'moving technologies' to different contexts; often the confrontation between the 'imagined' user and the 'real' user renegotiates the very meaning of a technology (Akrich, 1992).

This review has revealed that the outcomes of solar energy technologies across a diverse set of geographical regions are far from certain. The benefits (or otherwise) of small scale solar energy technologies depend on the way in which they are delivered, and the contexts within which they are implemented. It also highlights that intra-household dynamics are an important factor to consider. These factors should be embedded within an analysis of how these are shaped by national and international political economies.

2.4.4.2 Challenges facing solar energy

Multiple scholars have discussed the challenges associated with making off-grid renewable energy technologies (particularly applications of PV) 'work' in the Global South (see also section 2.2.1 above which explores the obstacles to alleviating energy poverty). These challenges may be grouped into technical, economic, political, and socio-cultural aspects. For example, a systematic literature review conducted by Watson et al. (2012) reveals that economic and financial barriers are presented as the most pervasive obstacles to improving access to RETs such as SHS. While there are differences between delivery mechanisms (see discussion in section 2.4.3), empirical evidence suggests that often high upfront costs of new energy hardware reduce affordability (Chaurey et al., 2012; Wong, 2012). Even if the upfront costs can be overcome, ongoing operation and maintenance costs can be too high for users, especially for replacement BOS components. Corsair's (2009) research on solar energy in Guatemala notes that while individual solar panels are often provided with guarantees of up to 25 years, batteries have to be replaced at much shorter intervals, which incurs a significant capital cost to the end-user. In Corsair's (2009) case study, she found that despite the SHS having been donated to users, the ongoing savings required by users for future battery replacements were prohibitive. Paradoxically, traditional fuels were viewed as more 'affordable' than saving for the maintenance or repair of the SHS, because households were able to choose how many candles or how much kerosene to purchase (see also Mala et al., 2009). This relates to the discussion on energy ladders in section 2.3.1 – an idea illustrating that households simply replace 'traditional' fuels with 'modern' fuels of technologies. Instead, Corsair's research demonstrates that fuel stacking is more likely to occur in households in the Global South, allowing households to make use of multiple fuel sources at once.

In addition to the economic and financial challenges, there is increasing recognition of political and institutional challenges. For example, the typically project-centred character of energy development assistance imposes restrictions on the longevity of both the systems and the programmes that support them. In Papua New Guinea (PNG) Sovacool et al. (2011) find that the World Bank programme established to promote SHS did not produce a robust organic market; instead 'one off programmes' deposited technologies and departed without training people how to use them. This raises important questions about what happens once programmes have been initiated, implementing organisations leave and users are without the means (financial or otherwise) to replace components (see also Gustavsson and Ellegård, 2004). Indeed, in a broader critique of 'energy development' style assistance programmes, Byrne et al. (2012) suggest institutions' have a limited focus on hardware and finance, rather than on the skills, knowledge or social and economic conditions required to sustain technologies in the long term. For example Tillmans and Schweizer-Ries (2011) in the case of Uganda found that solar energy technology installers did not consider the end-user as a major component of the system, or one that required training. Wheelock-Horvilleur and Gent (2011) observe similar findings in Nicaragua where technologies would be installed without providing detailed instruction on how to operate and maintain the system.

A further political and institutional challenge relates to the promise of expanded grid infrastructure to rural areas. As discussed above in section 2.4.3, for reasons of political expediency, the promise of the grid may pose a barrier to the desirability and ongoing viability of SHS programmes and systems (Foley, 1992; 1995; Groh, 2012; Rehman et al., 2012; Sovacool and Drupady, 2012). This is because households' aspirations often mean that a grid connection is a favoured choice due to the greater quantities of power that may be accessed. Indeed, Wamukonya and Davis (2001), IEA PVPS (2013) and Shyu (2013) find that households often desire to operate higher wattage appliances and/ or productive machines. However, a failure to deliver on promises may lead to a loss of faith that grid infrastructure will arrive; Acker and Kammen (1996) for instance discuss the haphazard and politicised progression of the electricity distribution network in Kenya, which rendered it too 'distant' from households in both financial and temporal terms.

A further barrier, which encompasses both political, but also cultural challenges, relates to the inherently unequal power relations of 'development'. In PNG, Sovacool et al. (2011) find that households participated in solar energy programmes because they felt obliged to do so - not wanting to appear 'ungrateful', or to turn away free gifts from the international development community (p. 1539). The presence of external actors led households to state they had certain needs and wants (for instance, solar electricity, water or toilets) because they did not want to appear 'backward'. Sovacool et al. (2011) delve into the cultural specificities of rural households in PNG and instead find that key concerns such as fulfilling clan obligations, raising money for dowries, or accruing land were prioritised over access to solar electricity. While the Sovacool et al. (2011) paper later goes on to examine how the multiple (political, economic and social) barriers to SHS could be overcome in this context, a pertinent question arises: should we view these issues as barriers to be overcome? And are solar electricity interventions appropriate in the context of rural householders in PNG? A post-development perspective is particularly instructive in this regard. Post-development theorists argue that understandings of 'development' reflect prevailing power relations, presenting some ideas of 'development' as correct, while others are rejected as inferior (see Sachs, 1992; Escobar, 1995; Willis, 2005). Indeed, Escobar (1995) argues that different priorities and problems are relevant to different communities. He further argues that 'most often, the interpretation of people's needs is taken as unproblematic, although it can easily be shown otherwise' (Escobar, 1992: 45-46). If solar electricity is not a priority amongst rural households, then why is it promoted as such?

The final group of barriers relate to socio-technical challenges. Solar home systems are relatively easy to roll out, however it is difficult (financially) to scale up individual systems in capacity (Pielke Jr., 2012). Related to the complicated notion of priorities and needs, household energy demand is likely to increase over time (Foley, 1995). For example, Shyu (2013) examined user experiences with mini-grid solar PV power stations in China. He reports that users increasingly expressed the desire to operate high power electrical appliances. This raises interesting questions about how solar energy programmes can be designed so that SHS may be scaled in line with changing local circumstances, priorities and expectations. These issues will be explored in greater detail in subsequent empirical chapters, especially Chapter Seven. Challenges of a technical nature are frequently cited in the literature, which include poor quality components or installation and a lack of product diversity and/or flexibility (Chowdhury et al., 2011; Sovacool et al., 2011; Chowdhury, 2013). Again, user participation may be limited to purchasing or making financial contributions to whichever technology is available (as discussed by Wong, 2012). While the challenges have been grouped according to economic and financial, political and institutional, social and cultural barriers, in reality there is a great deal of overlap. The promise of grid extension provides an example of the multiple obstacles facing solar energy technologies. This echoes Sovacool (2012b) who notes that such challenges often transcend technical, economic, political, and socio-cultural domains, making them particularly tenacious and difficult to overcome.

2.5 Conclusion

This chapter has outlined the conceptual framework within which this thesis is situated. It has provided a detailed analysis of three key bodies of literature (and the links between them): global energy governance, energy poverty, and the delivery of distributed solar energy technologies in the Global South. This discussion represents one of this thesis' novel contributions in that few, if any, studies have linked these literatures in the way that has been attempted here. The chapter began by outlining the challenges facing the contemporary energy era - the so-called energy trilemma -

which suggests that energy 'governors' are faced with a set of unprecedented and often contradictory challenges.

Focusing on one particular aspect of the energy trilemma, energy poverty was explored in detail in the subsequent section of the chapter. This discussion provided an exploration of recent debates surrounding this concept and in particular how the international agenda to take decisive action towards tackling energy poverty has gained increasing currency over the past decade. Discussion of the recently launched UN SE4All initiative revealed the momentum behind addressing the needs of the several billion people experiencing energy poverty and its growing significance within the current international development landscape. As one of the keystone technologies of the urgent push for 'sustainable energy for all', in the final section of the chapter decentralised applications of solar energy, particularly the SHS, were introduced as the empirical focus of the thesis. While solar energy apparently provides a 'silver bullet', since it appears to simultaneously respond to each facet of the energy trilemma, an in-depth review of published case studies reveals that in practice, the outcomes of this technology cannot be guaranteed. The benefits (or otherwise) of solar energy technologies cannot be easily determined due to the number of challenges that face its implementers and users – a formidable range of technical, political and institutional, social and cultural, financial and economic barriers stand in the way of system uptake and long term sustainability.

Building on the research approach, aim and objectives outlined in Chapter One, this chapter has emphasised the importance of analysing multiple scales, and engaging with the political-economic frameworks within which energy systems operate. Indeed, as discussed in the preceding pages, energy policies and realities are shaped, not only by global and regional influences (governance 'from above'), but also by national-level politics (governance 'from below'), which in turn, have implications at the local level.

Solar energy technologies offer a fascinating entry point for examining these multi-level processes. The establishment of solar PV technologies in the Global South as the 'go to' choice for off-grid electrification, as discussed in-depth in section 2.4, has emerged through the complex interplay of the agendas of IFIs and international 'energy development' agencies, Northern technology developers and politicians, as well as being influenced by broader energy paradigm shifts. The ways in which such technologies ultimately 'work' (or not) in a particular context is shaped by these broader influences, but also by micro processes operating at the household or community level. This reflects Jacobson's (2007) call to examine solar energy technologies through multiple lenses and arenas, i.e. both 'inside and beyond' the household. However, empirical work that examines both the macro historical and political-economic contexts within which solar energy technologies are embedded, alongside such micro processes, has hitherto been lacking. Over the coming chapters, therefore, this thesis adopts a multiple, nested scale approach to explore the multiple practices of decentralised solar energy technologies in off-grid areas of Nicaragua within their broader political and economic contexts. This encompasses a thorough assessment of the policy frameworks, actors and institutions that have influenced Nicaragua's energy landscape (research question one, Chapter Five), and the market for off-grid solar energy interventions (research question two, Chapter Six). Embedded within these contexts, Chapter Seven examines local level experiences with the technologies (research question three), while the challenges facing solar energy interventions are addressed at both the level of implementers and users (Chapters Six and Seven respectively, research question four).

Through analysing the local level experiences of solar energy technologies, nested within these multiple scales, specific knowledge gaps identified during the discussions of the existing literatures conducted within this chapter (see also Chapter One) can be addressed. Firstly, a critical analysis of solar energy interventions is provided in the forthcoming chapters, responding to the concerns expressed by numerous scholars about the lack of neutral scholarship on programmes that promote the use of RETs, such as SHS (Schäfer et al., 2011; Sovacool and Drupady, 2012; Brass et al., 2012; Watson et al., 2012). Related to this, many studies report on programmes in the early stages of implementation; this thesis offers analysis of user experiences with different lengths of solar use or ownership. Finally, the local level aspect of this research aims to address the worrying dearth of studies that report on the actual lived experiences and voices of solar home system users. Clearly, having an in-depth understanding of the experiences of end-users is likely to increase the long-term sustainability of energy interventions.

Having discussed the bodies of literatures key to this thesis, the following chapter aims to situate these debates within the specific context of Central America – which as identified in Chapter One is where the empirical research of this thesis is grounded. The decision to focus on Central America, and Nicaragua more specifically, addresses a further knowledge gap identified: namely, that despite presenting an important case study, the Central American region has been largely overlooked in the literature on energy geographies.

Chapter Three. The Central American Energy Landscape

Having explored the key debates around global energy governance - specifically in the energy access arena - and the proliferation of small scale decentralised solar energy technologies, this chapter provides the background and context to where this study is situated empirically: Central America. Drawing on the discussions of global energy governance examined in Chapter Two, Central America is highlighted to explore the consequences of evolving global energy paradigms and national political-economic frameworks.

As Chapter One emphasised, Central America is a fascinating region in terms of its history, culture, politics and energy landscape. From a research perspective, Robinson (2003) argues that the region provides an important entry point for 'understanding of the dynamics of change elsewhere' (p. 3) in this case, the governance of energy. The Central American region indeed offers an interesting case in terms of the global energy trilemma debate. While global discourses increasingly focus on the transition to low carbon energy, Central American energy sectors have, until recently, undergone a transition away from renewable (largely hydropower derived) electricity generation towards increased dependency on fossil generation. This transition is surprising since not only are the countries of Central America highly vulnerable to climate change - positioning them as potentially 'leading edge adaptors to climate change' (Rogers, 2012: n.p.) – but they are also endowed with significant renewable energy resource potential (CEPAL, 2009), and heralded as a key region for private investment in renewable energy (IDB, 2012; 2013). Furthermore, over 6 million people lack access to electricity, and approximately 20 million people rely on firewood to satisfy their most basic energy needs. The Central American 'energy challenge' (Eguizábal, 2011) is receiving increased attention from state, international financial institution (IFI), private sector and civil society actors, seeking to achieve a more sustainable energy future (see Dolezal et al., 2013).

The lack of academic research on energy in the Central American region is therefore surprising. While the UN Economic Commission for Latin America and the Caribbean (CEPAL) provides comprehensive and up-to-date statistics for energy sectors, there is a general dearth of academic research on the energy systems of the region. Some articles adopt a technical-quantitative approach to the investigation of Central American energy systems (e.g. Hosier et al., 1992; Apergis and Payne, 2009a; 2009b; 2011), while other important contributions are produced by and for the international financial institutions (IFIs) (e.g. Tomiak and Millán, 2002; Millán, 2007; Cayo, 2011; Lecaros et al., 2010; Reinstein et al., 2011). There are few publications on recent transitions and the challenges posed by the global energy trilemma in this region however, especially those which situate the study within the wider social and political-economic contexts of Central America (for further discussion see Gent and Tomei, forthcoming).

This chapter therefore addresses a gap in the literature, and furthermore establishes the contextual frame of this thesis. In reviewing the energy systems of the six Central American countries, Nicaragua emerges as an interesting and exceptional case in which to pursue empirical research. Having long been an implementation space for global policy priorities and external intervention, Nicaragua is seemingly undergoing an 'energy revolution', driven in part by the global architecture for 'sustainable energy', but also because of increasing political prioritisation from a government 'interventionist' in many aspects of the country's development. Nicaragua is a country which has long suffered the socio-economic consequences of a highly inequitable and high carbon energy system; current efforts to overhaul this system, and to provide electricity access to the large off-grid segment of the population – in particular, favouring the use of decentralised applications of solar energy – make this a fascinating context within which to situate the research.

This chapter draws on secondary data analysis, policy documents, peer-reviewed articles and a limited number of stakeholder interviews[9]. It is structured as follows: section 3.1 introduces the region of study, drawing attention to key socio-economic development indicators and the disparities between the isthmus' six countries. Section 3.2 examines the challenges currently facing the Central American energy landscape. Section 3.3 traces historical energy paradigm shifts and the consequences of this on Central American energy systems. Section 3.4 examines contemporary developments in sectors, and questions the extent to which an 'interventionist turn' is being realised. Section 3.5 draws the discussion together and identifies Nicaragua as the empirical focus of this thesis. Section 3.6 draws attention to its current governance arrangements and the drive for increased electricity access through the deployment of small scale solar energy technologies. The final section outlines the objectives of this thesis.

[9] The following chapter is reserved for a discussion of the specific methodologies adopted in this research

3.1. Region of study

Central America (Figure 5) is a relatively small region; the six states[10] have a total land area of 49 million hectares and a combined population of almost 43 million (UNData, 2013). Over half the population of Central America live in poverty, while one in two of those who are poor live in extreme poverty (Hammill, 2007). Central America is by no means the poorest region in the world, however there is considerable variation within and between the countries; Costa Rica and Panama are the wealthiest countries with per capita GDP of over US$ 8,500, while Nicaragua and Honduras are the poorest countries in the region with per capita GDP of US$ 1,243 and US$ 2,250 respectively (UNData, 2013).

Figure 5. Map of Central America

Source: freeworldmaps.net

In comparison to the wider Latin American region, Central America stands out as relatively poor. Table 3 highlights some key socio-economic development indicators in Central American countries

[10] The six countries of Central America are Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, and Panama. Although Belize is located in the Central American isthmus, as an English-speaking former British colony, it has a distinct history from the other countries in the region. Belize has not participated in efforts towards regional integration and is here considered to be separate.

and selected Latin American countries Historically the economic base of the region was dependent on agricultural exports, but more recently has diversified towards manufacturing and tourism (Apergis and Payne, 2009a). Central American economies rely heavily on remittances from family members working abroad; the extent to which the 2008-9 economic crisis has affected this income are still uncertain (CEPAL et al., 2010).

Table 3. Socio-economic development indicators in Central America and selected Latin American countries

Country	Central America						Latin America		
	CR	ES	GU	HN	NI	PA	BV	CH	PY
Population (thousands) 2010	4,659	6,193	14,389	7,601	5,788	3,517	9,930	17,114	6,455
Gross domestic product (GDP) per capita $US (2011)	8,676	3,702	3,178	2,250	1,243	8,590	2,374	14,395	3,485
Human Development Index (HDI) 2011	0.744 (High)	0.674 (Med)	0.574 (Med-low)	0.625 (Med-low)	0.589 (Med-low)	0.768 (High)	0.663 (Med)	0.805 (High)	0.665 (Med)
Life expectancy (years) 2011	79.3	72.2	71.2	73.1	74	76.1	66.6	79.1	72.5
Urban population (%) 2011	64.9	64.8	49.9	52.2	57.6	75.5	67	89.2	62.1
Population living below $1.25 USD daily (%) 2011	0.7	5.1	13.1	23.3	15.8	9.5	14	0.8	5.1
Energy consumption per capita 2008 (kgoe)	1,083	796	590	633	625	851	622	1,744	720
Electricity consumption per capita 2008 (kWh)	1,865	954	543	709	459	1,642	539	3,321	1,003

Source: adapted from UN Data (2013) and World Bank Data (2013). Note: CR = Costa Rica; ES = El Salvador; GU = Guatemala; HN = Honduras; NI = Nicaragua; PA = Panama; BV = Bolivia; CH = Chile; PY = Paraguay

3.2 Central American energy challenges

In 2011, the most recent year for which data are available, the regional maximum electricity demand was 7,093 MW, which has more than doubled since 1990. Over the same period, installed capacity almost trebled. Electricity coverage has also increased significantly since 1990, rising from 57% of the population to 86.9% by 2010. Electrification rates vary significantly between and within countries however. For example, some urban areas in Guatemala, Honduras and Nicaragua have coverage rates of up to 90%, while rural areas have as little as 20% electricity access (CEPAL, 2008). Table 4 illustrates the evolution of the Central American electricity sectors from 1990 to 2011.

Table 4. Evolution of the Central American electricity sectors, demand and electricity coverage 1990 to 2010-2011

Country	Maximum demand (MW)		Installed capacity (MW)		Net generation (GWh)		Electricity coverage (%)	
	1990	2011	1990	2011	1990	2011	1990	2010
CR	682	1546	887	2650	3543	9760	91	99.2
ES	412	962	650	1504	2164	5813	n.d.	91.2
GU	452	1491	811	2591	2318	8147	35.8	85.3
HN	351	1240	533	1731	2274	7127	39.1	81.3
NI	253	567	363	1094	1251	3567	44.7	74.6
PA	464	1287	883	2296	2709	7703	72.8	90.1
C. America	**2614**	**7093**	**4127**	**11866**	**14259**	**42117**	**56.7**	**86.9**

Source: adapted from data in CEPAL (2009; 2011a; 2012). Note: CR = Costa Rica; ES = El Salvador; GU = Guatemala; HN = Honduras; NI = Nicaragua; PA = Panama.

The region is endowed with impressive renewable energy resource potential (Table 5), particularly due to abundant hydroelectricity, geothermal and solar resources (CEPAL, 2009; IDB, 2012). However, for reasons which this chapter will explore, the region has not always been able to exploit these resources.

Table 5. Estimated renewable energy potential, installed capacity and percentage renewable energy exploited in Central America, 2011

Country	Hydro			Geothermal		
	Max potential (MW)	Installed capacity (MW)	% exploited	Max potential (MW)	Installed capacity (MW)	% exploited
CR	5,802	1,644	28	235	218	93
ES	2,165	487	23	333	204	61
GU	5,000	902	18	1,000	49	5
HN	5,000	528	11	120	0	0
NI	1,760	105	6	1,200	170	14
PA	2,341	1294	55	40	0	0
C. America	**22,068**	**4,959**	**22**	**2928**	**6401**	**22**

Source: adapted from data in CEPAL (2009; 2012). Note: CR = Costa Rica; ES = El Salvador; GU = Guatemala; HN = Honduras; NI = Nicaragua; PA = Panama.

3.2.1. Energy reforms and challenges

From the 1960s to the 1990s, most of Central America was a site of upheaval and repression as revolutionary insurgencies were met by counter-insurgencies. By the late 1990s, all Central American states had civilian democratic regimes, which had arisen in response to the civil conflicts of the preceding decades, but also due to external pressure to liberalise and open up markets to global trade and investment (Robinson, 2003; Brown and Cloke, 2005). However, more than three decades of civil war, oil price increases, deteriorating terms of trade and excessive external borrowing, had left the Central American economies on the verge of collapse. In exchange for international credit, IFIs demanded fundamental economic transformations, which were informed by neoliberal economic thinking on the appropriate role of the state and markets in economic development (Booth et al., 2006). Structural adjustment programmes and economic liberalisation led to the privatisation of several sectors previously under state control, including energy, banking, telecommunications, transport and agricultural marketing and finance (Hamill, 2007). Thus the transformation of energy systems was conditioned by larger macroeconomic reforms underway across the region. As discussed in Chapter Two, these reforms sought to reduce the size and responsibilities of the governments and to promote deregulation, privatisation, institutional reform, and to eliminate subsidies. Although broader restructuring reduced debt burdens and led to economic growth, it is widely accepted that these macro-economic improvements took place at the expense of increased poverty and income inequality (e.g. McIlwaine and Willis, 2002). According to Robinson (2003) this shift in economic paradigm reflected a move from national to transnational governance, wherein old conflicts between revolution and dictatorship were superseded by 'a new set of problems bound up with the region's integration into the emergent global economy' (p.3).

In Central American power sectors specifically, two decades of market-led governance saw each state's electricity sector at various stages of reform. For instance, while Panama has developed the strongest and most independent electricity sector, the Costa Rican *Instituto Costariccense de Electricidad* remains a state-run, vertically integrated company (Tomiak and Millán, 2002; Lecaros et al., 2010). Despite the differences between them, the six Central American states face similar challenges to their energy systems.

Firstly, the region's electricity markets are relatively small. In 2010, the region generated approximately 40 TWh of electricity, which is equivalent to around 70% of the annual electricity supply of a medium-sized Latin American country, such as Chile or Colombia (Lecaros et al., 2010). Small markets do not provide a sufficiently large demand base to support competition in generation. This runs the risk of the sector being dominated by one or two players, therefore inhibiting competition (Tomiak and Millán, 2002). In Central America, the regional integration of electricity markets (the Mercado de Electricidad Regional, MER) is posed as a solution, as discussed below.

Secondly, several countries have faced challenges in balancing supply and demand, at times leading to supply deficits and rationing (Posas, 1995; Herrera-Montoya, 2005; World Bank, 2006). This has been most acute in Honduras and Nicaragua, which have both experienced power shortages and electricity blackouts (Hunt et al., 2000; McGuigan, 2007). Lecaros et al. (2010) attribute these difficulties to relatively small national electricity markets, high growth in demand, lowered reserve margins, oil price hikes, droughts and delays in the construction of new generation.

Thirdly, the largest part of commercial[11] energy is generated by oil and its derivatives. While Guatemala is an oil producer, these activities are very small scale (an estimated 736,000 tonnes were produced in 2009, compared for instance to Venezuela's 151,365,000 tonnes)[12] and the majority of production is exported. In addition to this, Costa Rica, El Salvador and Nicaragua have limited refining capacity (Apergis and Payne, 2009a), which makes Central America a net hydrocarbon importer (CEPAL et al., 2010). Increased private sector participation in electricity generation has arguably led to an increasing reliance on oil, which is discussed further in section 3.3.1. This has exposed the region to high and volatile international oil prices, arguably draining more money out of the poorest countries than debt cancellation has contributed as well as curbing

[11] Including electricity, transport
[12] See: http://www.iea.org/stats/prodresult.asp?PRODUCT=Oil

expenditure on poverty-related areas (Jubilee USA, 2006; McGuigan, 2007). Political constraints have prevented the increased cost of oil being passed on to consumers, creating financial difficulties for governments and distribution companies (Byer et al., 2009).

Finally, despite improvements in electricity access, in 2008 an estimated 6 million people still did not have access to electricity, while around 20 million relied on firewood to satisfy their most basic energy needs (CEPAL, 2008). Central America yields a primary energy matrix, which is typical of other developing world regions, where modern power generation technologies are lacking. Electricity accounts for 12% of final energy consumption, which is relatively low in comparison to the South American average (17%) and the US (20%), which indicates low electricity use and coverage. Petroleum based products account for 45% (a similar ratio to that of South America and the US), whereas biomass (mainly firewood) accounts for 42% (very high in comparison to South America and the US, 19% and 3 % respectively) (Lecaros et al., 2010). It is important to note that the regional average figure masks important national differences, for example, in Costa Rica and Panama biomass accounts for only 17% of final energy consumption.

High firewood consumption corresponds with low HDIs (CEPAL et al., 2010); indeed the biomass-dependent populations are largely concentrated in Guatemala, Honduras and Nicaragua, the countries with the largest percentages of people living in poverty and extreme poverty (Byer et al., 2009). Recent trends indicate that household fuelwood consumption is growing, which is attributed to a series of inter-related factors, e.g. increasing costs of oil and its derivatives during 2004-8, the impact this had on electricity prices and increasing poverty levels in the region (CEPAL et al., 2010). This trend is occurring despite Central American nations experiencing increased urbanisation (average urban population in 1970 was 39.4%, and by 2010 it averaged 60.8%) (CEPAL Stat, 2013) and electrification levels (in 1990 coverage averaged just 56.7%, rising to 85.9% by 2010) (CEPAL, 2011a).

For CEPAL et al. (2010) heightened dependence on firewood is indicative of the lack of progress being made with respect to expanding modern and efficient energy sources to households. Indeed, as Taylor (2005) explores, a key priority of Central American governments has been to expand grid electricity the length and breadth of the peninsula. However, Taylor questions the extent to which this is congruent with the realities of rural dwellers, where ‘electrification is synonymous with a single light bulb hanging in a house where wood-burning stoves boil water from local streams’ (p. 181).

In an extensive review of policy documents from the Latin American region, CEPAL et al. (2010) find that approaches to rural electrification, access to clean and renewable energy sources, and the substitution of firewood with modern and efficient fuels have often been confused, where no distinction is made between the energy problems faced by the rural and urban poor, nor have strategies been formulated to address different electricity uses (e.g. lighting and communication) and heating uses (e.g. cooking) in an integrated fashion. As Chapter Two highlighted, national governments typically view the alleviation of energy poverty as synonymous with the expansion of electricity grids. While improving electrical coverage is a key concern for national governments and key actors in the region (as section 3.4 goes on to discuss), CEPAL et al. (2010) warn that the energy needs of the region's population cannot be satisfied through electricity alone, and Taylor (2005) further highlights that off-grid populations may have more rudimentary human needs than energy – for instance, access to water. A call for 'integrated energisation' is therefore made by CEPAL et al. (2010).

Recent events in Central American electricity sectors suggest that state actors, in partnership with IFIs and the private sector, are seeking to address what has been termed the Central American 'energy challenge' (Eguizábal, 2011). In addition to significant investments being made in electricity generation and access, four Central American countries recently opted in to the SE4All initiative (Costa Rica, Guatemala, Honduras and Nicaragua). As discussed in Chapter Two, this global initiative reflects the energy trilemma facing many developing world regions – and in the Central American region, has the potential to scale up action in key areas such as renewable energy, energy efficiency and energy access through attracting new investments. Having discussed various facets of the Central American energy challenge, the following section provides an historical analysis of energy paradigm shifts in the region.

3.3. Shifting energy governance: from state to market

In Central America, until the 1960s the generation and distribution of electricity was dominated by the private sector, with only minimal government participation (World Bank, 2001; Batlle et al., 2010). Access to electricity was limited, reaching just 12 to 20% of the population, with access limited to urban areas (World Bank, 2001). Government involvement in the energy sector increased during the 1960s and 70s, with efforts focused on expanding coverage, again focused on urban areas. Although electrification increased, the programmes were considered 'unsustainable, inefficient and [a drain] on public resources' (ibid: 17).

Following the oil crises of the 1970s, the Central American countries sought to reduce dependence on oil for electricity generation. The share of oil declined from 50% in 1970 to 27% by 1985, and was mainly substituted by hydroelectric power (Solá Monserrat, 1989). However, by the late 1980s, it was judged that the state institutions responsible for electricity utilities were 'not up to the task' (Barnes and Waddle, 2004: 5). Deteriorating electricity sectors faced high levels of supply losses, scarce resources and were rife with inefficiencies (Dussan, 1996; Tomiak and Millán, 2002; Barnes and Waddle, 2004). Analysing indicators from the mid-1980s to the early 1990s, Rufatt (2005) argues that the annual investments required to meet the forecasted growth in electricity demand surpassed the capacity of state utility companies. As a result, decisions were made to divest state interests in electricity utilities. It was assumed that shifting ownership from public to private hands would provide relief to state treasuries burdened by the strain of state owned enterprises (ibid). It was also assumed that private ownership would promote reliability and efficiency, stimulate growth and increase affordable electricity access for the poor (CEPAL, 2003; Byer et al., 2009). However, as discussed in Chapter Two, reform processes did not always deliver the expected benefits.

Throughout the 1990s and into the 2000s, neo-liberal reforms led to structural changes including the privatisation of state-owned utilities and the initiation of market liberalisation processes (Ruffat, 2005; CEPAL et al., 2010). Structural adjustment policies were adopted in response to protracted fiscal crises and debt repayment problems, while increasing electricity demand and the need for efficient power management created additional pressure on regional governments (Jonakin and Stephens, 1999; Nagayama, 2007). At the centre of reforms were two 'mutually reinforcing parallel processes' (Ruffat, 2005: 103): the reform of national power sectors, and their subsequent integration into a regional grid. To facilitate this process, changes were made to the way in which the Inter-American Development Bank (IDB) supported the region's power sectors: direct finance for infrastructure was replaced by technical and financial support to drive sectoral reforms. This support would enhance efficiency and attract private investment in the sector (Rufatt, 2005).

The World Bank financed reform programmes in Nicaragua (1994), Honduras (1991), Guatemala (1997), El Salvador (1991 and 1996) and Panama (1992)[13], and the IDB in the Honduran and Nicaraguan power sectors in 1994[14]. Fundamental reforms to electricity sectors were implemented

[13] For World Bank energy financing in the region see: http://web.worldbank.org/external/projects/main?query=undefined&menuPK=51526592&theSitePK=40941&piPK=217470&pagePK=218616

[14] For IDB energy financing in the region see: http://www.iadb.org/en/projects/advanced-search,1301.html?query=&ProjectNumber=&Status=&Country=&Topic=&Sector=&SubSector=&Fund=&Cofinancing=&FinancialProd=&ProjectType=&YearFrom=1990&YearTo=&FinancingOver=&FinancingUnder=&FinCurrency=&adv=true

in every country (with the exception of Costa Rica), which have had varying outcomes for the six countries. In El Salvador, Guatemala, Nicaragua and Panama, vertically integrated utilities were unbundled; initially generation capacities and later distribution networks were opened to competition (Barnes and Waddle, 2004; Martin and Posadas, 2012). In Honduras, legislation aimed to implement similar reforms, but these were not fully implemented, leaving the utility a vertically integrated state owned enterprise (World Bank, 2006; Flores et al., 2011). Costa Rica made only moderate changes and its electricity sector remains state dominated. Table 6 outlines the impacts of electricity sector reform on institutional arrangements and ownership in the six Central American states.

Table 6. Electricity sector reform in Central America: institutional arrangements and shifts in ownership

Country	Year of reform	Institutional arrangements	Net private ownership of electricity generation (%)					
			1990	1995	2000	2005	2010	2011
CR	1995	Integrated	0	1.6	16.3	13.1	19.8	16.1
ES	1997	Retail competition	0	6.1	43.7	66.3	64.6	65.5
GU	1998	Wholesale competition	0	32.3	58.7	70.0	69.9	68.9
HN	1994	Integrated	0	31.6	39.5	70.6	62.7	65.0
NI	2000	Wholesale competition	0	0.6	55	77.6	80.5	86.1
PA	1998	Wholesale competition	3.1	3.8	100	89.3	88.2	86.0
C. America			0.6	12.4	50.4	68.4	59.8	60.1

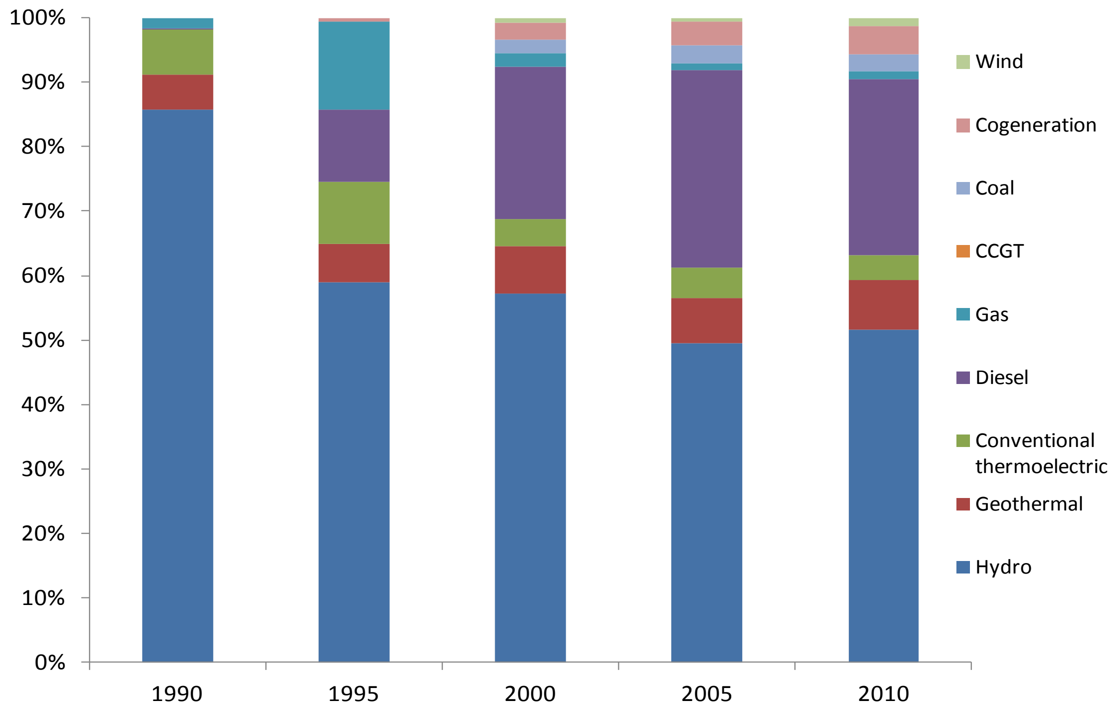
Source: adapted from CEPAL (2010; 2012). Note: CR = Costa Rica; ES = El Salvador; GU = Guatemala; HN = Honduras; NI = Nicaragua; PA = Panama.

Frequent supply crises, triggered by growth in demand, lowered reserve margins, oil price hikes, climatic events (particularly droughts), and delays in the construction of new generation, galvanised efforts to create a regional energy market (*Mercado Eléctrico Regional*, MER) (Byer et al., 2009; Lecaros et al., 2010; Cayo, 2011). The development of an interconnected electricity grid, or Proyecto SIEPAC (*Sistema de Interconexión de Electricidad para los Países de America Central* – Electricity Interconnection System for Central America), would integrate regional electricity markets, thus improving the region's energy security (Lecaros et al., 2010; Martin, 2010; Martin and Posadas, 2012). SIEPAC would interconnect the six countries through a 230 kV and 1,800 km transmission network (Cayo, 2011; Flores et al., 2011). The creation of a larger regional market was anticipated to enhance competition, secure electricity supplies where generation deficits existed, and help countries to match supply and demand more efficiently, while economies of scale would lead to gains in efficiency and lower costs (Lecaros et al., 2010). For Cayo (2011: 146) regional electricity integration 'makes sense', but is no panacea to Central American energy challenges. Indeed, Cayo identifies other critical issues affecting electricity sectors (e.g. access), while others (e.g. Taylor, 2005; El Observador, 2008) have questioned the extent to which the extended infrastructure would benefit populations currently without electricity access in Central America. At the time of writing, SIEPAC's construction was still underway, with an uncertain timetable for completion.

3.3.1. The impacts of electricity sector reforms

In the five countries that underwent structural reforms, electricity sectors experienced a shift from public to private ownership (Table 6). Only Costa Rica imposed restrictions on private investment in generation (Mostert, 2009). The transition from state-led to market-led governance had a considerable impact on the way in which electricity generation and distribution networks operated, and therefore wide-reaching consequences on the ways in which populations accessed and were able to afford electricity.

Figure 6. Percentage share of net electrical generation by source in Central America, 1990- 2010



Source: adapted from CEPAL (2012)

In the post reform period, shifts occurred in the region's electricity generating mix (Figure 6); the share of hydroelectric power generation reduced, while fossil-fuel based generation increased (Lecaros, 2010; Reinstein et al., 2011; CEPAL, 2011a). This shift is partly linked to the privatisation of electricity generation activities, which led to risk-averse private investors avoiding capital intensive RE technologies. Diesel generation presented lower perceived risks for private investors than renewable electricity generation due to lower lead times and upfront costs. In the context of high growth in demand, for private investors, it was easier to install diesel generation than RE electricity generating facilities. An additional benefit of non-RE electrical generation was that plant could eventually be moved out of the country (Reinstein et al., 2011). For instance, electricity shortages during the 1990s led the Guatemalan government to install a power barge anchored in the main Pacific Port, which had a capacity of 124 MW and ran on heavy fuel oil (Taylor, 2005). However, fossil-based generation locked countries into higher costs in the longer term due to reliance on imported fuels, and exposure to international price volatility (Lecaros et al., 2011). For instance, increasing oil prices meant that the region's oil bill increased nearly tenfold, from US$ 47 million in 1990 to US$ 444 million in 2002 (CEPAL, 2003), exacerbated further when international oil prices rose sharply between 2005 and 2007 (Lecaros et al., 2010). Since in some cases, political constraints prevented states passing rising fuel costs onto consumers (e.g. Byer et al., 2009), this meant such costs were subsumed by governments (e.g. in Nicaragua, see McGuigan, 2007). This represented a 'good deal' for private investors who were able to avoid risk, including the demand reduction that may have occurred if the full costs were passed through to consumers. The shift towards fossil-based generation can also be partly attributed to Central America's increasingly climate-sensitive hydropower installations, affected by phenomena such as El Niño (UNDP, 2002).

This is not to suggest that the dominance of hydropower in the pre-reform era was preferable to the latter shift towards greater levels of fossil-fuel based electricity production. Indeed, during the twentieth century, Central American populations suffered atrocities while large scale hydropower infrastructure projects were under development. For example, Johnston (2005) reports on the legacy of the Chixoy dam in Guatemala, concluding that 'hydroelectric energy development occurred at the cost of land, lives, and livelihood in violation of national and international laws' while at the same time 'considerable profits were achieved' by programme developers (pp. 6-7).

Between 1990 and 2007, twice as much new generation capacity deriving from fossil fuels was built than generation capacity from renewable resources in the Central American region (Cayo, 2011). Data from individual countries reveals differential experiences with changing levels of RE in generation capacity; for instance, in Honduras, thermal generation increased from nil in 1990 to 66% in 2010 (ARECA, 2010), and Nicaragua consistently displayed the lowest participation of renewable electricity in overall electricity generated (CEPAL, 2012). Both country experiences contrast markedly with Costa Rica, in which diesel has played a relatively minor role in net electricity generation (below

7% since 1990). Ramsing-Wilde and Potter (2008) attribute Costa Rica's success in this respect to high levels of state participation through the Costa Rican state electricity utility and strong public resistance to privatisation: 'in other countries in the region, the government has not intervened, and decisions about electricity production were made by private interests... this difference has led to the success of renewables in Costa Rica and the dominance of fossil fuels in other countries' (p. 79) (see also Avecedo, 2005).

CEPAL (2003) argue that reforms failed to bring about much needed investment in infrastructure, especially in the area of technical and non-technical electricity losses. The impacts of electricity losses in the four countries that privatised distribution activities were ambiguous. In the case of Nicaragua, for example, key actors interviewed felt that the sector underwent 'frank deterioration' and electricity losses were considered one of the contributing factors to the country's 2006-07 energy crisis (expert interviewee 22 – Nicaraguan government official, rural electrification department, Ministry of Energy and Mines; expert interviewee 33, finance official, Nicaraguan private electricity distributor - Disnorte-Dissur S.A)[15] (see also McGuigan, 2007).

The outcomes for electricity coverage were also ambiguous. While the regional average of electrical coverage has improved in the post-privatisation period (averaging just 71% of the region's households in 2000, and reaching nearly 87% by 2010) (see Table 4), approximately six million people remain without access to electricity, (CEPAL, 2011a). It can be argued that populations living in off-grid or in 'unprofitable' areas of service were neglected in the post-reform period; Barnes and Waddle (2004) for instance find that rural electrification was not integrated into the reform process until the key decisions regarding the former state distribution agencies had been made. Prior to reforms, rural electrification had been managed by state utilities, operating with limited budgets and personnel, whereas the challenge post-reform was how to encourage private sector service providers to extend their service to new customers (ibid, 2004). While private investors were effective in connecting consumers in urban and rural areas near to the power grid, progress in rural and low-income areas was slow due to the lack of natural incentives. Barnes and Waddle (2004:xix) argue that 'the belief that privatisation would lift the burden of rural electrification from the government has proven not to the true' in the case of Central America. This echoes the experience of other reform processes in countries of the Global South (see Chapter Two; Wamukonya, 2003).

Costa Rica again stands out as an exception to the rest of the Central American region, described as one of rural electrification's 'unique success stories' (Foley, 2007:18). Electricity cooperatives in

[15] See Chapter Four for an in-depth discussion of the research methodology

conjunction with the *Instituto Costariccense de Electricidad* played a vital role in the expansion of electricity to rural populations from the 1960s onwards contributing to almost universal coverage. By contrast only 30% of rural households have access to electricity in Nicaragua, and coverage (until 2009) had grown only modestly. As Ripley (2010) argues, post-privatisation there was no obligation or state initiative to 'fill the gap' unattractive to private investors; Nicaragua's privatisation process was predicated on a 'hands off' ideology, where it was assumed that the market would satisfy the population's electricity needs (p.123). El Salvador and Panama experienced growth in rural electrification at a similar rhythm to the years prior to privatisation. Guatemala and Honduras were able to increase electrical coverage from roughly 40% at the time of reform to between 75-85% in 2010; Guatemala was the only country to make explicit plans to pursue aggressive electrification plans using state resources. In contrast, Nicaragua experienced stagnation in the late 1990s and early 2000s, with population growth outpacing increases in connections (CEPAL, 2012).

Millán (2007) argues that almost two decades since the start of reforms in the electricity industry, there is consensus that their implementation was more difficult than anticipated. Thus, the extent to which power sector reforms were 'successful' is contested (CEPAL, 2003; Acevedo, 2005; CNE, 2010; Flores, 2012). Neoliberal reforms of power sectors failed to take into account the particular circumstances of the region and, as a result, were 'over-optimistic' both in terms of what could be achieved and the time-scales within which they could be achieved (Tomiak and Millán, 2002: 1). CEPAL (2003) argue that the specificities of the relatively small Central American markets and socioeconomic-political contexts presented significant challenges to the reform process, which were overlooked by the national authorities and the IFIs implementing them. Indeed, the IDB has since acknowledged that enthusiasm for liberalisation obscured the question of whether or not it was an appropriate policy option for all countries (Tomiak and Millán, 2002). Others have argued that reforms were not fully implemented, specifically in the case of Honduras, which caused delays in investment and left the energy sector vulnerable to political intervention (Flores, 2012).

It is important to recognise that across Central America – with the exception of Costa Rica – reforms coincided with financial, social and political crises. Furthermore, at the turn of the new millennium the region's energy sectors were exposed to severe shocks, including natural disasters (e.g. drought in Honduras in 1993-94, and Hurricane Mitch which affected Honduras, Nicaragua, El Salvador and Guatemala in 1998) (CEPAL, 2003), in addition to a 200% increase in the price of crude oil between 1999 and 2006 (Byer et al., 2009). It is impossible to know whether circumstances would have been any different had reforms not have been implemented. Indeed, Millán (2007) argues that the history of the electric power sector in Latin America has been 'dominated by a constant search for the most appropriate model to meet its needs' (p. 205). He argues that once reforms are implemented, difficulties often arise that bring into question the pertinence of that model and an ideological debate ensues about whether the state or market should provide electricity services. Millán (2007) argues however that the state vs. market approach is a false dichotomy that ignores the complexity of power sectors. Citing Djankow (2003), Millán argues that in a country with abundant civic capital and appropriate institutions, either of the two systems could guarantee the robustness needed for the reasonable operation of the industry. Thus, what is witnessed in the broader Latin American region is a return to a more statist model, where states are assuming more central roles in the governance of energy sectors (Batlle et al., 2010). The 'swinging pendulum' metaphor used by Batlle et al. (2010) neatly sums up shifting governance arrangements - between state and market – in the Central American region. The latest energy developments in Central America are now examined, questioning whether there is any evidence to suggest the emergence of a new energy paradigm.

3.4. Is a transition underway? From the market to an era of intervention

As discussed in Chapter Two, the current era is one characterised by a resurgence of the state in energy sectors – a turn which Goldthau (2012) labels 'interventionist'. According to Goldthau (2012), during the 2000s, there was increasing recognition that the market could not be relied upon to deliver normative energy goals, including environmentally and socially sustainable energy, which has led to the re-emergence of the state. Interviews with key actors identified three factors behind this interventionist turn, namely, energy security, climate change and energy poverty - in other words, the three facets of the energy trilemma (expert interviewee 7 – founder of NGO with off-grid RE initiative, convenor of Nicaraguan national renewables association; expert interviewee 18 - energy specialist, Sistema de Integración Centroamericana; expert interviewee 30 - coordinator of large donor funded solar energy programme in Nicaragua).

In Central America, the most important of these to date has been energy security. This was a view held by stakeholders - that increases in international oil prices marked a critical 'turning point' in the region's energy landscape (Expert interviewees 18 and 33). The rising dominance of diesel in the electricity mix over the previous two decades (Figure 6) had meant that countries faced escalating energy bills, affecting economic development and supply security. The oil price shocks drove home the challenges faced by the Central American states, specifically with regard to energy security, and galvanised political will to foment renewable energy generation. The signing of *Estrategia Energética Sustentable Centroamericana 2020* (Central American Sustainable Energy Strategy 2020) represents an important response. Estrategia 2020 is a regional strategy coordinated by the *Sistema* *de la Integración Centroamericana* (Central American Integration System, SICA) and CEPAL, which represents a collective vision for Central America's energy system, with its overall objective framed in energy security terms; namely to reduce (the economic burden of) imported oil and to diversify regional energy matrices (CEPAL, 2007; 2009). In 2007 the strategy was approved by Central American energy ministers, providing a common vision for each national government through establishing goals that address each facet of the energy trilemma, to a) reduce dependency on hydrocarbons; b) increase participation of renewable energy resources; c) reduce greenhouse gases; and d) expand electricity coverage (CEPAL, 2007).

After two decades of liberalisation, there has been a re-emergence of Central American states in energy sector governance. The role of the state is no longer merely one of 'rule setter and enforcer', as it was under the market-led paradigm, but to safeguard the 'public interest' in the delivery of public goods (Goldthau, 2012: 204). For instance, El Salvador's 2010 energy policy explicitly acknowledged that sectoral reforms had weakened the state's capacity to develop long term energy strategies. It observes that, as a consequence, the ability to plan and think holistically about the energy sector was lost. Thus, one of the four objectives of the policy is to re-establish the role of the state in the development of the energy sector (CNE, 2010: 23). Discontent with the privately-led energy model was evident in the Nicaraguan context, manifested in the part-renationalisation of the electricity distribution company Disnorte-Dissur (INE, 2009), and an increased focus on 'electricity access without exclusion'.[16] Costa Rica (MINAE, 2011) and Guatemala (GU-MEM, 2013) have also recently published energy policies, which emphasise the role of the state in meeting normative energy objectives. The shift towards interventionism is also evident in the wider Latin American region. Indeed, CEPAL et al. (2010) explore post-reform sector experiences and argue that in some countries the State has been forced to intervene to ensure expansion in supply and diversified energy mixes (e.g. in Brazil, the government has invested heavily in electrification programmes to promote universal electricity access (Goldemberg et al., 2004) and in Chile, Latin America's leader in energy sector privatisation, the government created a strong central government agency to promote RE in the absence of action from the private sector (Hall et al., 2009) and provided significant investment subsidies to increase electricity coverage in rural areas (Byer et al., 2009)) (see also Batlle et al., 2010).

Central American governments have responded to the complex challenges associated with the energy security and climate change facets of the trilemma with different strategies. As the region's

[16] See: http://www.mem.gob.ni/index.php?s=3&idp=351&idt=2&id=267

only oil producer, an objective of Guatemala's energy policy is to 'explore and exploit' national hydrocarbon reserves with a view to self-sufficiency (GU-MEM, 2013). The policy also demonstrates a commitment to diversifying the energy mix through renewable energy resources. Costa Rica's recent energy policy states that the exploration of possible hydrocarbon reserves will not be undertaken on environmental grounds, but rather will take advantage of the country's renewable energy potential (MINAE, 2011). El Salvador is similarly planning to expand renewable electricity generation, including large-scale geothermal, hydroelectric and concentrated solar power, as well as small-scale wind and solar (CNE, 2010). The Nicaraguan government is pushing to enact an ambitious overhaul of its energy system, through the transformation of the electricity generating mix (MEM, 2011). Honduras, which has historically suffered supply deficits, has ambitious plans to construct new electricity generation capacity; the state plans to replace large thermal generation plants with small and medium-scale renewable electricity generation projects (ARECA, 2010; GoH, 2010). Finally, Panama is planning to install an additional 1300 MW of generation capacity by 2023, 60% of which will be met by hydroelectric and wind resources (SNE, 2009).

In tackling the energy poverty angle of the trilemma, national governments have responded with different strategies. The *Estrategia 2020* urged for electricity services to cover at least 90% of households in the region by 2015, to support the attainment of the MDGs (CEPAL, 2007). Those countries with the lowest levels of electrification are pursuing various strategies. For instance, in Guatemala and Honduras, grid extension has been the preferred method to expand electricity services to rural populations. For instance, in Honduras there are plans to reduce the rural population without access to electricity to 55% by 2022 and to 0% by 2034, which in the short term, requires 400,000 new grid connections by 2015 (GoH, 2010). The Honduran government's social electrification fund has received significant backing from international donors to expand grid electricity to rural areas. ESMAP (2010) however identify this strategy as financially unsustainable and recommend the use of off-grid solutions, namely solar home systems (SHS) as a least costly and practical solution for servicing energy isolated rural communities. Indeed, CEPAL (2007) present the electricity access challenge facing Guatemala, Honduras and Nicaragua as an opportunity to incorporate low carbon, decentralised energy sources to remote rural areas. In a comprehensive review of Central American policy documents, CEPAL et al. (2010) find that individual Millennium Development Goal (MDG) reports link the development of renewable energy sources to the attainment of the Millennium objectives and the alleviation of poverty; a report on energy and the MDGs in Guatemala, Honduras and Nicaragua, for instance, specifies the use of micro-scale renewable energy generating technologies, such as solar photovoltaic or small hydro or wind power applications as the best options to electrify isolated communities (CEPAL, 2008). The country facing the biggest challenge in increasing electricity services is Nicaragua, which has the lowest connection levels in the region, where 74.6% of the total population have access to grid electricity (and only 40% of the rural population have access) (CEPAL, 2011a). The Nicaraguan government has responded with a strong mandate to extend electricity access, with the Minister of Energy and Mines declaring a strategic focus on rural electrification which favours renewable sources of electricity (MEM, 2011).

Decentralised solar energy technologies have been particularly important in the Central American region. Located in the so-called 'sun belt', Central America is well suited to the deployment of solar photovoltaic technologies (Huacuz, 2003). Solar home systems and larger solar photovoltaic installations have been deployed in various countries of the isthmus on a small scale demonstration basis (see Foster and Cota Espericueta, 2005), for instance in Guatemala (see Palma-Cajas and Foster, 2001) and Honduras (see Smith, 2000; ESMAP, 2005; Lallement et al., 2006; GoH, 2009). SHS and solar battery charging stations (SBCS) have emerged as particularly important technologies in the Nicaraguan off-grid context; Ley et al. (2006) and Corsair and Ley (2008) describe the beginnings of the solar energy market catalysed by the World Bank financed programme *Proyecto de Electrificación Rural para Zonas Aisladas* (Rural Electrification Project for Isolated Zones, PERZA). Aside from a cursory analysis presented by Cárcamo Ruíz et al. (2012), there has been little scholarly interest in the major growth of Nicaragua's off-grid solar energy market segment since the PERZA programme was initiated.

Current activities in Central American electricity sectors suggest that an interventionist turn in governance is underway. The interventionist paradigm is characterised by a shift to a hybrid mode of governance wherein multiple actors work in partnership, with the state resurging to play a stronger role in steering and guiding the energy system (Dubash, 2011). For instance, in the case of the Nicaraguan government's mandate to overhaul the energy matrix and expand electricity access, efforts are buttressed by the support of various actors, including the IFIs, private sector and civil society. For example, the PNESER programme (*Programa Nacional de electrificación sostenible y energía renovable* - Sustainable Electrification and Renewable Energy Programme) sees the IDB leading a multi-donor and private sector effort to enact an energy transformation (PNESER is examined in more detail in Chapters Five and Six). This programme aims to 'transform [Nicaragua's] energy matrix and expand electricity access'[17] through providing up to US $381 million in loans and technical cooperation. As Chapter Two highlighted, the conjuncture of the climate, energy access

[17] See the IDB website for more information on the PNESER programme:
http://idbdocs.iadb.org/wsdocs/getdocument.aspx?docnum=35280898 and
http://www.iadb.org/en/news/news-releases/2010-07-08/sustainable-electrification-and-renewable-energy-in-nicaragua-idb,7416.html

and energy security challenges, or the new international scripture of sustainable energy, have translated into financial opportunities for governments, civil society and the private sector. The 2012 Climatescope report (IDB, 2012) provides data on the overall funding landscape for renewable energy in Latin America. The report ranks countries according to factors such as enabling frameworks, clean energy investment and low carbon business value chains. It identifies significant momentum in renewable energy investment in Latin America, in particular highlighting Central American countries as 'leaders' with all states finishing in the top half of the rankings (p.7). The report found that between 2006 and 2011, the Central American states harnessed more than US$ 4.3 billion in clean energy investment. Nicaragua emerged as a leader in this context, through being named the second most attractive country in Latin America (after Brazil) to invest in renewable energy and the preferred destination for clean energy related grants from international donors (IDB, 2012).

At the time of writing, four states (Costa Rica, Guatemala, Honduras and Nicaragua) had very recently signed up to the SE4All initiative. In addition to this a series of IFIs and development agencies had pledged actions under SE4All for the region, which include: the IDB's commitment to spend US $5 billion on the three objectives of SE4All in the wider Latin American region[18], and various programmes to address electricity access[19], clean cooking[20] and the promotion of renewable energy resources[21]. One key actor interviewed questioned the extent to which SE4All represented something 'new' for the region however. Independently of the initiative, he argued that governments were already pursuing these goals, although under different auspices. SE4All was just a new way of labelling these activities; however he expressed hope that the initiative would harmonise action across sectors and countries, and would attract new financing flows (expert interviewee 18 – energy specialist, Sistema de Integración Centroamericana). Examination of the future implications of Central American nations' inclusion into the SE4All initiative warrants further research.

3.5 A sustainable energy future for Central America?

This chapter has traced the evolution of Central American electricity sectors from the statist 1970s and 80s through to the neoliberal reforms of the late 1990s to the current era which it has been

[18] See: http://www.sustainableenergyforall.org/actions-commitments/commitments/single/idb-sets-financing-target-of-us-5-billion-over-the-next-five-years
[19] See: http://www.sustainableenergyforall.org/actions-commitments/commitments/single/enabling-electricity
[20] See: http://sustainabledevelopment.un.org/index.php?page=view&type=1006&menu=1348&nr=907
[21] See: http://sustainabledevelopment.un.org/index.php?page=view&type=1006&menu=1348&nr=1674

argued is characterised by an interventionist turn. This analysis finds evidence for Goldthau's (2012) thesis that shifts in energy governance have reflected wider paradigm shifts in economic policy making. In Central America, the 'interventionist turn' has coincided with a shift in global energy policy priorities, embodied in the energy trilemma. Central American governments have adopted a more prominent role in the delivery of normative energy goals, with recent energy policy documents promoting the uptake of renewable energies and highlighting the importance of energy for economic development. The region's renewable energy potential has been noted by IFIs and others, and has attracted considerable investment. The current policy discourse and the scale of investment indicate progressive steps towards addressing Central America's energy trilemma, namely the increased penetration of renewable energies, a push for energy efficiency and improved energy access. While recognising that Central America has come a long way in enacting sector transition, Dolezal et al. (2013) argue that existing policies and governance structures are insufficient to bring the region to its full sustainable energy potential. The jury is still out as to whether an 'energy revolution' is fully underway in the region therefore, and whether the implications of this will be a more sustainable and equitable energy landscape. Having examined the multiple energy challenges facing Central American electricity systems, the following section introduces Nicaragua as the site for empirical data collection.

3.6 Nicaragua: site for empirical data collection

Nicaragua has been signposted throughout this chapter as an interesting and exceptional national context in the Central American region. The paradox of Nicaragua is that despite possessing the best renewable energy potential in the Central American region, the greatest amount of land and the smallest, youngest population, it is the most 'energy poor' country (Miranda-Urbina, 2006). Indeed, the International Energy Agency's 'Energy Development Index'[22] places Nicaragua in 40th place out of 64 of the least energy developed countries in the world, with indices comparable to Sri Lanka and Gabon (IEA, 2011). With the exception of Haiti, Nicaragua demonstrates the lowest level of 'energy development' in Latin America.

Figure 7. Map of Nicaragua

[22] The Energy Development Index (EDI) was developed by the International Energy Agency to mirror the UNDP's Human Development Index and ranks countries according to progress made on indicators such as the use of modern fuels or increased electricity access. The EDI is composed of four indicators: commercial energy consumption (indicating overall economic development); per capita electricity consumption (indicating reliability and consumer's ability to pay for electricity services); share of modern fuels in total residential sector energy use (indicating levels of access to clean cooking facilities) and share of population with access to electricity (IEA, 2010).

Source: ineter.gob.ni

Recent years have seen Nicaragua suffer the macroeconomic and structural consequences of over-reliance on imported hydrocarbons for electricity generation, culminating most visibly in the energy crisis of 2006-7. That Nicaragua's lights went out caught international headlines (see McGuigan, 2007) and revealed the weaknesses of the Nicaraguan electricity sector, however it also diverted attention away from the country's other energy crisis – the fact that in 2006, only 59% of the population were connected to the electricity grid. On the back of this energy crisis a government 'interventionist' in many aspects of the country's development was re-elected (Staten, 2010). Since their re-election, the Frente Sandinista de Liberación Nacional (the Sandinista National Liberation Front, FSLN) have been particularly interventionist in the energy sector, as this thesis goes on to examine. A particular priority has been energy access – and Nicaragua out of all the Central American countries faces the greatest challenge in addressing this, still possessing the highest proportion of population without access. Within this context, a policy environment in which off-grid solar energy is gaining importance and momentum is also evident; Cárcamo-Ruiz et al. (2012) summarise government, IFI, donor and civil society engagement with solar energy technologies, and find great diversity in the type, scale and governance of these activities. Table 7 lists a number of solar programmes active or recently active in the Nicaraguan context[23].

Despite the exciting contemporary developments in the Nicaraguan energy landscape and significant growth in the dissemination of solar energy technologies, there has been relatively little academic attention given to the political economy of energy (with the exception of Cupples (2011) and Grogan and Sadanand (2013)) or more specifically, off-grid solar energy applications (with the exception of Ley et al., 2006 and Rebane and Barham, 2011)[24] in this territory. This thesis therefore contributes to an emerging area of literature on energy in Nicaragua, as will be explored throughout the following chapters.

Table 7. Selection of off-grid solar energy-related programmes

Programme	Donor	Years active	Financing	Activities
Programa Nacional de Electrificación Sostenible y Energía Renovable (PNESER)	IDB[25]	2010-2014	US$ 381,000,000	- Electricity sector transformation - Electrification via grid extension (117,390 households) and deployment of decentralised residential solar energy technologies (3,820 households)
Proyecto de Electrificación Rural para Zonas Aisladas (PERZA)	World Bank/GEF	2003-2011	US$ 22,980,000	- Launch of 'Solar Photovoltaic Market Development Programme' - 6,863 SHS sold through a national solar credit line - Five 2.4kWp SBCS installed in remote communities of the Northern Atlantic coast region
Euro-solar	European Union	2006-2011	EU€ 2,488,906	- Solar energy for community services in 42 rural communities of Nicaragua - Provision of solar kits, laptops, vaccine refrigerator, internet, data projector, water purifier, battery charger

[23] These data were obtained through interviews, document analysis and web searches

[24] There is marketing material available on the impacts of SHS in Nicaragua at the local level (e.g. Van der Jagt, 2011), however as Schäfer et al. (2011) and Sovacool and Drupady (2012) argue, it is necessary to provide critical and impartial evaluations of solar energy access programmes in order to draw lessons for future interventions

[25] Other donors include: World Bank, International Finance Corporation, Spanish Agency for International Development Cooperation, the Korean Exim-bank, Latin America Investment Facility, European Investment Bank, Central American Bank for Economic Cooperation, Climate Investment Fund and the Nordic Development Fund.

Sustainable access to renewable energy for rural families	IDB	2013	US$ 1,606,400	- SHS for rural households ~ 467 - PV for rural refrigeration and water pumping - Support to establish local SHS dealers
Renewable Energy Microenterpise Initiatives for Low Income Rural Populations	IDB	2006-2009	US$ 970,000	- Promotion of social entrepreneurship with solar photovoltaic technologies
Global Energy Development programme	European Development agency	2006-present	n.d.	- Solar home systems for rural households ~ 2000 subsidised systems sold - Other activities include grid extension, grid densification, construction of micro-hydro centrals
Project Solar	UK housing associations and NGOs	2005-present	UK£ 200,000	- Solar home systems for rural households ~ 200 systems sold with micro credit facility
Gestión Ambiental Local para el Manejo de los Recursos Naturales en la Reserva de Bosawás	Spanish government and UNDP	2010	US$ 660,000	- Solar home systems for rural households ~ 276 systems donated, with community sink fund for future maintenance - Micro hydro systems constructed and operational
Programa de Desarrollo de Zonas Fronterizas en América Central (ZONAF)	European Union	2010	n.d.	- Solar home systems for rural households ~ 1000 systems donated
Las Mujeres Solares de Totogalpa	Overseas volunteers; international funding bodies	1999 – present	n.d.	- Cooperative consisting of 19 females and 2 men that work in the promotion, production, and research of renewable energy (particularly solar photovoltaic and solar cooking technologies) for the sustainable development of their community
Blue Energy	Overseas volunteers; international funding bodies	2002 - present	n.d.	- Promotion of renewable energy and energy efficiency - Connection of communities in the Atlantic coast region to energy through decentralised RE (solar and wind)
Asofenix	Overseas volunteers; international funding bodies	2005 - present	n.d.	- Delivery of renewable energy projects (particularly solar energy) for productive use in rural communities

Chapter Four. Researching Energy in Nicaragua

This chapter examines the 'how' and the 'why' of this research. As well as focusing on the mechanics of data collection, this chapter also engages with debates on the nature of qualitative research methods in Human Geography and the social sciences more broadly. Discussions surrounding the inherently unequal power relations of 'development fieldwork', as well as the challenges posed by cross-cultural research are also examined.

During the research period a total of ten months (October 2010 to July 2011 and October 2011 to November 2011) were spent living and researching in Nicaragua. Living in Nicaraguan society facilitated gaining a deeper understanding of issues relating to sustainable energy development, allowing not only for full immersion in the political debates surrounding this, but also engagement with different world views. The research employed a multiple method approach focusing predominantly on qualitative research methods. Semi-structured interviews were conducted with 36 stakeholders within Nicaragua's energy sector, and 38 households participating in solar energy programmes in rural communities. This was complemented with 152 household questionnaire surveys of SHS users and 4 focus group discussions involving both users of solar energy technologies as well as households without access to electricity.

The rest of this chapter is structured as follows: section 4.1 reflects on the research 'journey', discussing the various factors that influenced its direction during the fieldwork phase and re-introduces the research questions. Section 4.2 discusses this study's qualitative multiple-method approach, introducing the research methods selected and their relevance to the research questions. Section 4.3 introduces and critically appraises each of the methods adopted. Sections 4.4 to 4.6 reflect on the challenges presented by this research; these include the ethical dilemmas of 'developing world' research, issues relating to access and gatekeepers, the complexities and politics of second language research, and finally the challenges of writing and representing 'voices' from the field. The final section concludes.

4.1 The research journey: the evolving nature of research in the field

The overseas case study element of this thesis implied a series of discrete research phases; firstly research design and planning in the UK, followed by two periods of intensive fieldwork in Nicaragua, with subsequent analysis and writing up taking place in the UK. For researchers the initial design phase may be the most daunting where the expectation is that field plans ‘should be made watertight… before flying off to do the real research’ (Murray and Overton, 2003:17). The research is likely to evolve during the fieldwork however, ‘as the subsequent phases of the project unfold and the perspectives of the researcher almost invariably shift’ (ibid: 17). Murray (1997; cited in Murray and Overton, 2003) provides examples from his doctoral work in Chile, where despite detailed fieldwork plans, the first few months of research were dedicated to re-defining the entire project methodology. This was also true for me during the initial weeks and months I spent in Nicaragua. Prior to departure I had formulated research questions and a detailed work plan, but on arrival, the realities of the field presented certain challenges. As is suggested in the literature, these challenges required me to be flexible and able to ‘let go’ of my previous research plans (Murray and Overton, 2003; Binns, 2006).

The original research design aimed to investigate energy poverty and the impact of solar photovoltaic technologies in rural Nicaraguan households, using ethnographic tools. I had envisaged living, or spending prolonged periods of time, within the communities participating in one solar energy project delivered by a community development organisation. Through becoming immersed in these communities, I planned to observe and participate in everyday activities, and obtain a detailed understanding of the implications that solar technologies have on the everyday lives of individuals, households and communities. Prior to my fieldwork I had established a relationship with an NGO implementing a solar programme, which had agreed to support my research. On my arrival in Nicaragua, I soon discovered that the case programme I had intended to study (and indeed, many other solar energy programmes) faced significant challenges with regard to long-term system and programme sustainability, which had not been contemplated in my original research plan. For example, in some communities, it became apparent that many SHS were not functioning beyond the useful life of the initial battery (i.e. 1-2 years), when the solar panel itself could have a useful life of up to 25 years. Initial literature scoping and online research into potential case study programmes in Nicaragua had not suggested the existence of such issues in relation to their successes/failures; therefore these issues were not originally made an explicit focus of the research question. Only with immersion in the field and engagement with key stakeholders, did I fully acknowledge the high failure rates of SHS programmes in Nicaragua. The initial research questions which had focused on the micro-scale impacts of just one solar energy programme suddenly felt trivial given that in many instances SHS were no longer functioning, or the financial viability of programmes were under threat. These initial findings directed field inquiry towards a greater consideration of the variety of challenges facing solar energy interventions, as well as the different delivery methods.

The reality of spending long periods of time in rural environments furthermore altered the direction of this thesis; I experienced recurrent health problems, which made living in remote places without access to water, sanitation and medical facilities, incredibly difficult. I had also underestimated the challenges of reaching remote field sites; indeed, 2010 saw the most destructive and heavy rainy season Central America has experienced in recent years (UNICEF, 2010). Severe rains caused landslides and flooding, leading to loss of lives and livelihoods, damage to national economies and infrastructures; this resulted in some of the anticipated field sites being inaccessible for many months (see Figure 8).

Figure 8. Foot bridge destroyed by heavy rains during 2011, preventing access to the community of San Ramón (Condega, Estelí)

Source: author's own photograph

The direction of the research was also greatly influenced by significant developments in the national and global energy governance arenas within which individual solar energy programmes were situated (particularly since fieldwork began in 2010). In the national context, field research was undertaken during a period of significant flux; while the electricity sector was in chaos between 2006 and 2007, with little more than half of the population grid-connected, by 2012, major donor programmes had been approved to support the state in pursuing aggressive (on-grid and off-grid) electrification programmes and Nicaragua had been ranked the second best country in Latin America in which to invest in low carbon energy projects (IDB, 2012). The fieldwork also took place during an electoral year – where an interventionist government sought re-election, expressing explicit aims of transforming Nicaragua's energy sector. On the global stage, increased momentum in the 'energy for development' arena was witnessed particularly from 2010 onwards (see Table 1) and the international community launched an ambitious global initiative to achieve 'sustainable energy for all' was launched (UN, 2011).

These factors all contributed to a significant change in the research trajectory. Upon considering both the local level realities and dramatic shifts in global and national energy governance arenas, I decided that the research required a different approach. Influenced heavily by the global energy governance and political economy literatures discussed in Chapter Two, I redirected the research design to consider the interconnections between multiple (global, national, local) scales and embed issues relating to the use of solar energy technologies within broader political-economic frameworks. Identifying and mapping the constellation of key actors and institutions operating at multiple levels to influence the governance of solar energy in Nicaragua was one of the first tasks therefore. This map illustrated the key players (hailing from government, IFIs, donor agencies, the private sector and civil society organisations) and their interconnections; I sought to conduct interviews with a broad cross-section of these. The discussions conducted with those key actors during the initial period in the field were framed around the theme of the social impact of solar programmes, however under this general thematic umbrella, a number of sub-themes arose which led to new areas of inquiry, for instance, the importance of the historical development of the electricity sector (and those segments of society which had typically been excluded from it), the rapid growth of the off-grid solar energy market in the post electricity sector privatisation era and the challenges facing the deployment of solar energy technologies in off-grid areas.

At the local level, I sought to examine the implications of these wider shifts on the operation of solar programmes, in particular their consequences from the perspective of the households using the technologies. Instead of examining just one solar programme as was originally intended, I researched three in total. Through contacts I made in the field, and as research opportunities were presented[26] (e.g. one programme was the subject of a consulting project I helped to coordinate, see Wheelock-Horvilleur and Gent, 2011[27]; Gent and Wheelock-Horvilleur, 2013), I selected two further

[26] See Murray and Overton (2003) who discuss the impact of chance discoveries and encounters on field research.
[27] I was co-author of this consultancy work which evaluated the solar component of a large European development agency's solar programme. This project provided me with direct experience of the evaluation processes of a major donor and gain access to a wider number of respondents in different locations. It also

programmes to investigate. Broadening the scope to consider three programmes instead of one, enabled me to examine the local experiences of solar energy technologies, which had used different delivery methods in a variety of socio-economic contexts. The three programmes selected were 'project organised' (see van der Vleuten et al., 2007), that is, they derive from the planned effort of an organisation to facilitate access to solar energy - illustrative of the wider Nicaraguan solar landscape, which has been heavily influenced by the presence of donor institutions. Each programme, however, operated slightly different delivery mechanisms (e.g. in financing, implementation, accompaniment and follow-up) (Table 8) and carried out their activities in different regions of the country (Figure 9).

Table 8. Solar energy programmes selected for research[28]

Programme	Location (department)	Institution	Delivery mechanism
A. Project Solar	Masaya, Managua	Community development NGO	Dealer model where long term micro finance is provided by the institution to enable users to purchase SHS.
B. Global Energy Development (GED) programme	Estelí, Madriz, Nueva Segovia	Major European development agency	Dealer model where highly subsidised SHS are offered by the institution to enable users to purchase SHS.
C. Proyecto Santa Clara	RAAN	Implemented by the Ministry of Energy and funded by a major donor	Community managed solar battery charging station. Donated systems, but 'fee-for-service', where a sinking fund is collected for future system maintenance costs.

enabled me to return to Nicaragua for a second field visit in 2011, thus giving me the chance to revisit respondents and 'fill the gaps' on themes that had emerged from data analysed during the first field season.

[28] For simplicity, when identifying interview/survey/focus group data from each of the case programmes, the prefixes A, B or C is used to denote which programme the data derives from.

Figure 9. Locations of solar energy programmes selected for research

Source: author's own illustration

The three locations are distinctive in socio-economic and cultural terms; programmes A and B are located in the relatively wealthy Pacific and Northern regions of Nicaragua, whereas C is located in one of the poorest areas of the whole of Latin America. Census data reveals significant disparities between the departments in terms of access to basic services, living conditions and socio-economic indicators, such as illiteracy and infant mortality (see INIDE 2005a; 2005b; 2005c; 2005d; 2005e; 2005f and further discussion in Chapter Seven, sections 7.1.1 to 7.1.3). Studying three solar programmes or 'cases' provided an excellent opportunity to strengthen the evidence base, and perform a more generalising analysis (Yin, 2009).

The research design therefore evolved as a consequence of the initial period spent in the field; it moved from a study that would have largely emphasised the local, community level impacts of solar energy technologies, using mainly ethnographic tools, to one that considered the global and national political-economic frameworks within which the users of solar technologies are embedded. The research therefore broadened in scope to examine multiple scales and actors (see Figure 10 below). As outlined in Chapter One, the core aim of the study became **'to explore the multiple practices and experiences of off-grid solar energy within the broader Nicaraguan political economic context'**. Under this aim, the following research questions were identified:

1. How has Nicaragua's electricity sector been shaped by global energy paradigms and changes in the domestic political-economic context?

2. Who are the key stakeholders involved in the promotion and deployment of off-grid solar energy technologies in Nicaragua, and what are their positions, motivations and expectations?

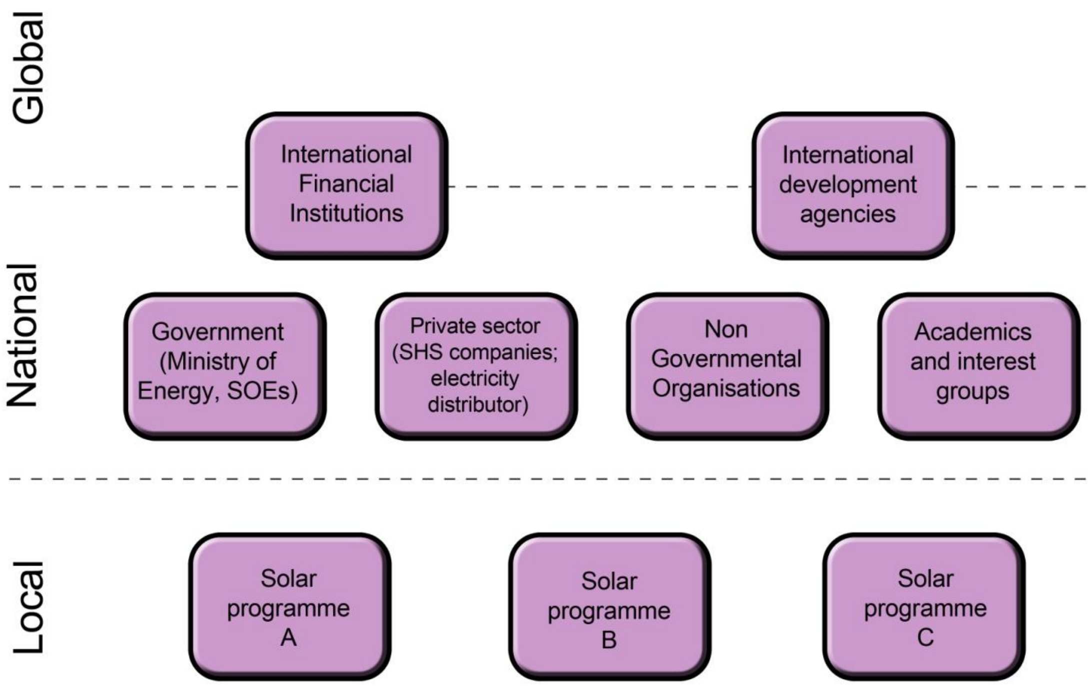
3. From the perspective of users, what are the implications of solar energy technologies?

4. What are the challenges facing solar energy interventions in Nicaragua?

This demanded a change in method; the predominant use of ethnographic tools was deemed inappropriate given the new scope and multiple levels of the research and instead, semi-structured interviews became the main tool (complemented with focus group discussions, questionnaire surveys, secondary data collection and field notes), which are discussed in sections 4.3.2 to 4.3.6. This evolution was beneficial in two key ways: firstly, it made the research more policy relevant and secondly, it lessened my reliance on fieldwork in rural areas, therefore reducing the very real possibility that I would be unable to reach communities because of adverse conditions, but also reducing the personal risks posed (the previously mentioned health problems I faced arising from spending extended periods in rural communities) (see Lee-Treweek and Linkogle, 2000 and Tomei, 2014).

The research journey was not a straightforward, linear experience, but rather one which was shaped by the practicalities, opportunities and challenges of the field; this illustrates the importance of researcher flexibility and responsiveness to difficult and evolving contexts. Having discussed the issues influencing the direction of the research, the chapter turns to examine in detail the qualitative approach and multiple methods selected.

Figure 10. Research approach: multiple scales and actors



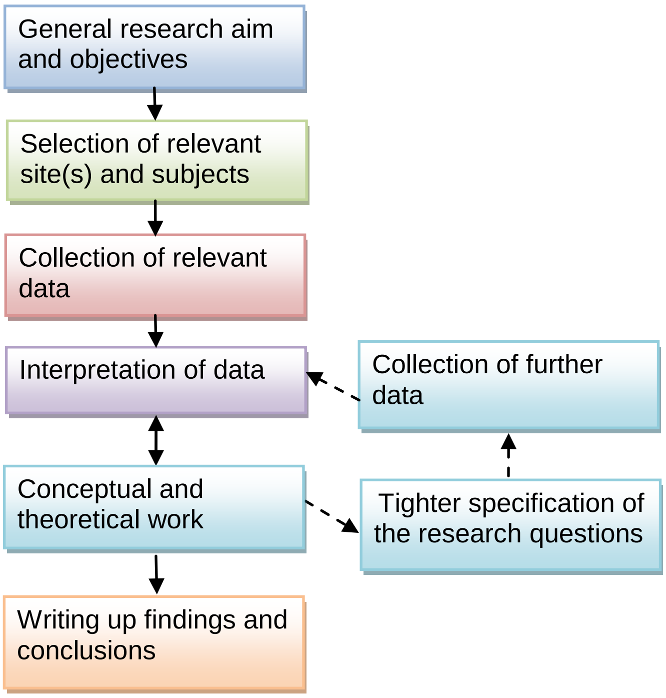
Source: author's own illustration. Note: International financial insitutions and development agencies are involved in both national and global policy processes

4.2 Research approach

As re-emphasised above, the objectives of the research are multi-scalar, incorporating analysis at different levels with a range of stakeholders. The objectives were to examine key national energy governance issues, the position that decentralised solar photovoltaic technologies occupy within this context and how the nature of the 'solar energy for development' sector has been constituted through those governance structures. A further objective was to examine the narratives of key actors involved in the delivery of SHS and the key challenges facing solar energy interventions in Nicaragua. At the local level, I sought to validate and/or challenge the views of the solar sector actors by conducting qualitative (and a small amount of quantitative) research within three contrasting case study solar programmes delivered through different financing mechanisms and institutions (Table 8). This involved spending time with individuals in remote rural communities, discussing their daily lived experiences of energy and what changes, if any, the arrival of solar energy had wrought on their lives. The research, therefore, sought to understand the motivations and positions of those implementing energy policies and designing solar energy programmes, but also the world views of those using solar energy technologies in their homes, with an emphasis on individual and household experiences, understandings and perceptions. As discussed in Chapter Two, this approach addresses knowledge gaps identified in the literature. These objectives lend themselves to mainly qualitative methodologies ‘which explore the feelings, understandings and knowledges of others’ through interviews, discussions or participant observation, to examine ‘the complexities of everyday life in order to gain a deeper insight into the processes shaping our social worlds’ (Dwyer and Limb, 2001:1).

In contrast to quantitative approaches, qualitative research is characterised by an ‘in-depth, intensive approach rather than an extensive or numerical approach’ seeking ‘subjective understanding of social reality rather than statistical description or generalisable predictions’ (Dwyer and Limb, 2001:6). An interpretivist epistemological position is central to this approach, where emphasis is placed on understanding the social world through interacting with, empathising and interpreting the actions and perceptions of its actors (Bryman, 2008; Brockington and Sullivan, 2003). This approach also tends to emphasise multiple meanings and interpretations ‘rather than seeking to impose any one dominant or correct interpretation’ (Winchester and Rofe, 2010: 8). The constructionist ontological position adopted in qualitative research approaches sees social properties as a result of interactions between individuals, rather than just phenomena ‘out there’ waiting to be found (Bryman, 2008). Qualitative methodologies, rather than testing pre-existing theories, are used to build theories from the ground up (Dwyer and Limb, 2001). This influenced the research in that findings were generated out of the data rather than testing any pre-determined hypotheses (see Figure 11).

Figure 11. The main steps involved in qualitative research



Source: adapted from Bryman (2008)

Energy studies are typically dominated by quantitative methodologies; for instance, in the area of household energy use in the Global South, research consists of large scale household surveys (e.g. Adkins et al., 2010; Bond et al., 2010; Komatsu et al., 2011a) to collect primary information relating to the types of fuels used, the time it takes for households to acquire fuels or the cost of acquiring new energy technologies. Secondary quantitative data collected from national censuses and multi-topic socio-economic household surveys are also typically analysed in energy research as they often include elements relating to household energy use (e.g. see O'Sullivan and Barnes, 2007). For Cook et al. (2005) however, a priority for future energy studies is the use of qualitative and participatory methods; they argue that these approaches are necessary to gain insights into the direct and indirect effects of electrification activities on populations. This thesis therefore aims to contribute to an increasing body of empirical work that employs qualitative methods to explore the social, cultural and political-economic aspects of energy (e.g. Sovacool et al., 2011; Wong, 2012; Sovacool, 2014), rather than its technical (quantifiable) aspects. This is not to say, however, that quantitative data has no place in this research. Indeed, elements of quantitative data were generated (e.g. in the household questionnaire survey, data relating to household energy consumption prior to the installation of the SHS were elicited) or analysed (e.g. secondary data are analysed in Chapter Three to paint a picture of the wider energy landscape of Central America) to help meet the objectives of this research. However, quantitative data were not approached in a traditional positivistic manner, but were instead used to enhance and support the primary qualitative or secondary documentary data.

As explained above, this research drew on three case study solar programmes to explore the local level implications of solar energy (Table 8). However, a 'typical' case study research approach (in which methods are replicated in each case, e.g. see Yin, 2009), was not adopted. Indeed, this would have been impossible due to the budget, time constraints and different forms of access I gained to each solar programme. For instance, my home base during the 10 months of fieldwork was Masaya, which enabled relatively easy access and multiple visits to those participating in Programme A. Access to Programme B was greatly assisted by the European development agency that funded the research on this case (providing vehicles and a research team). By contrast, Programme C was located in a highly remote part of Nicaragua (access required an entire day of travel by aeroplane, 4x4 vehicle and boat), and I only had one opportunity to conduct research on this programme during a two week period. These differing levels of access and support had implications on the methods used, the quantity and type of data produced. While it was possible to conduct in-depth qualitative interview methodologies for Programmes A and C, research on Programme B was dictated somewhat by the agency funding the research. Indeed, the scale, scope and final application of the data sought by the agency meant that a household questionnaire survey was more appropriate than the in-depth interview method conducted to examine Programmes A and C (see section 4.3.3 for more discussion). I recognise that the inclusion of Programme B into this research complicated the methodology somewhat, for instance, in how a large quantitative data set could be analysed to complement and strengthen the in-depth qualitative research. It also raises questions about using data that was collected for another purpose, and funded by a development agency with different interests in the research. Despite these limitations, I felt that the incorporation of Programme B greatly strengthened the breadth of the research – it not only provided a further case programme (located in a different part of the country, delivered through another mechanism, and via a large donor institution), but also enabled me to tackle research questions three and four with a greater evidence base.

This thesis therefore adopted multiple methods to aid data triangulation[29], improve confidence in the overall findings and provide a diverse array of evidence for a wide ranging analysis and interpretation of solar energy at different scales in the Nicaraguan context. As suggested by Schoenberger (1992: 217), 'different methods miss different things, and this is why access to a range of research strategies is useful'. The research methods selected included semi-structured interviews, focus groups, household surveys, participant observation and secondary document analysis. Table 9 illustrates the relevance of each method in tackling the research questions listed in this chapter.

Table 9. Research questions and methods

Method	Research question	Relevance
Semi-structured interviews	1;2;3;4	Interviews were the main method adopted to elicit data at multiple levels. Key actors were interviewed to draw out data relating to the Nicaraguan (solar) energy landscape. Participants in solar Programmes A and C were interviewed to elicit the lived experiences of solar energy technologies.
Focus group discussions	3;4	Focus group discussions were employed to strengthen the interviews conducted with groups of individuals participating in solar Programmes A and C.
Household surveys	3;4	Household surveys were adopted to collect data on solar Programme B. This method enabled a large data set concerning the experiences of users and the technical SHS four to five years after the programme had been initiated.
Participant observation	1;2;3;4	This method was conducted on a daily basis - in the offices of key actors, when participating in events with key actors (e.g. at the launch event of a European donor funded solar programme, a UNDP practitioners' workshop and renewables association meeting) and finally, when working closely with the organisations and actors integral to the design and delivery of solar Programmes A, B and C. This 'ubiquitous' method supported each of the research questions.
Secondary data analysis	1;2;3;4	This was a key supporting method for each of the research questions. Secondary data enabled a thorough analysis of the state of national energy governance and also enabled the identification of key actors. Previous studies on the experience of solar in Nicaragua provided important contextual information in the design and execution of research on solar Programmes A, B and C.

[29] Valentine (2005:112) states that triangulation is where researchers 'draw on many different perspectives or sources in the course of their research'. This allows the researcher to maximise their understanding of a research question, but also to verify data.

4.3 Data collection and methods

Having discussed the multi-method research approach, the chapter turns to critically examine each of the methods employed and describe the selection of research participants. This begins with a discussion of the main primary data collection methods, including semi-structured interviews, focus group discussions and questionnaire surveys. It is important to emphasise that proficiency in the Spanish language was critical in undertaking each of these methods. This enabled me to directly communicate with participants, which I found was crucial for enhancing inter-personal communication and cross-cultural understanding. However, collecting data in my second language did raise some challenges, which are addressed in detail in the following section. The final part of section 4.3 discusses the use of participant observation techniques, secondary data, field notes and diaries.

4.3.1 Semi-structured interviews

As Table 9 indicates, interviews were an important method for addressing each of the research questions. According to Kitchin and Tate (2000), interviews allow researchers to examine the 'experiences, feelings or opinions' of informants (p. 213). Valentine (2005:111) states that the emphasis of interviews is to 'understand the meanings people attribute to their lives and the processes which operate in particular social contexts'. Indeed, there is far more to an interview 'than just talking to people', rather it should be considered as 'a complex social interaction in which you are trying to learn about a person's experiences or thoughts on a particular topic' (Kitchin and Tate, 2000: 215). Interviewing was therefore considered an appropriate technique for the qualitative approach described in section 4.2; interviews were the primary method employed to elicit the perspectives of different stakeholders across different scales of governance. This included not only key actors involved in the electricity, renewables and 'development' sector at the national level (Appendix 1), but also the perspectives of solar programme participants at the local level (Appendix 2).

The selection of participants for this research was motivated by the theoretical approach adopted, as well as practical considerations, which is termed a 'purposive' sampling approach (Longhurst, 2003; Bryman, 2008). This study's focus on political-economic power structures - the decision makers, institutions and regulations at multiple scales (Moe, 2010) - required delving into the complex network of actors converging around and shaping the dissemination of solar energy technologies in Nicaragua. The full range of these actors, spanning different groups (Table 10), were therefore targeted for interview. It is important to stress that the categories listed in Table 10 are not discrete (e.g. the national renewables interest group incorporates members from each of the actor groups identified), and that the scale of each interest group is not fixed (e.g. donor organisations are engaged in both national and global policy processes). Similarly, these groups do not constitute homogenous entities, but rather can be understood to be ‘filled with internal contradictions and conflicts and cannot be regarded as either unitary or predictable structures’ (Lewis, 2003: 220, cited in Hunsberger, 2010).

Table 10. Key actor groups engaged in Nicaragua’s energy sector

Actor group	Details
NGOs	Includes NGOs directly operating solar programmes and NGOs working indirectly with solar programmes (e.g. supporting the implementation or follow-up of solar programmes executed by other bodies or working in the same communities where solar programmes operate to support users or engage with other 'development' style programmes)
Private sector	Includes private sector SHS companies and micro-finance institutions providing SHS loan products. Also includes private actors in the wider electrical subsector (e.g. private distribution company, generators, etc.)
Government	Includes government officials promoting increased electrical coverage (using decentralised solar technologies and grid extension) and working with donors on ‘energy development’ assistance programmes. Also includes the energy regulatory body
Donors	Includes IFIs and international development agencies who finance 'energy development' assistance programmes
Academics and interest groups	Includes the national RE interest group (which represents 38 members of the RE sector, including small scale renewable electricity generators, private sector RE companies, external donors, academics, etc.) and university departments, teaching RE degree courses, conducting research and promoting the use of RE. Also includes consumer defence organisations

As Valentine (2005) suggests, the aim of recruiting participants for interviews in qualitative research is not necessarily to choose a representative sample, but rather to select an illustrative one. Furthermore Patton (2002: 244) states that ‘there are no rules for sample size in qualitative inquiry’, rather than ‘the validity, meaningfulness, and insights generated from qualitative inquiry have more to do with information-richness... and the observational/analytical capacities of the researcher than with sample size’.

The key actors, for example officials at the Energy Ministry, solar companies or NGOs, were predominantly part of organisations with clearly identifiable structures, with contact details, and institutional information often available on the Internet. This combination of clear and transparent organisational structures with modern telecommunications, as Herod (1999: 315) has pointed out in other contexts, provided an excellent means of making initial contact with the organisations I was interested in studying. I was able to identify further key stakeholders through a well-connected academic contact, which helped for further engagement in academic circles, civil society and government. This was invaluable for identifying the organisations and institutions of potential interest for this research. The contact acted as a 'gatekeeper'30 (issues of accessibility and gatekeepers are discussed further in section 4.5) also providing me with legitimacy and credibility within the communities of interest or actor groups that they operated within (Table 11). Appendix 1 details the key actor or 'expert' interviewees.

As with the key national stakeholders, community-level participants were selected purposively. They were chosen on the basis of their involvement in one of the three solar programmes. Criterion sampling (i.e. picking cases that meet certain criteria) and snowball sampling (i.e. using one contact to help recruit another) are two forms of purposive sampling identified by Patton (2002) that were relevant to this research. In contrast to the actor interviews, rural householders participating in the solar programmes could not be identified through formal organisational structures; rather selection and recruitment involved visiting the case study programme locations and talking to participants in their communities or homes, and then either conducting the interview or survey that same day, or scheduling a future visit. In each case study programme, gatekeepers played a key role in facilitating my entrance into the communities and households that were participating in the solar energy programme in question.

In total, 38 participants were recruited for interview from solar programmes A and C – with the majority (31) from Programme A; this was due to the greater levels of access to these communities described in section 4.2. Programme A offered a rich cross-section of user experiences, including those of pre-adopters, current users of SHS, as well as households that did not adopt or had since abandoned SHS. The seven interviewees from programme C had been involved in the programme since its inception in 2006, however due to the devastation caused by hurricane Felix in 2007 (which damaged the solar battery charging station and destroyed many homes), had experienced intermittent use/functionality of their systems. Respondents within programmes A and C hailed from a variety of cultural and socio-economic backgrounds, as described further in sections 7.1.1.1, 7.1.1.2 and 7.1.2. When using quotes from interview I have provided details about respondents, for

[30] The individual in an organisation with the power to withhold access to people or situations for the purpose of research (Scheyvens et al., 2003).

instance, relating to their occupation/main economic activity, or the length of time they had used solar energy technology. Appendix 2 lists anonymised details of all community-level respondents.

The type of interview adopted was the semi-structured or 'interview guide' approach, one of five styles of interview identified by Kitchin and Tate (2000). This style allows for specific topics and issues to be covered which are prepared in advance of the interview, in a way that the interviewer can vary the wording and the sequence in which the questions are tackled. I considered this technique to be the most suitable for interviewing both key stakeholders and solar technology users, since according to Valentine (1997:11), it can take a 'fluid' form, where each interview can be tailored to the different interests, views and experiences of the respondents. Similar to Longhurst (2003) and Willis (2006), I found that the semi structured approach offered flexibility in the way that issues were addressed, and greater freedom for myself and respondents to explore new avenues of inquiry. It was important however to strike a balance between asking similar questions of respondents (for comparability), whilst also allowing respondents the freedom to explore other ideas and themes. For Limb and Dwyer (2001), the less rigid structure of a semi-structured interview empowers participants, as individual views and experiences can be divulged without any structural restraints; indeed, I found that this method was particularly useful at countering the asymmetrical power relations that often characterise research encounters (see section 4.5 for further discussion of power).

The semi-structured approach to interviewing was also highly appropriate because of the support it provided me as a researcher working in a second language – in this case, Spanish. Having learnt to speak Spanish during a previous study year in Spain, I had not anticipated that language would represent one of the greatest challenges during the early stages of the field research. I found that I was almost required to re-learn my Spanish, to learn the accents, vocabularies and vernaculars of different Nicaraguan actors, and to feel fluent and confident that I understood and would be able to portray as accurately as possible different voices (see Gent, 2014). While I was eventually able to communicate effectively in Spanish with research participants in the Northern and Central regions of the country, in the North Atlantic Region (where solar programme C is located), the language commonly used was *miskito* with which I was unfamiliar. For a handful of interviews (and two focus groups) I enlisted the help of a local guide to translate from *miskito* to Spanish.

The semi-structured approach is supportive to the researcher operating in a second language as it provides a partly 'scripted' guide and may therefore help to avoid the 'comedy of errors', misunderstandings, frictions and tensions that go with operating in a second language in the field (see Gade, 2001; Veeck, 2001; Watson, 2004; Crane et al., 2009). Even with an interview guide however, at times, the language presented challenges. This was especially so during the early interviews in rural communities participating in solar programmes. I remember returning from my first interviews with SHS users feeling utterly downhearted, disappointed and anxious. Having arrived with an interview guide of questions – and having what I thought was an interview schedule of grammatically correct, comprehendible and logically ordered questions - I found that my phrasing, choice of words, as well as the level of formality I had adopted, were incomprehensible to some participants. In early interviews respondents would look bewildered at my accompanying gatekeeper for clues to what I could be asking them about, who then proceeded to 'translate' my question into more appropriate words. In facing these difficulties, I decided that having the support of a dedicated field assistant for the interviews would be beneficial. Jimmy, a social anthropologist and my field assistant, came to be both a friend as well as a cultural and linguistic 'broker' at interviews. With a semi-structured interview guide and the support of Jimmy, I found that interview experiences were greatly enriched. As Bujra (2006) suggests, the presence of a research assistant - even if they cannot translate the local vernacular into English – is valuable as they may be able to offer an 'extended gloss' which facilitates a greater grasp of meaning.

Careful interview preparation was crucial for successful interviews, not only in terms of selecting the themes to be covered, but also the appropriate register. In the case of the interviews with local solar technology users, I researched the specific SHS programme and prepared a guide of questions and themes. Questions that explored household motivations to participate in solar programmes, energy usage prior to/ following the solar programme and perceptions of solar technologies were formulated, however time was also allowed for respondents to explore other pertinent issues. Similarly for the interviews with key actors, preparation involved research into the institution or individual and their role in governing energy in the national context. The semi-structured approach in this instance was particularly helpful as it demonstrated the effort that had gone into interview preparation, but also fostered a degree of formality which as Willis (2006) suggests, was viewed positively and increased engagement with the actors.

It was also important to consider the location of the interviews as evidence suggests that where interviews are held can make a difference to the data generated (Denzin, 1970). Valentine (2005) and Willis (2006), both for example, argue that interview location is highly important, and that in many cases interviewees may feel most comfortable in their own home. The majority of interviews with SHS users were, therefore, conducted in their homes. Aside from interviewee comfort, the home environment also provided important insights into my research – for example, not only did first-hand experience of participants' living conditions provide context and perspective, it also enabled participants to physically demonstrate their use of the SHS and previous fuel use practices, rather than just describe them. On some occasions, interviewees were distracted by other household members – as Willis (2006) warns may happen during home-based interviews – however, I found the interactions between household members to be really insightful, and in some cases other household members made important contributions during the interview exchange. In several cases, whole families participated, sharing and discussing their perspectives on household energy issues, which I found, enriched the whole interview experience. In the case of the actor interviews, the majority were conducted in the office of the institution. As Willis (2006:148) suggests, through meeting in the workplace and dressing appropriately, you can present yourself as a 'serious' researcher to elite actors, not out of place within their environments.

As advised by Flowerdew and Martin (2005), interviews were initiated with simple, non-threatening questions. For interviews with SHS users, these included how long the individual had lived in their community or how the user came to know about solar energy. In the case of actor interviews, factual questions related to the organisational vision, mission and objectives were used to begin the interview exchange. This created what Dunn (2010) terms the 'warm up' period, which has been found to be important to establishing rapport. More abstract and thought provoking questions were kept until later in the interview, as recommended by Longhurst (2010), creating what Dunn (2010) refers to as a 'pyramid' structure. As recommended by Flowerdew and Martin (2005) and Dunn (2010), I attempted to finish interviews on a positive note and by asking participants if they had any questions arising from the interview or additional comments. Despite following these recommendations, in practice, some of the interviews were challenging to conduct. For instance, in the case of the actors, some avoided questions or controlled the dynamic of the interview (section 5.5 discusses power relations). Indeed, some of the actors were accustomed to being interviewed, and as suggested by Marshall and Rossman (2003) and Kvale (2007), were sophisticated in managing the interview process. Schoenberger (1991: 182) highlights the risk that the respondent will 'impose his or her agenda... taking it in directions that are not directly relevant to the research or not worth lengthy elaboration'. This occurred in several of the actor interviews and required me to reorient questions, and try to steer the interview back on course. Interviews with respondents in rural communities were equally challenging. This was especially so when users were dissatisfied with the solar programme they were participating in; the interview provided the opportunity to voice a complaint or concern. The following exchange is transcribed from the first minute of an interview with a SHS user, and illustrates how a respondent avoided the question posed in order to voice his concerns about the functionality of the SHS kit:

> **DG**: OK, let's start with the start of the project, in what way did you first hear about the solar energy project?
>
> **A14**: Well this project…. This project is very good, but it has its technical problems because there is a problem in several of the houses… the gadgets are good, they work well, but some, including mine have had problems… The battery charge does not last, it runs down quickly, I mean it is OK, but we're a little unhappy because it goes down quickly, and once the lights didn't even switch on.

These interviews therefore required a balancing act between providing the respondent with a space to share their views, while also eliciting responses to the questions posed, and not generating unrealistic expectations that I might be able to address respondent problems.

The majority of interviews were recorded using a digital recorder, which was beneficial for a variety of reasons. This allowed me to concentrate completely on the interview (without having to take comprehensive notes during the interview or remembering points to write up later), and after the interview I was able to re-listen to the recording to clarify my understanding of words and phrases used by interviewees (e.g. with a Spanish-English dictionary or with my research assistant, Jimmy). Recording interviews rarely inhibited the interaction and only on one occasion did an interviewee request that I switch off the recorder. On other occasions it was not possible to record the exchange due to background noise, in which case I took extensive notes during and immediately after the interview. After interviews had finished, Jimmy and I conducted debriefs, which provided the opportunity for us to challenge each other's interpretations of the exchange. I found that this technique not only enhanced understanding, but as Heller et al. (2011) suggest, it was also a useful exercise for gaining another's perspective on issues raised. We also used this time to compare notes relating to interviewee behaviour, local surroundings and context, as well as any 'off the record' exchanges. The next stage was to transcribe the recordings; while this was an incredibly lengthy process,[31] the final transcriptions were what Minichiello et al. (1995) refer to as written reproductions of the interviews. Analysis of the transcriptions from the semi-structured interviews is discussed in section 4.7.

In summary, the semi-structured interview technique provided a flexible means of gaining in-depth accounts from both key actors integral to the governance of energy in Nicaragua and the users of technologies at the household level. Despite the challenges relating to language and interview

[31] I acknowledge the assistance and patience of Jimmy Sequeira in this task.

dynamics, my confidence in interviewing grew throughout the fieldwork period and I became more proficient at managing and negotiating the challenges discussed above.

4.3.2 Focus group discussion

An additional technique adopted to add depth to the semi-structured interviews conducted with solar technology users was the focus group discussion. Four focus group discussions were conducted with groups of individuals soon to participate, or already participating in solar programmes A and C (Table 11).

Table 12. Focus group interviews conducted

Focus group	Location	Department	Programme
1	Chiquistepe	Managua	A
2	El Rosario	Managua	A
3	El Semau	RAAN	C
4	Santa Clara	RAAN	C

Focus group discussions are a method of interviewing, therefore the challenges discussed above (relating to language, staying on topic, the location of the discussion and interview preparation) also apply to this technique. The main distinction is that the focus group involves more than one interviewee and tends to focus on a specific topic or theme in depth (Kitzinger and Barbour, 1999). The focus group discussions were less structured than the interviews, and sought to gain in-depth 'contextual' data (Wilkinson, 1999) on the communities and households within which the solar programmes were situated, or soon to be operating. Rather than asking each participant questions, I stated a broad theme or question (e.g. views on solar energy) and encouraged participants to talk to one another, exchange anecdotes and comment on each other's experiences. According to Bryman (2008) this allows participants to bring to the fore issues which they deem to be important and significant. The themes I encouraged discussion around were energy-related, however the focus group discussions revealed other topics important to the respondents, for instance, broader issues facing households and communities, such as the lack of potable water or sanitation facilities, the lack of employment opportunities or their perceived vulnerability to a changing climate. While some of these themes emerged during the semi-structured interviews, the focus group discussions provided a more unstructured and open space to expand on them. The focus group discussion therefore provided important contextual data, situating household energy issues and the use of solar energy in communities within a broader set of priorities and challenges faced by respondents. As with the semi-structured interviews, focus group discussions were digitally recorded, transcribed and analysed (as discussed in section 4.7).

4.3.3 Household questionnaire surveys

Household questionnaire surveys were conducted with SHS users participating in solar programme B, the Global Energy Development (GED) programme. Research on this case programme came from my involvement in a consulting project that was funded by the European donor agency that implemented GED. The aim of the project was to collect ex post data on the experiences of users and the technical state of solar home systems five years after GED had been initiated[32]. A questionnaire survey was used to ascertain what had taken place during the post-installation period of the programme. It did this by tracing and following up with individuals and households who had adopted SHS four to five years previously. Questions regarding user experiences, perceived impacts/benefits and satisfaction were asked, in addition to information regarding the presence of the SHS and its functionality.

This study presented an excellent opportunity to collect and analyse data on an additional solar programme, and made an invaluable contribution to the thesis. Due to the scale (sample size of 152), scope (both socio-economic and technical data were sought) and final application of the study (the donor intended to use the data to design a project to replace batteries and other components on a large scale), a repeat of the semi-structured interview method employed to investigate programmes A and C was considered inappropriate. A household questionnaire survey was therefore designed in line with the donor's objectives, which I also considered to be highly relevant to research questions three and four of this thesis. A stratified random sample technique was employed to select households according to the concentration of SHSs in communities. Households were identified through project documents held by the European donor agency and the assistance of an agricultural cooperative that participated in delivering the programme in 2006-2007. However, operationalising the stratified random sample technique in the field was challenging; it was

[32] Specific objectives established by the donor included: 1) Determine the presence and current use of SHS five years after installation 2) Conduct a technical assessment of the state of SHS and to project the number of batteries, inverters, controllers and lamps needing to be replaced in the short term; 3) Determine the technical and non-technical barriers to the sustainability of SHS; 4) Describe basic socio-economic aspects of the families benefiting from the project, their motivations to acquire SHS, their expectations of systems and available resources for the acquisition and maintenance of SHS; 5) Determine the impacts of SHS on the daily lives of families including an estimate of changes in energy costs by using solar panels; 6) Collect feedback from users on their experiences of the SHS and the programme more broadly.

discovered that some of the documentation provided by the agency was incomplete (or false)[33], and some households could not be located or reached (e.g. see Figure 8). The research team therefore took a pragmatic approach to recruiting participants – e.g. relying on the accompanying gatekeepers to guide us to additional households that participated in the programme (some of the challenges of this are considered in section 4.5 of this chapter), through talking to solar homeowners/shopkeepers, or relying on visual inspections of households with a solar panel on the roof. The questionnaire surveys were conducted from May to November 2011 across 43 communities in eight municipalities within the departments of Estelí, Madriz and Nueva Segovia (Table 12) by a team of researchers, including myself and a group of students and academics from the Universidad Centroamericana in Managua. Surveys were carried out with the household member that had chosen to participate in the SHS programme, which in most instances was identified as the male head of the household. However, similarly to the interviews discussed above, multiple household members participated in responding to the survey questions.

Table 13. Household questionnaire surveys conducted in solar programme B

Location (municipality)	Location (department)	Number of surveys
Estelí	Estelí	83
San Nicolás	Estelí	15
San Juan de Limay	Estelí	7
La Trinidad	Estelí	1
Condega	Estelí	7
Santa Rosa del Peñon	León	4
Palacagüina	Madriz	10
Jalapa	Nueva Segovia	25
Total		**152**

The questionnaire is one of the most frequently used methods for collecting data in the social sciences, as the same or similar questions can be asked in the same way and in the same sequence to a large geographically dispersed number of people. Questionnaire surveys are useful for gathering original data about people, their behaviour and social interactions, attitudes and opinions (McGuirk and O'Neill, 2005; McLafferty, 2010). Kitchin and Tate (2000) state that, in general, questionnaires seek a mix of descriptive and analytical answers, i.e. the 'what' and 'why', generating both factual and subjective data relating to people and their circumstances. The questionnaire

[33] The donor agency and institutions involved in project delivery voiced concerns about potential corruption in the delivery of SHS – a theme which is picked up again in Chapter Six.

survey incorporated both open and closed question types to elicit this type of data (see Appendix 3 for the questionnaire survey).

Closed questions have a limited number of options to choose from and may or may not be mutually exclusive of each other, responses may be numerical or involve checklists, categories or yes/no answers (McLafferty, 2010). Examples of closed questions included Q20, which asked how much had been paid for the SHS (numerical value) and Q14 which asked for the year in which the panel was purchased (2006 or 2007). The survey was pre-coded (e.g. 'Yes' was coded by a 1 and 'No' by a 2), so that responses to closed questions could be easily inputted into the statistical analysis software, SPSS (statistical package for the social sciences). Open questions were also employed to yield in-depth and less structured responses, 'inviting respondents to recount understandings, experiences or opinions…' (McGuirk and O'Neill, 2005: 152). Open questions sought the opinions and recommendations of the users, for instance Q70 and Q71 asked respondents to elaborate on the benefits and disadvantages of their participation in the SHS programme. Open questions provided valuable and unanticipated responses that 'brought to life' the controlled responses deriving from closed questions.

Having decided the question types, it was then important to consider question language, wording and sequencing; indeed Parfitt (2005) suggests that getting this right helps to ensure the flow of questionnaires, which is arguably crucial to reducing response biases. The questionnaire was originally constructed in English, then translated into Spanish, and checked by native Spanish speakers for accuracy and appropriate vernacular. Questions were carefully worded, heeding the advice of De Vaus (1996: 83) who suggests a sixteen question checklist to ensure the clear wording of questions, ranging from 'is the language simple?' to 'does the question artificially create opinions?'. Similar to the sequencing of the semi-structured interviews discussed above, Simon (2006) recommends beginning with the most basic and un-contentious information, leaving the more controversial or subjective questions towards the end of the questionnaire. This advice was duly noted – the survey began with relatively short and factual questions (e.g. Q14: in which year did you purchase the SHS?), concluding with relatively open-ended questions (e.g. Q72: what advice would you, as a beneficiary of the project, give to the organisation to improve future phases of the project?) which explored respondent ideas, opinions and perceptions. Questions were grouped thematically and connected by introductory statements to be read aloud by the interviewer (e.g. Section VIII. Changes in daily routine, family life and community as a result of using the SHS – 'Now let's talk about the changes that you and your household have experienced at home and in the community as a result of using the SHS') which added greater coherence to the survey.

Several field visits were made prior to executing the full survey, to 'road test' its robustness and identify any problems, ambiguities or interpretational difficulties. The initial visits also enabled me to find out more about the programme, how it had been implemented and the context of the communities where it had been active. The pilot phase revealed that the surveys took over one hour to complete, and that this resulted in participants becoming less engaged in the survey, a consequence of which is described by Parfitt (2005) as fatigue bias. This phase also identified problems related to the clarity of written instructions for interviewers (e.g. stating how many options could be selected by the respondent) and also highlighted the need for extra blank pages for notes, giving the interviewer the flexibility to add extra observations. Piloting was a vital step in the questionnaire design process, helping to improve the overall quality of the survey instrument; however it did not identify every issue. For example, when conducting the full survey, we found that some participants struggled with questions relating to their energy use prior to the installation of the SHS (see Section VII of the survey, Appendix 3). For example, some participants were unable to remember the cost of fuels, but could recall quantities and vice versa. In order to overcome this issue it was decided that the interviewer should ask for as much information as possible about previous fuel usage. In the analysis stage this data was triangulated with data on historical fuel prices from the Nicaraguan Central Bank, and standardised fuel costs were calculated for the period in question. New variables were then created with estimated figures of each household's expenditure on fuels prior to the SHS installation.

For such challenging questions it was particularly helpful that the survey was conducted face-to-face,[34] as the interviewer could clarify questions and assist the respondent. The presence of the interviewer was also extremely beneficial when asking open-ended questions, as the interviewer could probe for further detail. However, there is the danger of responses being affected by 'social desirability considerations' as De Vaus (1996:110) cautions, wherein respondents may feel pressure to respond in an 'acceptable' way – an issue also common to interviews. We suspected that some of the responses may have been influenced in this way. Despite our efforts to distance ourselves and the research from the donor organisation sponsoring it, in the minds of respondents, we were associated with the donor, which may have altered the information provided to us. Did our association with the donor organisation create expectations of new projects, or equipment, and

[34] McLafferty (2010) describes different strategies for conducting questionnaire surveys, including those which involve an interviewer (e.g. face-to-face surveys) and those which are self-administered (e.g. internet survey). Due to the nature of the sample (i.e. households in remote areas predominantly without access to the internet or telephone reception), face-to-face interviews were necessary to complete the surveys.

therefore alter responses?[35] For instance, the question relating to household income proved to be particularly problematic. Some participants struggled to answer the question, others avoided the question, while others may have provided false responses.

As highlighted earlier, the questionnaire data was analysed using SPSS software. SPSS was the most useful software tool for exploring the household questionnaire data, used to examine solar Programme B. Questionnaire data were entered into the SPSS spread sheet coded values (e.g. 'Yes' was coded by a 1 and 'No' by a 2). By pre-coding questionnaire answers (as discussed earlier) data input was made easier. This study made use of descriptive statistics and cross-tabulations.

The household questionnaire surveys were a suitable method for eliciting a large data set on the technical and socio-economic aspects of a SHS programme five years after its implementation. It generated policy relevant material for the donor agency (who were then able to estimate how many batteries, inverters or charge controllers required replacement amongst the SHS kits installed in the region), and provided me with further data to enhance and support the interview and focus group data collected from participants in solar programmes A and C. As well as the large number of participants we were able to cover through the survey, I found that the highly structured nature of the exchange overcame some of the communicational difficulties I faced when conducting semi structured interviews, as discussed above.

4.3.4 Participant observation

The participant observation method supported each of the research questions. Laurier (2003), whilst describing participant observation as 'ubiquitous', with no prescribed template for realising the observation, suggests that the production of structured commentaries is a useful tool. This method was conducted on a daily basis (recording observations in field notes, see section 4.3.6) - while I was in the offices of key actors, or participating in events organised by them (e.g. at a launch event of a European donor funded solar programme, a UNDP sponsored energy practitioners' workshop or a national renewables association meeting) and finally, when working closely with the organisations and actors integral to the design and delivery of solar Programmes A, B and C. This method provided a vital source of primary evidence, and was crucial to understanding the constituents, structure and mechanics of Nicaraguan energy governance.

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[35] This was a theme discussed at length at the Micro Perspectives on Decentralized Energy Supply conference (2013), Technische Universität Berlin, February 28th – March 1st, 2013. Participants questioned whether the practice of researchers entering the field to discuss energy access with unserved or marginalised populations, generated expectations.

Participant observation was particularly important in the case of research on Project Solar. During the first two months of field research, I was based in the office of the NGO implementing this project. This period was highly instructive – I experienced how this NGO operated on a day-to-day basis, including their engagement with rural populations in which Project Solar (and other rural development programmes) were operational, but also the administrative side of their work, for example, applying for project funds, entertaining potential donors, or preparing newsletters/feedback for project donors (these were all activities in which I participated). This experience was highly insightful; I learnt a great deal about the pressures facing such organisations (for instance, the need to generate funds) and the way that donors supporting the work of NGOs operate. During my stint in the office, one donor organisation approached the NGO, suggesting that they apply to them for funds to finance a new solar energy project. After a considerable amount of resources were dedicated to elaborating the proposal, the application was ultimately unsuccessful because the donor felt that the populations targeted by the proposed project were 'not poor enough'. This experience provided a fascinating insight into the way that solar energy interventions are designed – including the underlying assumptions made by organisations about the technology, the 'beneficiaries', etc., but also the political economies of donor institutions and the types of interventions that 'sell well' (this is a major theme discussed in Chapters Five and Six). I also came to appreciate the difficulties that organisations face when working in remote and rural areas, for instance, the expense and travel/access difficulties (see Figure 8).

Participant observation was also an important method when researching the communities and populations within which solar energy interventions 'hit the ground'. This was especially so when researching Project Solar. For reasons explained earlier, I spent most time with the participants of this project, and in three concentrated *caseríos* (settlements) specifically, where a handful of SHS had already been established, and more SHS were due to be installed. Outside of these *caseríos,* participant observation was more difficult to conduct due to the more dispersed nature of households (also in the case of the GED programme). This method provided important insights that would not necessarily have been revealed simply through interviews or questionnaire surveys. For instance, in one *caserío,* I spent time visiting, talking and accompanying people in their daily tasks. Through these activities, I got to grips with some of the broader challenges facing this community (relating to political consciousness, access to other basic services and land) and I gleaned an idea about how rural Nicaraguan households 'work' (i.e. livelihoods, the household division of labour, etc.).

4.3.5 Use of secondary sources

The collection and analysis of secondary data has been an important thread to this research, not only aiding the contextualisation of the primary research, but also enabling me to position this research amongst broader literatures (Clark, 2005). Secondary sources have been collected and analysed throughout the trajectory of this research. Data unavailable in the UK or online, such as the publications and internal reports of international and national institutions, were collected throughout the fieldwork period from the offices of individual institutions and university libraries.

A vital source of secondary data was the United Nations Economic Commission for Latin America and the Caribbean (CEPAL); annual reports dating back to 1990 present information on the electrical subsectors of Central American countries, and are widely available online. CEPAL publications provide information relating to the energy policies, energy mixes and electrical coverage levels. All of these data were invaluable for making comparisons between each of the Central American countries over time, and for highlighting Nicaragua as a particularly fascinating and relevant site for empirical work (as utilised extensively in Chapter Three).

Secondary data sources were particularly crucial for responding to research question one. Historical and contemporary documentary evidence was required to examine the evolution of national energy governance arrangements in Nicaragua (see Chapter Five). However, I found that historical data on the Nicaraguan energy sector was particularly difficult to source. In attempting to obtain good quality secondary sources, a leading energy academic explained that much of the public data on the electricity sector produced prior to 1979 had been destroyed during the revolutionary struggles.[36] This meant that there were a limited number of sources through which governance issues could be examined. As well as the issue of data paucity, sourcing good quality data was also problematic; indeed as Clark (2005) states, it is important to acknowledge that secondary data is a 'cultural artefact', produced for administrators and organisations with different priorities and ways of seeing the world. I attempted to overcome these challenges by drawing on as many secondary sources as possible and cross-checking the data with the expert actors I interviewed. For instance, an interview conducted with a former official of the state electricity company (expert interviewee 31), was particularly useful for triangulating and examining the validity of the secondary data sourced.

In terms of more contemporary secondary data sources, development bank websites provided a valuable mine of information. As Chapter Two highlighted, such institutions are key actors in the

[36] Personal communication with academic at the Universidad Centroamericana, Managua, April 2012

global energy arena, and their policies are influential at multiple scales of energy governance. Data widely available online relating to IFI funding priorities, lending portfolios and energy programme documentation were therefore crucial for examining the ways in which the Nicaraguan energy sector was shaped by wider shifts in the global energy arena. Examining how other donors and civil society actors framed and financed Nicaragua's 'energy problem' was also crucial to address research question one; grey literature, country reports and studies were therefore sourced and analysed. In terms of the national level, political and economic factors that shaped Nicaragua's energy sector, internal reports from the Ministry of Energy and Mines, renewable energy companies, NGOs or consulting firms, as well as national newspaper articles and blog entries[37], were drawn on to support analysis on contemporary shifts in Nicaragua's energy sector.

While secondary data sources were primarily relevant for addressing research question one, there were also secondary sources available to support objectives two, three and four. For instance, some of the key actors' selected for interview were identified through institutional websites. In terms of addressing research questions three and four, other field studies conducted on Nicaraguan solar energy programmes provided important contextual information for planning the in-depth research on the solar programmes highlighted in Table 8 (e.g. Findlay, 2006).[38]

4.3.6 Field notes and diaries

During the fieldwork I made field notes, which were essential to record day to day events, descriptions and observations, which proved to be valuable sources of primary data. Indeed, Patton (2002) suggests that the researcher's own experiences and observations are part of the data in qualitative inquiry. The notes also provided a record of how the research changed during the fieldwork (as detailed in section 4.1). Similar to Storey (1997; cited in Scheyvens et al., 2003) who describes an 'evolving think pad' for research design and methodology, I found that taking field notes was invaluable for linking ideas and refining my research questions.

Throughout the research I also kept a field diary and online travel blog[39]. I was able to use the field diary to record and reflect upon the research process – the difficulties and frustrations I faced (and the ways in which I coped with them) but also the positives and achievements. Indeed as England

[37] For instance, the Nicaragua Dispatch (http://www.nicaraguadispatch.com/) is an English-language news publication on Nicaragua, and regularly features energy-related content.

[38] Wellbrock (2010) and UCA (2010) are examples of unpublished field studies on SHS programmes in the Nicaraguan context

[39] Travel blog, written to record experiences and to communicate with family and friends. Available at: http://daniandmatt-centralamerica.blogspot.co.uk

comments, 'the researcher cannot neatly tuck away the personal behind the professional, because fieldwork is personal' (1994: 85). Self-reflexivity and awareness of one's own positionality is therefore critical to the conduct of fieldwork. In recognising our positionality, for example our race, gender, class experiences, levels of education or age, it is possible to see how these have a bearing upon who we are and how we conduct our research; the researcher's 'biography' will directly affect fieldwork (England, 1994). As Skelton (2001:89) comments: 'we are amalgams of our experiences and these will play different roles at different times'. The field diary, therefore, served as an important tool for reflecting on these issues in the field. As Punch (2012:93) suggests, using a field diary 'may enhance the awareness of the ways in which the self and the personal affect both the research process and outcomes'.

4.4 Reflections on 'development fieldwork': power, positionality and ethical practice

Moving on from a consideration of the different methods employed in this research, the following three sections of the chapter turn to examine some of the challenges faced not only during the fieldwork phase, but also returning home and 'writing the field'. This section in particular considers issues of power, positionality and the ethics of research in developing world contexts.

Murray and Overton (2003: 18) state that for a developed-world researcher in the developing world, research is different than in the developed world for a number of reasons: it takes place in localities, cultures and languages unfamiliar to the researcher, but also in a discrete time period where ordinarily little opportunity exists for the researcher to return. Sidaway (1992) further argues that for developed-world geographers travelling to the developing world, overseas fieldwork is more than just physical displacement and quite often researchers enter the 'local' society further up the social hierarchy than in their respective position at 'home'. As a result of these inherent power gradients, Scheyvens et al. (2003: 139) argue that 'fieldwork in the Third World can give rise to a plethora of ethical dilemmas'.

England (1994: 85) regards exploitation and betrayal as 'endemic' to fieldwork, where the researched might actually be exposed to risk. Sidaway (1992) discusses geography's dark history as the science of colonialism, and questions the extent to which fieldwork practices reinforce these relations. Field researchers periodically or permanently leave the 'field' in order to analyse and write about it (Katz, 1994), and often the results of studies are not repatriated (Sidaway, 1992). Are research practices in such contexts therefore exploitative or a one way extraction of knowledge? Such questions have urged Northern researchers to reflect on their actions in the field, leading to a so-called 'crisis of legitimacy' (Scheyvens and Storey, 2003). Despite these criticisms regarding power gradients and potential exploitative tendencies, I agree with James Sidaway who argues that fieldwork can help to counter universalistic and ethnocentric views of 'other' cultures and societies (Sidaway, 1992), and can also allow for greater understanding of social and cultural lives, through discovering phenomena that would otherwise remain invisible (Gupta and Ferguson, 1997:37).

The preceding paragraphs revolve around concerns about the power gradients inherent in circumstances when relatively privileged Northern researchers travel to the Global South to study people living in poverty. Research in the Global South however can also be undertaken with the elite and powerful. Scheyvens et al. (2003) identify a large gap in the literature that investigates elite actors in the Global South, and argue that the main focus of methodological writings is on scenarios where the researcher is in a relatively privileged position, holding more power than the researched. In the case of my fieldwork, research comprised of research across very different 'worlds' in Nicaragua; for instance, commenting on my experiences whilst in the field I wrote:

> 'All the while I feel I'm living a double life – on week days I get to grips with rural people living in extremely difficult and impoverished conditions, interspersed by meetings with key decision makers in air conditioned offices in Managua, and when I get a day off, I take advantage of being in a beautiful country half way across the world.... there really are many different 'worlds' to Nicaragua' [11th February, 2011].[40]

The above excerpt from my field diary describes the challenge of experiencing different realities which were geographically close, yet socially disparate. At times, I found the very different 'worlds' of Nicaragua difficult to negotiate. The objectives of the research, to create layers of analysis at different scales of governance, however inevitably involved spending time in Managua with key stakeholders in the energy sector, who may be considered 'elites'[41], but also with 'non-elite' informants in off-grid and remote areas. This reality had important implications on the power dynamics of different research encounters and the data produced. Being conscious of aspects of my positionality – e.g. being white, female, British, Anglophone, relatively young and carrying out research in one of the least 'developed' nations of Latin America – and recognising how these played different roles across the different spheres of my research was crucial. As Valentine (2005) urges, researchers must be aware of their relatively privileged positions and that research in the developing world is ultimately embedded within the context of colonialism; this is something I felt very aware of

[40] 'A long awaited update (Jan-Feb)', available at: http://daniandmatt-centralamerica.blogspot.co.uk/2011_02_01_archive.html

[41] Herod (1999:313) describes 'foreign elites' as 'foreign nationals who hold positions of power within organisations such as corporations, governments'.

during my fieldwork and the potential power that this afforded me in research encounters. For Skelton (2001:93) each interview she conducted was a 'negotiation', where different facets of positionality and power (both her own and that of her informants) came into play. The following paragraphs consider these issues within the different 'worlds' in which this research was situated, as Cormode and Hughes (1999:299) state: 'the characteristics of those studied, the power relations between them and the researcher and the politics of the research process differ considerably between elite and non-elite research'.

Mais (2009) commenting on his doctoral research in Nicaragua, considered that his 'whiteness' dominated his identity. My experience very much echoed this and I came to realise that being white carried significant meaning in Nicaragua, for example, I was frequently referred to as *'gringa'* (foreigner/Yankee) or '*chela*' (white person). For the research I conducted with key actors in the energy sector, my identity as a white, European, female may have placed me in a privileged position, potentially presenting greater opportunities for engagement with powerful actors in Nicaraguan society. The power gradients I had experienced in past research interviewing such actors in the UK were not so accentuated when accessing key actors in Nicaragua (see Gent, 2009). McDowell (1992) explores how the researcher is frequently in a less powerful position, because time and expertise are requested from the actor, and have little to offer in return. In this study however, I found it relatively easy to access key actors and decision makers. For instance, making appointments with officials via email would often receive positive and prompt replies, with interviews offered within short time frames. I discussed this at length with a Nicaraguan friend who argued that he, as a 'non-white', native Nicaraguan would not have been granted the same access. I concluded that my identity granted benefits and privileges in accessing research participants.

The conduct of semi-structured interviews with key actors ran very smoothly - the concept of my research was well understood and in most cases elicited great interest from informants. We shared a common language – that of sustainable energy, but also understandings of SHS programmes and electricity. We also shared certain aspects of our biographies; this included racial, class and educational backgrounds, which I would argue facilitated personal rapport with interviewees (see also Mais, 2009 and Oglesby, 2010), potentially granting me a temporary 'insider' position (e.g. Mullings, 1999).

In other ways, I was perceived as an 'outsider', for example, some informants went to great lengths to provide detailed answers to questions and provide me with documents, to bridge the perceived cultural and knowledge gap between us. Herod (1999) found when interviewing foreign elites, that his 'outsider' position afforded him a warmer reception than if he had been a local researcher. Having travelled thousands of miles to conduct interviews, Herod found that his research was taken very seriously, and that often his status granted him 'neutrality' and 'objectivity' which sometimes resulted in elites being more open and honest (ibid: 322).

Both Herod (1999) and Mullings (1999) argue that the binary labels of 'insider' or 'outsider' in the research encounter are problematic however; arguably researchers experience different degrees of 'outsiderness'. In my own interviews with key actors my insider/outsider position would shift. Interview icebreakers and small talk would usually comprise of the respondent asking about my nationality, my first language, how far away I lived from Nicaragua - in other words emphasising my difference or 'outsiderness'. In some interviews however, I was reminded of our 'sameness' (as relatively privileged urban dwellers, sharing common aspects of our biographies), contrasting with rural sectors of Nicaraguan society:

> 'For me and you....from the moment we opened our eyes, we saw electric lighting in the hospital we were born, but these people [in remote populations], no. They don't know this... they have never had this access' [Expert interviewee 22, government official, rural electrification department, Ministry of Energy and Mines]

In the other 'world' of my research I was acutely aware of my accentuated 'outsider' position, frequently being the only white foreigner in the remote and rural locations of my fieldwork. For some researchers this degree of 'outsiderness' presented signficiant risks in remote fieldwork locations (see Tomei, 2014). As well as potential risks, I consider that this status granted certain privileges in accessing research participants. Howard (1994; cited in Valentine, 2005) for example discusses the perceived power and superiority of white Anglophones, which may result in potential respondents feeling obliged to participate in research. For Valentine (2005:125) 'the cultural and economic power of first world countries casts a shadow over relationships between North American and European researchers working with interviewees in Third World countries'. I remained aware of this potentially unequal power relation and worked hard at countering it, not only during the recruitment of participants, but also throughout the execution of the methods. I made potential participants aware of their right to refuse or to withdraw from the research and I was also transparent about the purpose of the study and what exactly participation entailed. Secondly whilst conducting interviews and surveys, I adopted the position of 'supplicant', which England (1994) describes as the researcher explicitly acknowledging reliance on the research subject to provide insight into particular issues. Making it clear to respondents that I respected them as the experts from whom I wished to learn, I attempted to disassociate myself from any potentially asymmetrical power relationship.

In contrast to the key actor interviews, I found interviewing at the local level much more challenging. Part of this was due to initial communicational difficulties I experienced, which are discussed in section 4.3.1, but I also think that my enhanced 'outsider' position, lack of shared biography with participants, our different ways of understanding the world and concepts like 'research' also played a role in this. Gade (2001) cites the example of his research in predominantly non-literate populations, where participants did not grasp the sentiment of his interrogations; he found that in the Andes, anyone wearing boots and carrying a map was referred to as '*ingeniero*' (engineer) - the notion of 'research' or 'researcher' was not comprehended. I encountered similar challenges in presenting myself and my research to remote communities without previous experience of foreign researchers - I, the '*gringa'* '*investigadora'* (researcher) was at times perceived as a *'cooperante'* (aid worker). Despite emphasising my aim as a researcher, the view - that I may have 'friends' who could assist the community in getting 'projects' to improve their standard of living – was pervasive. This could have profound implications on the data I produced, but also from an ethical perspective, it led me to question my presence in such remote and relatively marginalised communities. Similar to Patai (1991: 141), who encountered the 'unease of being a well-fed woman briefly crossing paths with an ill-fed and generous and poor woman whose life I was doing nothing to improve', I questioned why I was researching rather than practically engaging with communities to face their perceived challenges?

The issue of researchers contributing or 'giving back' to participants is something well cited in the literature (e.g. Scheyvens and Storey, 2003; Binns, 2006; Brydon, 2006). To overcome this ethical tension, I attempted to give something back, albeit indirectly, through disseminating results and making recommendations to the organisations I worked with. Since my field research, the NGO supporting solar programme A has conducted an evaluation of its operations and has taken on board my suggestions to improve user experience. With the data generated from the household questionnaire surveys, the donor agency responsible for solar programme B was able to arrange a mass component replacement with SHS providers – users were therefore able to access components at reduced cost and increased convenience. In addition to the data being relevant for improving the solar programmes, I also helped to write a funding bid for the NGO that I worked very closely with.

This section of the chapter has discussed the issues of power and positionality and how these were important at different times across the different 'worlds' of my research. These issues all have ethical implications. Attempting to reverse potential power gradients, rather than exploit them, was integral to my ethical conduct as a researcher. This involved adopting the position of supplicant, being transparent and sensitive to concerns regarding harm, consent, privacy and confidentiality (e.g. Hay, 2003). Ethical considerations are not a one-off event, limited to the ethical checklist I completed to comply with institutional requirements, but rather a process of constant negotiation that was continually addressed as the research evolved. Unexpected issues inevitably arise in the field and across the different research 'worlds', but must be negotiated with sensitivity to local contexts and without causing harm to participants or to ourselves. As Hay and Israel (2006: 142) argue, a commitment to theoretically informed, self-critical conduct, revolving around awareness of how to identify and resolve ethical dilemmas when they arise, is required from researchers. Ethical considerations must therefore be taken into account throughout the research process - from the recruitment of participants to the execution of the research methods (as discussed in this section) - to writing and the dissemination of results, a discussion of which forms the focus of section 4.8.

4.5 The challenges of working with gatekeepers

As discussed in the previous section, access to institutions and key decision makers was relatively uncomplicated, aided potentially by my position as a 'white' outsider. Accessing rural communities for the local level research on the other hand, required permission and local knowledge to reach the most remote of households. Communities outside of the national electricity grid are by nature remote and difficult to access, typically with highly dispersed settlements, rather than concentrated villages. To ensure that I was able to reach potential participants – and ensure my personal safety - I was reliant on the support of the organisations implementing the solar programmes (in terms of indicating the location of participant households and providing introductions). These organisations therefore served as 'gatekeepers' to the research communities. This was mostly unproblematic, however, I did experience some tensions when examining one of the solar programmes; not only did I feel that my research was being 'micro-managed' by the organisation (Mercer, 2006a cautions researchers about this), but that I was also being directed towards the programme's success stories. I soon realised that my gatekeeper was taking me to the programme's 'show homes' - those frequented by programme sponsors and the UK ambassador to Central America.

Indeed, Willis (2006) suggests that relationships with gatekeepers are often problematic as researchers may be guided (not always intentionally) towards particular individuals that they deem to be suitable or representative. The outcome of this is that certain groups or sectors of the community are excluded from research (Valentine, 1997). Once I had been introduced to several more participant households, I attempted to remain independent from the organisation in my day to day activities. Through establishing contacts within communities participating in the SHS programme, I initiated a snowballing process to recruit further participants. This strategy helped to reduce bias in the selection of participants.

It is also important to consider that the presence of a gatekeeper may affect the research interview or survey; Willis (2006) for example suggests that participants introduced by a gatekeeper may feel obliged to cooperate with a researcher. If respondents do agree to take part, it is important to recognise and mitigate the influence that gatekeepers may have on interview/survey responses. When examining solar programme B for example, I was accompanied during survey work by members of local cooperative organisations, which had helped to implement the programme, and had extensive knowledge of both the programme and the locales it was introduced to. One of the survey questions asked users to rate their experience of the programme and make recommendations for future improvements. Participants may have experienced some unease in sharing their true thoughts on the programme due to the presence of local cooperative members. To address this, we attempted to conduct the survey in private, so that the person being interviewed did not feel pressured to give a particular response. We also emphasised our neutrality as researchers and attempted to gain confidence from the participant that their responses would be anonymised (e.g. Overton and van Diermen, 2003).

4.6 From data analysis to writing and representing the field

Analysing and interpreting 'diverse types of materials, from diverse people, on diverse occasions' (Crang, 1997: 220) is a daunting part of the research process. In the case of this thesis, the analysis and interpretation of qualitative data was made more complex by the fact that the methods were conducted in Spanish, whereas the final thesis would be presented in English. Crane et al. (2009) argue that there is limited literature available for geographers on how second language data analysis and native language presentation should be negotiated. Amongst the limited literature, Smith (2003) advises that transcripts be kept in their original source language, and only excerpts be translated for the purposes of writing. This advice was put into practice and it helped me to analyse interview data with regard to the cultural context in which it was constructed - a process termed 'transculturation' (Twyman et al., 1999: 321).

'Coding' of the original transcripts was the procedure used for conceptually organising qualitative material (Crang, 2001). According to Cope (2005), the purposes of coding are data reduction, organisation, exploration, analysis and theory building. Emerging as a central process in grounded theory, Bryman (2001) suggests that coding is a continual process, where codes are made and remade as part of an iterative approach to data interpretation. Indeed coding encourages a thorough analysis of data and is intended to make analysis systematic, gradually building interpretation through a series of stages (Jackson, 2001). Bryman (2001) argues that there is no correct way of coding, rather, codes are 'creative', and rely on the researcher making sense of material and using knowledge acquired during the research process (Crang, 1997).

Transcripts from interviews and focus groups, and some secondary sources and notes were inputted into the computer assisted qualitative data analysis software (CAQDAS) NVivo9, which assisted me in the coding process. CAQDAS is increasingly used in qualitative research analysis (Peace and van Hoven, 2005); NVivo9 for example provides a flexible means to thematically code transcriptions, while also maintaining the original transcripts. While I found NVivo9 to be a very helpful tool for data management, I found that I was generating large quantities of codes, which was unhelpful for organising the data. Ultimately I used the software to create what Cope (2005) terms 'category labels' or 'initial' broad codes. I then printed out the codes and employed a manual 'highlighter pen' method to further develop interpretive and analytic codes. With codes being made and remade, I worked towards developing a coding structure, where I clustered codes with common issues or content. Once formed, the coding structure, or 'codebook' (Cope, 2005) was re-examined by revisiting the transcriptions to identify any connections or themes that had been missed. This coding structure eventually became the outline of the following empirical chapters.

In writing, I attempted to construct what Crang (2001:230) describes a 'collage' or 'dialogue', incorporating both the voices of participants – and their often differing positions – but also my own theoretical ideas and contextual readings. Creating this is a process fraught with dilemmas however. The researcher is in a powerful position when it comes to writing and representing, as Linkogle (2000:144) reflects: 'Outside the context of the fieldwork I had the power to determine not only how participants were represented to the outside world, but if they were represented at all'.

Linkogle's quote nicely captures the ethical dilemma of representation, something which Smith (1996) suggests is further complicated once foreign language and translation are involved. This quandary does not apply exclusively to researchers working in their second language however, but to all qualitative researchers, who, through their writing must choose whose voices, how, and to whom they are represented (see Bennett and Shurmer-Smith, 2001; Crang, 2001; Ley and Mountz, 2001). The researcher is in a powerful position as they play the part of 'mediator' between languages (Smith, 1996), but also 'transport people's spoken words, which are lively and used in everyday lives, into academic text' (Kim, 2012: 138). Kim refers to this as a 'dual transformation' – one not only of translation (into the home language), but also one of authorisation (into academic prose), where researchers face the ethical dilemma of choosing how to deliver others' words to perceived audiences (ibid, 2012).

According to Temple (2005), the act of translation is a process fraught with political and ethical difficulties. Translation is often presented as a *fait accompli* (Frenk, 1995; see also Müller, 2007 and Temple, ibid), which conceals the difficulties of the translation process and its assumed neutrality. Indeed the translating researcher faces enormous difficulties, due to the 'inadequation of one tongue to another' (Derrida, 1991: 244) and that 'any translation always seems to be a reduced and distorted representation of other social texts and practices' (Smith, 1996: 162). Recognising that it is impossible to reveal the 'truth' of the 'other' in the 'home' language (Smith, 1999), I followed the advice of Hassink (2007), who pleads for 'fewer translations: don't translate the untranslatable!' (p. 1286), suggesting that authors should use glossaries to paraphrase key terms in the native language. Maintaining source language expressions, as 'markers of difference' in the home language text, otherwise known as the 'holus bolus' technique, serves to 'problematise the fixation of meaning through translation and draw attention to the contingency of meaning' (Müller, 2007: 210; see also Meyer and Maldonado-Alvarado, 2010).

This section has examined some of the difficulties and dilemmas faced in organising, analysing and representing qualitative data. This is ultimately a difficult task, and as Ley and Mountz (2001:235) suggest, it is important for the qualitative researcher to recognise their 'value-ladenness' with different positionalities 'which shape our capacity to 'tell the story of others'.

4.7 Conclusion

This chapter has outlined the research design of this study. As asserted by England (1994), research is a process, not just a product, and it was therefore important for me to evaluate and reflect critically upon the process of actually 'doing' the research. The chapter has discussed the non-linear nature of this research which was shaped by the practicalities, opportunities and challenges of the field, highlighting the importance of researcher flexibility and responsiveness to difficult and evolving contexts. The 'research journey' influenced the predominantly qualitative multiple-method approach to the thesis. Research methods were systematically and rigorously conducted to collect data from semi-structured interviews, focus group discussions, household questionnaire surveys, participant observation, secondary data and field notes. Computer software aided the analysis of both the quantitative and qualitative data collected in this study. This chapter has also emphasised the challenges posed by the research in terms of ethical considerations, power, access to research participants and the complexities of representing participant voices.

The following three chapters present the empirical findings that resulted from the application of this research methodology.

Chapter Five. Nicaraguan Energy Governance

This chapter responds to research question one: 'how has Nicaragua's electricity sector been shaped by global energy paradigms and changes in the domestic political economic context?' and presents a detailed examination of the complex state of energy governance in Nicaragua. It pays particular attention to how energy policies have been shaped by changing global energy paradigms and national political-economies. Energy has been largely absent from accounts of Nicaragua's economic development; this chapter therefore aims to address this gap through embedding analysis within broader global energy debates.

This chapter charts the evolution of Nicaragua's electricity sector, examining how different actors, governments and policies have converged to shape a path which, until recently saw Nicaragua faced with Central America's most vulnerable energy sector. The sector was characterised by high dependency on fossil fuels for electricity generation, soaring electricity prices, deep consumer mistrust, inequitable distribution and a reform process which was widely considered to have failed.

The return of Daniel Ortega to the presidency in 2007 marked the beginnings of sector transformation, whereby the new FSLN government took strong measures to halt the energy crisis of 2006-7. The government guaranteed financial stability to a failing electricity distributor and created the conditions to begin reversing the country's hydrocarbon-based electricity generation matrix, while also championing universal electricity access. This is reflective of Goldthau's (2012) observation that over recent years societies have been embracing more interventionist models in energy system governance, driven by the complexity of current energy challenges (as discussed in Chapters Two and Three). The recent prioritisation of energy as a key developmental concern for Nicaragua is demonstrated not only in strong government intervention, but also by the growing focus of international donors and regional development bank activities in solving Nicaragua's 'energy problem'.

In recent years a significant number of programmes have emerged to strengthen distribution activities and expand grid access, but also to engage with the unserved, off-grid populations of Nicaragua, which have arguably been omitted from past energy policy considerations. Whilst these activities suggest a clear shift from the dire situation witnessed during the energy crisis of the previous decade, observers have expressed concerns over 'good governance' and populist policies.

The extent to which the ambitious sector transformation envisaged in the government's plans will constitute a veritable 'renewable energy revolution' remains to be seen. A detailed examination of this national context prepares the ground for profiling the emergence and propagation of small scale decentralised applications of solar energy. The perspectives of key actors integral to the governance of Nicaragua's electricity sector (outlined in Chapter Four) are drawn upon.

This chapter is structured as follows: section 5.1 provides an historical analysis of the Nicaraguan electricity sector. It traces electricity sector evolution from the early 1900s to the 1990s, a period of significant upheaval, during which the Nicaraguan state and market played different roles according to dominant thinking about their appropriate roles in economic development. Shifts from early market-led growth to state-led development in the 1950s are discussed, and the subsequent shift to liberalism in the 1990s is analysed in considerable depth. Section 5.2 examines one particular feature of the shift towards electricity sector liberalisation – the unbundling and privatisation of electricity distribution activities – analysing in detail its complexities and some of the associated negative implications. The repercussions for electricity coverage levels are emphasised in particular, and how the failure of both state-led and market-led models required an alternative approach to electrification in off-grid areas – namely the launch of the Proyecto de Electrificación Rural para Zonas Aisladas (PERZA) and its emphasis on filling the gaps in electrification plans with applications of small scale decentralised energy. Section 5.3 investigates the consequences of sector privatisation and how they – in combination with other drivers - ultimately contributed to the collapse of the Nicaraguan power sector in 2006-07. Section 5.4 examines the role of a re-elected populist government in stabilising the crisis situation. Drawing on Goldthau's energy paradigm thesis, section 5.5 examines the extent to which a shift in governance from liberalism to interventionism is being enacted. Section 5.6 analyses the contemporary political economy of electricity in Nicaragua, in particular discussing issues of transparency and politicisation. The final section concludes by outlining the chapter's contribution to the overall thesis and wider literature. It also links forward to the focus of the next chapter, which is to profile the emergence of the Nicaraguan off-grid solar energy market.

5.1. Historical perspectives

Over the years, energy sector governance in Nicaragua has been influenced by shifts in international ideological currents, changing energy paradigms as well as domestic political economic frameworks. In energy governance terms, Nicaragua can be characterised as a 'rule taker' (see Dubash, 2011) which does not stand in isolation from the dynamic and often dramatic shifts happening in the global energy arena. At the domestic level, history and politics have also profoundly shaped the development of the Nicaraguan electricity sector; the past forty years in particular have seen the greatest social and political turmoil, along with a series of devastating natural disasters (e.g. Managua earthquake in 1972, Hurricane Joan in 1988 and Hurricane Mitch in 1998). This section of the chapter historically contextualises the governance of the Nicaraguan electricity sector, in particular examining the influence of broader global and national political-economic shifts. The changing role of the state and influence of the political classes will be explored in depth.

Figure 12 summarises key milestones in Nicaragua's electricity sector from 1902 to the present day. The historical content draws heavily upon Ruth Selma Herrera-Montoya's (2005a) *'Crisis del sector energético: ¿Nicaragua apagándonse?'* (Crisis of the energy sector: Nicaragua switching itself off?). This reflects that there are few other known sources of historical data on the energy sector (as discussed at length in Chapter Three).

5.1.1. Development of Nicaragua's electrical sector: pre-1979

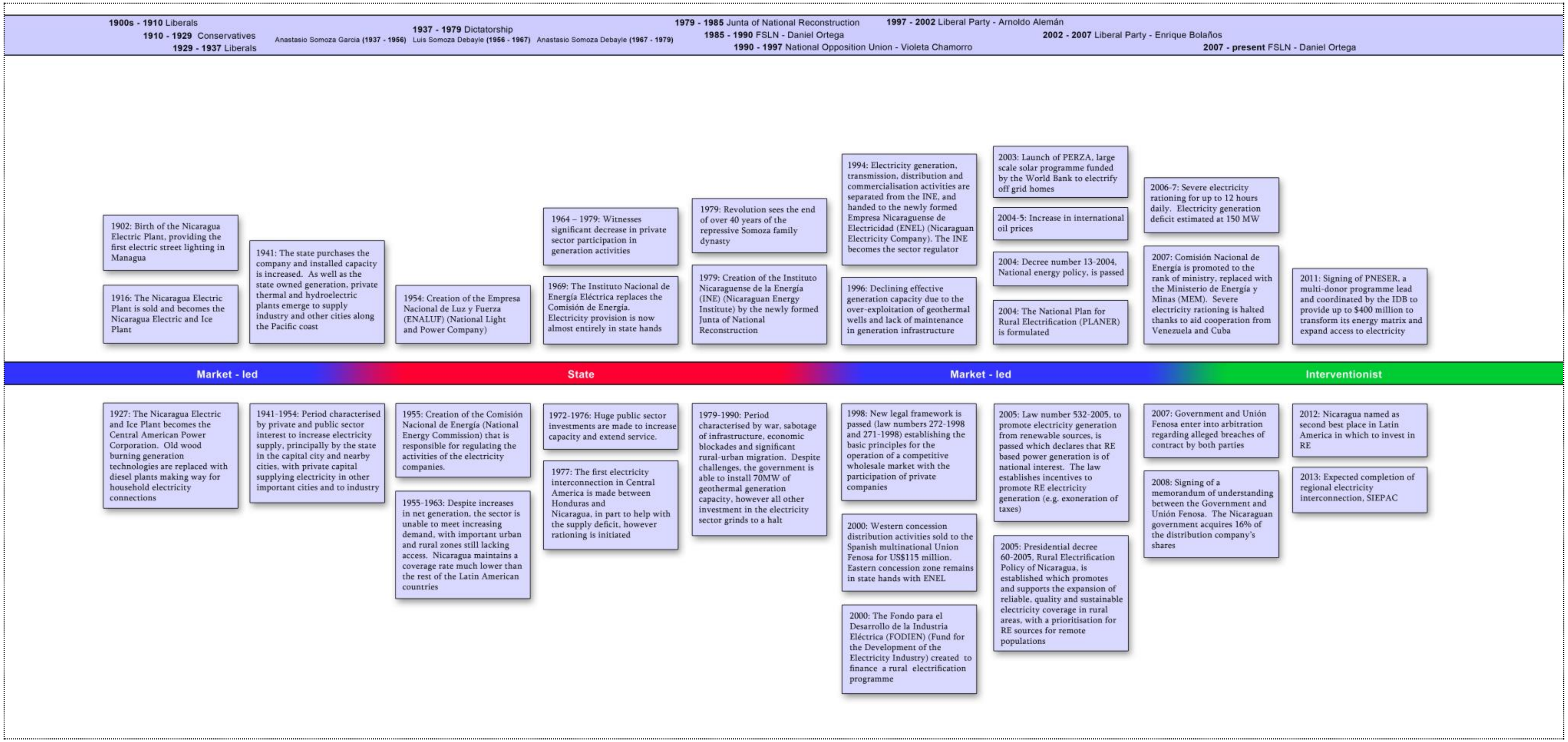
Up until the 1950s Nicaragua's electricity sector was predominantly led by private investors, serving the needs of industry. During this period the energy infrastructure is described as incredibly precarious and inadequate for meeting the demands of increased industrial development, let alone domestic consumption (Herrera-Montoya, 2005a). Only a small, privileged section of society benefitted from electricity access and expansion outwards to rural populations was slow. Prior to the 1950s, half of electricity generation was derived from thermal resources and half from small hydroelectric plants. The Nicaraguan state played a minor role in the sector, generating less than 30% of the national supply. From 1945 to 1955 the increase in the supply of energy lagged considerably behind demand.

In the mid-1950s, a decision was made to increase government participation in the sector and pre-existing private plants were purchased, creating the *Empresa Nacional de Luz y Fuerza* (National Light and Power Company) (ENALUF). Dictator Anastasio Somoza created the *Comision Nacional de Energía* (National Energy Commission) (CNE), which became charged with carrying out investigations to determine national renewable energy resource potential, with a view to drawing up a national electrification plan.

Increasing government investment in the sector replaced obsolete plants with the Managua steam plant, which enabled electricity to expand to the Pacific region, creating the *Sistema Interconectado del Pacifico de Nicaragua* (Interconnected System of the Nicaraguan Pacific). By contrast, the

Eastern Atlantic side of the country had very poor provision of services; electricity was controlled by private sector actors who supplied electricity predominantly to industrial and business users, e.g. mining and banana plantations.

Figure 12. Key milestones and governance patterns in Nicaragua's electricity sector



Source: author's own illustration

While investment in renewable energy feasibility studies was high (e.g. identifying suitable hydroelectric and geothermal sites) during this period, Herrera-Montoya (2005a) argues that the IFIs largely disbursed funds to thermal projects, displaying 'complete short sightedness' in the context of transitory low oil prices (Herrera-Montoya, 2005a:10). Indeed an examination of the World Bank's energy lending portfolio[42] supports this assertion; between 1953 and 1977, a total of nine power projects were funded in total, and of the seven generation projects approved, only one was based on renewable sources (hydropower).

Unfortunately identifying electrical generation capacity and its composition prior to the revolutionary years is difficult to ascertain due to the paucity of data available. While the data shows that installed capacity grew over seven-fold between 1960 and 1980 (from 42MW to 302 MW) (CIERA-Barricada, 1983a; Herrera-Montoya, 2005a), identifying its composition is more difficult. While Herrera-Montoya (2005a) states that oil accounted for a small amount of generation during the late 1960s and 1970s (less than 30%), Solá Monserrat (1989) and the *Instituto Nacional de Energía Eléctrica* (INEE, 1970) argue that high petroleum dependence was characteristic of the pre-revolutionary years. An interview with a state official confirmed that high dependence on petroleum had long been a feature of the Nicaraguan electricity generating matrix, resulting frequently in supply/demand imbalances and rationing (expert interviewee 31 – former official of the state electricity company).

Common to all three Somoza dictatorships (1937-1979) were high levels of corruption, unequal distribution in growth and access to services, which all served to widen the gap between the small elite and middle classes and the impoverished majority. According to Kinzer (2007) the greatest crime of the Somozas was their refusal to develop the country they ruled – despite Nicaragua having enormous potential resources and the Somozas, incredible power, they ruled cruelly and brutally, 'bequeathing to their successors a nation in physical, political, economic and moral ruin' (p. 75). At the time of the insurrection in 1979, average life expectancy was just 53 years, two thirds of children under five suffered malnutrition, the majority of young people could not read or write and many lacked access to basic services. One legacy of this reign was a dilapidated electricity sector, which was later described by the succeeding revolutionary government as one of the biggest burdens on the Nicaraguan economy (CIERA-Barricada, 1983a).

[42] See the World Bank website for a list of programmes financed: http://web.worldbank.org/external/projects/main?pagePK=218616&piPK=217470&theSitePK=40941&menuPK=51618494&category=simsearch&pagenumber=2&pagesize=10&sortby=BOARDSORTDATE&sortorder=DESC&query=energy%20nicaragua&status=ALL

5.1.2. Revolution, counter-revolution and an investment-starved sector: 1979-1990

The insurrection of 1978-79 was incredibly costly to the Nicaraguan people – over 50,000 people lost their lives, national income dropped by 30% in real terms, and production losses totalled US$2 billion, with cities, productive areas and key infrastructure (including the electricity sector) in ruins (Walker, 1985; Weeks, 1985). According to Walker (1985), despite the overwhelming economic problems faced in the years following the insurrection, the revolution achieved more social reform in five years than most pre-revolutionary Latin American countries had accomplished in decades. Under the *Junta de Gobierno de Reconstrucción Nacional*, and the subsequent victory of Daniel Ortega's *Frente Sandinista de Liberación Nacional* (FSLN) in elections in 1984, significant advances in the areas of literacy (Barndt, 1985), health (Bossert, 1985) and social welfare (Téfel et al., 1985) were witnessed. Ideological change and new leadership in the United States under the Reagan administration saw the masterminding of an international economic blockade of Nicaragua (Maxfield and Stahler-Sholk, 1985) and the waging of the low intensity *contra* war, aggravated by geopolitical rivalry between the United States and Soviet Union (Tijerino, 2008). Walker and Wade (2011) characterise the revolutionary period up to 1990 into four sub-periods; firstly 1979-1980 which they describe as a time of euphoria and optimism; 1980 to 1982 which saw the election of Ronald Reagan as president of the United States, raising concern over the hostile intentions of the new administration; 1982 to 1985 which saw the beginnings of economic strangulation and invasion, culminating with the victory of the FSLN at the polls in 1984; and finally 1985 to 1990 which saw economic collapse and internal political destabilisation (pp.45-56).

In weathering such political, social and economic upheaval, it is unsurprising that state investment in energy was significantly restricted in the post-insurrection years. At this time there was a desperate need for new generating capacity; the FSLN's newspaper *Barricada* (CIERA-Barricada, 1983a; 1983b) declared the revolutionary government's intentions to execute renewable energy projects to 'break the energy schematic inherited from the Somoza regime' and become a 'vanguard of energy development in Central America' (ibid, 1983a: 49). The newly formed *Instituto Nacional de Energía* (INE) investigated potential sites for geothermal electricity generation that had been identified during the Somoza dynasty, but was only able to add 70MW of geothermal capacity (Herrera-Montoya, 2005a). The US-orchestrated international economic blockade from the mid-1980s onwards ensured that requests for loans from the Inter-American Development Bank (IDB) and World Bank (which in previous years had provided key assistance to energy-related programmes) were vetoed (CIERA-Barricada, 1983a; Walker and Wade, 2011). By the late 1980s, installed electrical capacity was dominated by fossil fuel-based generation (58% of total generation) (Envío, 1988). Dependence on imported oil during the 1980s exposed Nicaragua to fluctuating oil prices and the will of international cooperation agreements. Various oil purchasing agreements were negotiated, for instance, the San José accord signed in 1980, saw Mexico and Venezuela selling oil to Central American and Caribbean countries at preferential prices (Jácome, 2011). However, towards the mid-1980s Nicaragua began to run out of countries to purchase oil from due to its inability to pay and accumulation of considerable debt. Table 13 illustrates the cost burden of imported oil in the late 1970s and early 1980s. According to Envío (1988) this trend continued and by the late 1980s, the country's petroleum bill was approximately equal to its export earnings, resulting in an increasing debt and fuel crisis.

Table 14. The burden of imported oil in Nicaragua: export earnings and oil expenditure 1977-1982

	1977	1978	1979	1980	1981	1982
Export earnings (USD$ millions)	632.2	646	615.9	450.4	499.8	414.6
Oil imports (USD$ millions)	-	89.1	81.2	157.2	187.9	196.5
Oil as a % of export earnings	-	13.8	13.2	34.9	37.6	47.4

Source: CIERA-Barricada (1983b)

Worsening macroeconomic conditions meant an unavoidable lack of investment in electricity generation; this led to a drop in effective installed capacity, while droughts also contributed to reduced hydroelectric capacity. This resulted in the government initiating a series of emergency measures – including rationing, efficiency measures and changes to the working week (CIERA-Barricada, 1983b). Herrera-Montoya (2005b) argues 'that in the middle of a war, the government lacked any strategic vision for the sector and failed to gauge its [electricity's] importance and convert it into a dynamic axis of the whole economy' (n.p.). By the mid to late 1980s, Nicaraguan society faced significant challenges, with the social, economic and political situation of the country deteriorating rapidly. This period is characterised as a 'war of economic attrition', where the *contra* strategy included carrying out attacks on state companies, oil storage facilities and pipelines, schools, health centres and electricity infrastructure (Tijerino, 2008:329). Expert interviewee number 31 recalled the difficulty faced by the government in addressing the country's energy problems at this time:

> 'The new revolutionary government was interested in creating new generation projects, but it wasn't possible to increase generation despite the geothermal programmes. We were experiencing a difficult period with regard to the electricity sector, and this was combined with an imposed war that affected us in a number of ways - they blew up transmission towers,

dynamited them, which meant blackouts for two to three days at a time in the country... this was crippling as we often had no electricity' [Expert interview 31 – former official of the state electricity company]

Envío (1988) supports this assertion, describing the 'daily battle for energy survival' to keep the 'revolution running' (n.p.), with rationing, frequent power outages, *contra* sabotage, technical problems at the country's oil refinery and long lines at petrol stations. While the government had made the rehabilitation of the electrical system a priority, the foreign resources needed to realise this were lacking (ibid).

By the late 1980s inflation had reached 30,000% and two drastic currency devaluations saw severe austerity measures, which led to the government cutting spending on public services (Tijerino, 2008). The *contra* war had killed over 30,000 people and left 31,000 injured or mutilated. By the end of the decade, 69% of the population were living in poverty (ibid). With large populations marginalised by the war and by poverty, rural to urban migration increased, transforming population distribution and exerting growing pressure on urban environments (see Rodgers, 2011). This is described by one expert interviewee from the Ministry of Energy and Mines (MEM):

> 'We suffered from a terrible war during the 80s... this war was principally seen in the rural areas. We're talking about the north of the country, the central part, in the Atlantic... Many of the people during this period sought protection and so headed for the Pacific zone of the country, or their department capital… So they began forming new population settlements, without any type of urban plan, without roads, without water, without energy, without telephones. These are *'asentamientos humanos'* [human settlements]... they are spontaneous… This was during 10 years of war, then came the post-war years, which in many cases were much harder than the actual war… So they began forming immigrant populations, displaced firstly by the war, and then displaced by severe economic problems… So these people went about settling, without any type of basic service, not water, not electricity, not communications' [Expert interview 22 – government official, rural electrification department, MEM]

The creation of informal urban settlements therefore created a series of challenges, not only for the electricity sector, but also for the provision of other basic services like water. The government was unable to serve new urban dwellers with electricity, so populations resorted to connecting illegally:

> 'Problems emerged with illegal [electricity] connections... which raised distribution losses, unrecorded consumption rose and overloaded the transformers which were now not able to meet demand... and so emerged a rather difficult situation which has stayed with us for many years' [Expert interview 31 – former official of the state electricity company]

Distribution losses arising from *asentamientos* indeed have remained an issue, where entire communities have resorted to connecting illegally to the electricity service; electricity theft is a recurring theme which will be discussed in the following sections.

By 1990, the Nicaraguan population was exhausted by war and the extreme suffering caused by the externally aggravated war (Robinson, 1992; Oquist, 1992; Walker, 1997); when Nicaraguans went to the polls in February 1990, the Sandinistas were defeated. The election of Violeta Barrio Torres de Chamorro, a US-backed candidate, in those elections signalled the end of the revolutionary government's administration and an end to the *contra* war. According to Walker and Wade (2011), 1990 represents a significant watershed in Nicaraguan history; the legacy of the *contra* war and the three subsequent conservative governments' commitment to neoliberal economic policies were largely seen to reverse the social gains made during the 1980s.

5.1.3. 1990s: from state to market

In the early 1990s, new fossil-based generating capacity was added in order to expand electricity supply to some of the *asentamientos humanos* which had been created by war displacement. Despite integrating some 38,000 new users, a considerable number of slums remained unserved and the country was largely running on infrastructure installed during the Somoza dynasty (Herrera-Montoya, 2005a). As a result, Nicaragua continued to face a severe generation deficit and thus frequent rationing (ibid). According to Herrera-Montoya (2005a), this deficit, or energy crisis, set the perfect scene for the 'Washington Consensus' to be imposed; indeed, Chamorro's government rapidly initiated the first steps to privatise the electricity sector. To suggest that Chamorro was the first leader to introduce neoliberal reforms is unfair however because according to Walker and Wade (2011), severe economic stabilisation policies had already been put in place by the FSLN government in the late 1980s to combat high inflation. Chamorro's government began its term by approving tough austerity policies, and moved swiftly to implement structural adjustment programmes, which brought financial support from the International Monetary Fund (IMF), World Bank, IDB and USAID (United States Agency for International Development) (Stahler-Sholk, 1999). Adjustment consisted of privatising state-owned enterprises (SOEs) (such as electricity, water and telecommunications) to raise funds to pay the country's external debts, reducing government expenditures and the government's role in the economy, in addition to decreasing barriers to international trade (Close, 1999). The 'almost religious devotion' of Chamorro and her two successors, Arnoldo Alemán (1996-2001) and Enrique Bolaños (2001-2007), to the neoliberal economic principles advocated by the United States, in many senses involved Nicaragua yielding its economic sovereignty to the international lending and donor community (Walker and Wade, 2011:142).

The end of economic isolation, and the government's adherence to neoliberal economic policies meant that multilateral loans once again became available. As explored in Chapter Two, the IFIs acted as key 'vectors' in the abrupt shift from a state-led to market-led energy paradigm. In Nicaragua, the IDB were instrumental in this shift, through their financing of the major 'public services reform programme'. This programme aimed to completely restructure the energy, water supply, sewerage disposal and telecommunications sectors 'to permit participation of the private sector; and to improve the operating efficiency of the sectors' (IDB, 1994: n.p). The World Bank was also instrumental in this shift; analysis of lending portfolios suggests that pre-1990 disbursed loans largely consisted of financing for infrastructure (such as the construction of thermal power plants), while in the 1990s, 'restructuring' loans, which sought to reform the electricity sector and render it more attractive to private investors, were disbursed[43]. The abrupt shift from a state-led to market-led paradigm was based on the premise that private ownership would deliver more effectively on the provision of goods and services; the policy implications of this shift were the privatisation and liberalisation of state-held assets, shifting the Nicaraguan state's role, to one of 'enabler' rather than 'owner'. This changing approach to energy policy reflects the broader paradigm change in global economic policy, outlined in Chapter Two.

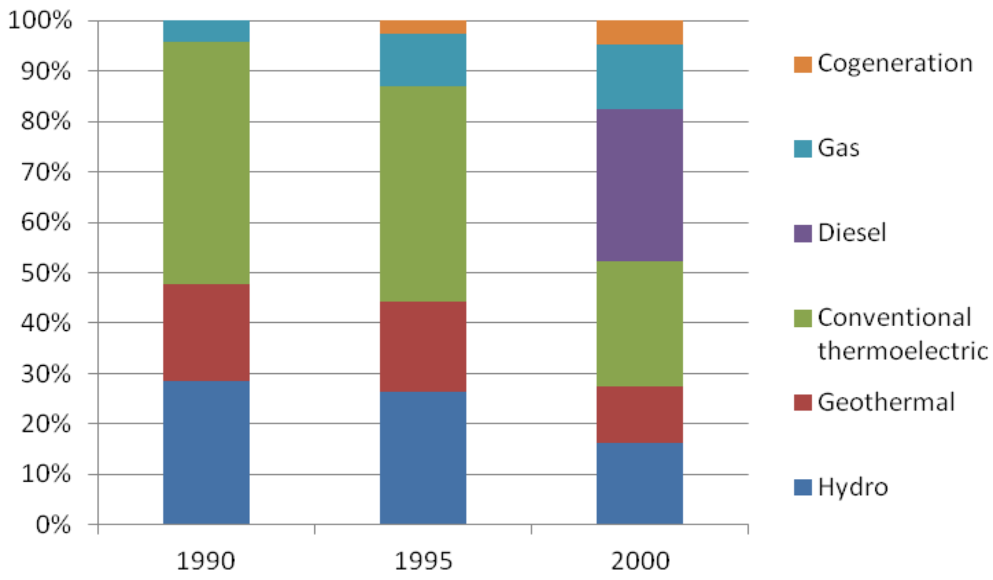
With the implementation of these reforms, the mid-1990s witnessed the entrance of private electricity generators, and with this the first power purchasing agreements (PPAs) were signed. According to Herrera-Montoya (2005a), the PPAs were negotiated secretly, offering highly favourable terms to generators. McGuigan (2007) examines the PPAs adopted in Nicaragua and finds a series of antiquated practices - ones long abandoned in the UK context, which is considered to have achieved a 'successful' electricity privatisation. Poorly negotiated PPAs saw guaranteed revenues even to inefficient generators, which provided little incentive to invest in risky renewable

[43] For the IDB's energy financing portfolio see: http://www.iadb.org/en/projects/advanced-search,1301.html?query=energy&ProjectNumber=&Status=&Country=NI&Topic=&Sector=&SubSector=&Fund=&Cofinancing=&FinancialProd=&ProjectType=&YearFrom=&YearTo=&FinancingOver=&FinancingUnder=&FinCurrency=&adv=true

energy generation projects (ibid; see also Tomiak and Millán, 2002). These issues are returned to in more detail below.

Increasing private participation in generation during the second half of the 1990s impacted considerably on the composition of installed electrical capacity in Nicaragua, as in the rest of the region (as discussed in Chapter Three). Figure 13 demonstrates this shift. This figure, adapted from CEPAL (2012), illustrates a boom in installed diesel capacity from 1995 onwards, with a relatively unchanged composition over time with respect to other forms of generation (e.g. hydro and geothermal), a slight growth in gas, significant growth in cogeneration and a slight decline in conventional thermoelectric.

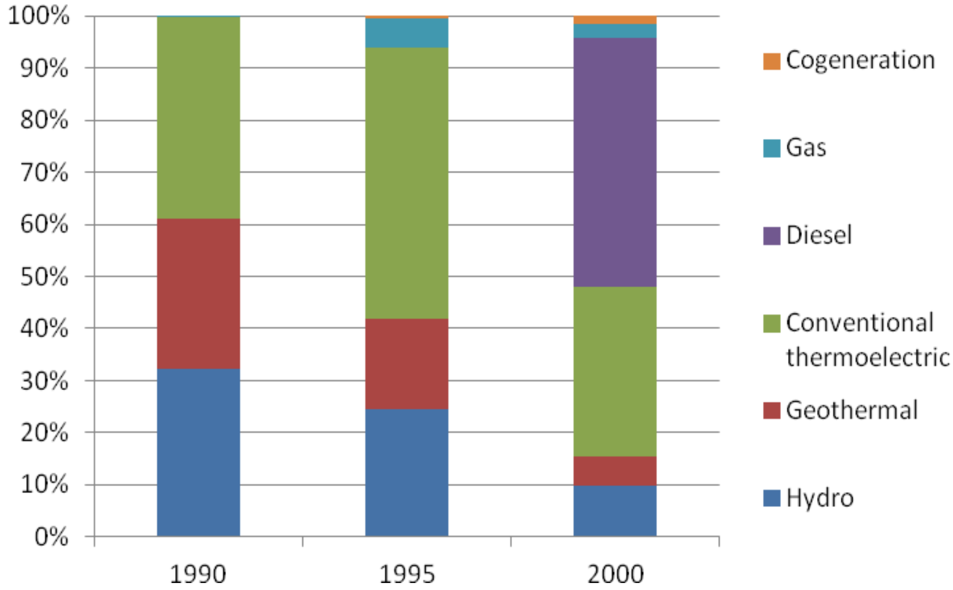
Figure 13. Installed electrical generating capacity by source (MW) in Nicaragua 1990 – 2000



Source: adapted from CEPAL (2012)

Figure 13 does not accurately reflect the situation however, given that during the latter half of the 1990s, effective installed capacity was significantly reduced, due to overexploited geothermal resources, droughts affecting hydroelectric plants and lack of investment in maintaining existing capacity (Herrera-Montoya, 2005a). Figure 14 illustrates data on electricity generated according to source, as opposed to installed capacity, which reveals an overall decline in renewable electricity generation with concurrent growth in diesel-based electricity. The share of renewable electricity generated declined from 61.2% in 1995 to just 17.1% by 2000.

Figure 14. Total electricity generation by source (GWh) in Nicaragua 1990 – 2000

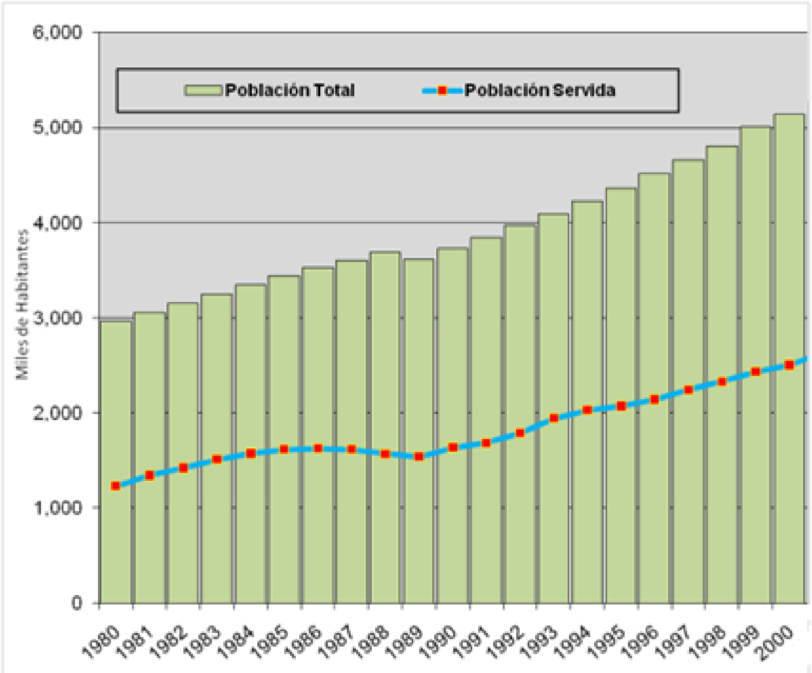


Source: adapted from CEPAL (2012)

This connects back to and supports the general observation made in Chapter Three that power sector reforms seem to have been associated with increasing reliance on imported oil for electricity generation in the wider Central American region (e.g. UNDP, 2002; Mostert 2009).

It is also important to acknowledge that by the end of the 1990s, the majority of the Nicaraguan population (69.9%) were living in poverty and there had been little change in the high level of inequality (Hammill, 2007). In addition to this, 55% of the population still did not have access to grid electricity (CEPAL, 2011a), with a large percentage of the population relying on fuelwood as their principal energy source (Vargas, 1999). Figure 15 displays the evolution of electrification levels in Nicaragua between 1980 and 2000, which illustrates that connections to the electricity grid barely increased in line with population growth during this period.

Figure 15. Total population vs. electrified population, 1980-2000



Source: MEM (2009). Note: the green bars represent population growth (thousands of inhabitants); the red and blue line represents the grid connected population

The late 1990s saw the administration of Arnoldo Alemán, which according to Walker and Wade (2011), was characterised by extreme polarisation, administrative incompetence and unprecedented corruption. While structural reforms carried out during the early and mid-1990s brought about economic stabilisation and the beginnings of growth, social unrest, high unemployment, poverty and inequality were widespread (Close, 1999). It was also during this presidency that hurricane Mitch devastated the Central American region, in Nicaragua, killing over 3000 people and inflicting severe damage to the country's infrastructure, industry and agriculture[44]. The problem of poverty in a country where half the population was already poor, and a large number of them living in conditions of misery, was made all the more severe by the hurricane. Table 14 illustrates the deteriorating standards of living experienced by Nicaraguans during the 1990s. In the electricity sector specifically, Mitch damaged 18 substations, destroyed 10 distribution lines, felled thousands of kilometres of cables and damaged three generation plants, with repair bills requiring an estimated investment of US $21.6 million (Vargas, 1999).

[44] See: http://www.iadb.org/regions/re2/consultative_group/backgrounder3.htm

Table 15. Deteriorating standards of living in Nicaragua 1990-1999

	Electricity (córdoba/Kwh)	Water (córdoba/m³)	Basic food basket (córdoba)	Average salary (córdoba)
1990	0.05	0.35		
1991	0.3	1.13	718.01	1032.72
1996	0.79	2.76	1225.59	1197.06
1997	0.93	3.24	1402.82	1195.87
1999	1.22	5.67	1789.41	1382.8

Source: Vargas (2001)

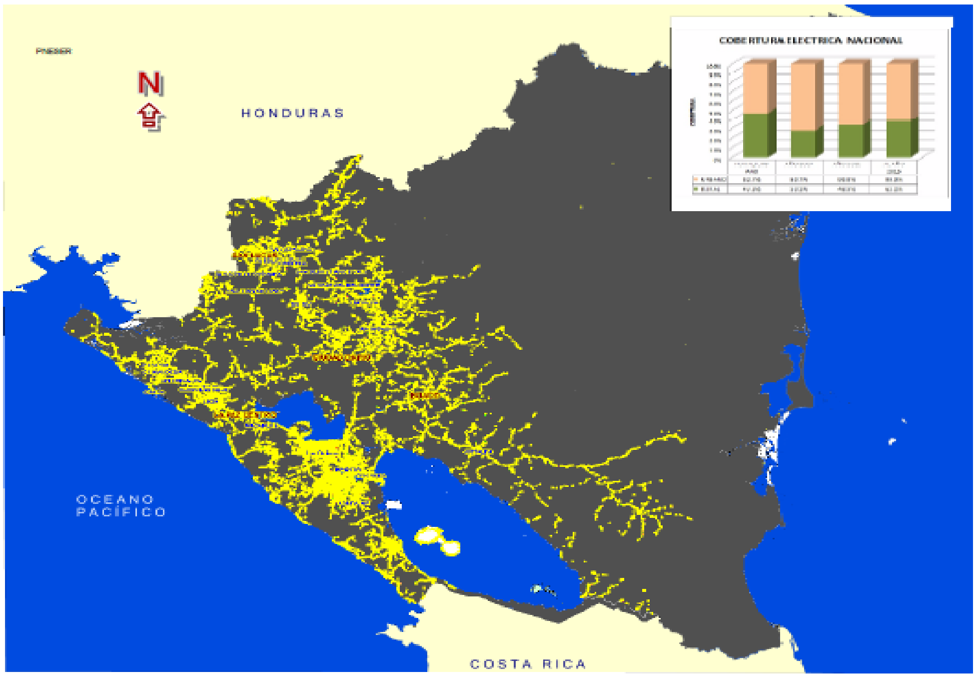
Under Alemán's government, Nicaragua experienced increased momentum for the privatisation of state utilities, including electricity and telecommunications. Nicaragua was also admitted to the Highly Indebted Poor Countries (HIPC) Initiative, which stipulated the divestiture of public utilities, specifically electricity, as one of the conditions to receive debt relief (IMF, 2004; Walker and Wade, 2011). Given the small size of the Nicaraguan electricity market, and the high percentage of technical losses, several 'favourable' arrangements were encouraged in order to render the sector more attractive to potential investors. The benefits offered included 'high value added' margins for distribution companies and 'transition contracts' guaranteeing a stable energy price to the distributor (IMF, 2004:20).

By 1998-99, Nicaragua had adopted and implemented a liberalised framework for the organisation and regulation of the power industry (Mostert, 2007), set in motion by the approval of the *ley de la industria eléctrica* (electricity industry law) (INE, 1998). The previous state monopoly of the Nicaraguan Electricity Company (ENEL) was unbundled, separating generation, transmission and distribution activities (DGERR-MEM, 2010). As well as increased momentum for privately-owned generation, in 2000 steps were also made to privatise distribution. Nicaragua's electricity distribution network was split geographically into Western and Eastern zones. The former was split into two concessions: Northern Distribution Company (Disnorte) and Southern Distribution Company (Dissur); while the latter, which included the least developed and most sparsely populated region of the country, was not offered as a concession zone to facilitate its sale[45] (Barnes and Waddle, 2004; Mostert, 2007). Figure 16 illustrates the stark difference in electricity distribution infrastructure development between the western and eastern concessions. A system already characterised by

[45] This is referred to as the 'Open Area' and since the unbundling and liberalisation of the sector, has remained in state hands.

uneven electricity coverage was further reinforced through privatisation, creating a dual system which saw electricity distribution half state-owned and half privately-owned.

Figure 16. Nocturnal simulation of electricity grid coverage in Nicaragua



Source: MEM (2012)

The notion that competition and enhanced efficiency could be achieved with the privatisation of distribution was undermined when only one company, the Spanish multinational Unión Fenosa, bid for both distribution companies, essentially shifting distribution from a state-owned monopoly to a privately-owned monopoly. Furthermore many of the privatisation deals were conducted with little transparency, and subsequent studies (e.g. McGuigan, 2007, Herrera-Montoya, 2005a; 2005b) have been unable to uncover the exact financial details of the transaction, which according to Cupples (2011) created a 'landscape of popular suspicion' amongst consumers (p. 941). A campaigner from a national consumer defence organisation for instance, argued:

> 'So with the international organisations came their conditionality and they said: 'Nicaragua has these problems with basic services because they just don't have the capacity to develop these sectors...so the best thing to do is open the market'... OK, so the responsibility falls on President Arnoldo Alemán and he wants to sell the company's shares, but the detail is in the following: who is ever going to bid? Who actually wanted to buy it? We sent out the tender and there was only one bidder... but there was always something being passed under the

> table...but who called who first, or who gave who a bribe I don't know' [Expert interview 32 – Campaigner and energy specialist, consumer defence organisation]

As discussed in Chapter Two, good governance is one of the objectives of global energy governance (Dubash and Florini, 2011); corruption in the governance of the Nicaraguan power sector however is a recurrent theme identified by interviewees during subsequent sections and chapters.

This section has traced the electricity sector's transition from state-led to market-led governance (Goldthau, 2012), stimulated by broader shifts in global economic policy in the aftermath of a bloody and ultimately strangled insurrection. According to Mostert (2009) the objectives of reform were threefold: to develop the country's RE generation potential, to reduce high system losses in distribution, and increase the national rate of electrification. However, the expected fruits of electricity market liberalisation were not achieved in Nicaragua; rather privatisation led to apparent sector 'lock in' to fossil fuel based generation (e.g. Unruh, 2000; Unruh and Carrillo-Hermosilla, 2006), and apparent disregard for the majority of the Nicaraguan population, 54% of whom remained without electricity access in 2000 (Avecedo, 2005). Furthermore, the expansion of diesel-based installed electrical generation capacity demonstrated a lack of foresight in relation to international oil prices, which would later contribute toward the collapse of Nicaragua's electricity sector in 2006-7 (discussed in section 5.3). The following section examines one particular area of reform in greater detail – the privatisation of the electricity distribution network.

5.2. Privatised electricity distribution: failure in the Nicaraguan case?

The privatisation of Nicaragua's electricity distribution sector is widely regarded to have failed. In the early 1990s, after nearly two decades of scant investment in the sector, it was believed that privatisation would reduce high system losses in distribution and increase the national rate of electrification (Mostert, 2009). Indeed Herrera-Montoya (2005a) argues that privatisation was 'sold' to consumers and political parties by linking it with ideas of sector modernisation. It is acknowledged however that privatisation did not bring about the expected benefits. Articles written on this topic tend to agree with Cupples' assertion (2011:945) that 'the privatisation of electricity has transformed everyday life in ways that are mostly negative for low-income consumers' (e.g. McGuigan, 2007; Miranda-Urbina, 2006; Perry, 2008; Ripley, 2010), characterised by electricity price rises, illegal charges, deficient services, and culminating in rolling blackouts during 2006-7.

As discussed in Chapters Two and Three, the privatisation of basic services, such as electricity, has been highly contested, especially in the context of the Global South. It should therefore come as no surprise that in Nicaragua - despite more than a decade passing since the reform process was initiated - the electricity privatisation debate remains highly emotive and contentious. A range of actors were interviewed regarding their positions on the unbundling and privatisation of electricity in Nicaragua, these included representatives from the sector regulator, the MEM, the private distribution company, NGO and civil society groups. Several ‘versions’ of electricity sector privatisation were articulated; from the notion of privatisation’s absolute ‘necessity’, through to it representing a flagrant attack on the rights of Nicaraguan citizens. For several of the actors interviewed, privatisation of the electricity sector was seen as the only option given its deteriorated state, in a country recently emerging from war:

> ‘The problem is that in 98, the government experienced an experiment... an experiment to privatise basic services, water, electricity and telephones… we suffered a war...and a great number of people migrated to urban areas, we were talking about a post-war period in which we had lost more than 17 billion of dollars in production, roads, bridges, factories... we are a very poor country... and so to privatise in these times was an experiment imposed on us by the International Monetary Fund... these were no conditions though, starting with its [the system] value... its value in weight was worth more ... but who was going to buy it? Nobody... so the distribution company was sold for 115 million dollars, which is now Disnorte - Dissur... it was sold with high loss rates... the [kind of loss rates it suffered] were not sustainable for anybody... Neither for the government nor for the private sector’ [Expert interview 22 – government official, rural electrification department, MEM]

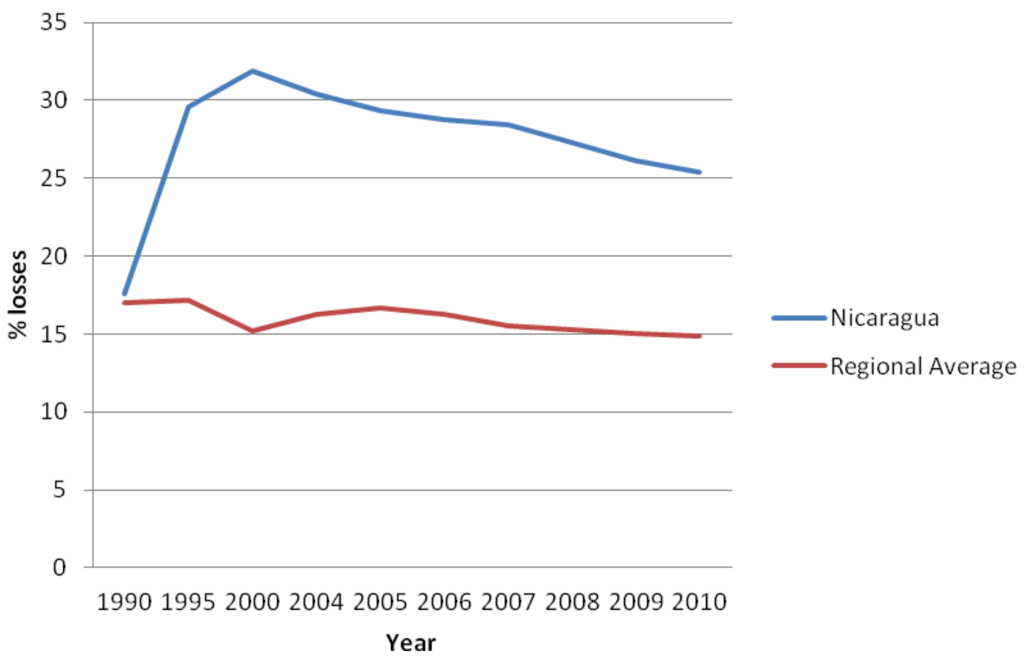
The interviewee therefore argued that electricity distribution was not an attractive venture for either the government or for the private sector due to high loss rates; privatisation became the only option available, especially given the preference of the lending institutions. This notion of ‘necessity’ is echoed by an official from the energy sector regulatory body, who argued that:

> ‘From 1979 to 1998 there was hardly any investment in the energy sector whatsoever, the sector was in complete ruins... so I don’t see that there was any other way but to privatise, with the hope that it would bring investment...’ [Expert interview 11 - official at the Instituto Nicaragüense de Energía (INE), energy regulator]

Expert interviewee 11 added that the regulator had little opportunity to intervene in the sale despite its role as sector regulator. He argued that the distribution company had been practically ‘gifted’ to Unión Fenosa, but that the contract had contained various ‘quality standards’, which were supposed to protect the interests of the consumer; for instance, specific clauses which stipulated significant investment in infrastructure were included in the contract (INE, 1999). An audit conducted during the 2001-3 period concluded that Unión Fenosa did not comply with these contracted investments however (Herrera-Montoya, 2005a). Interviewee 11 explained that Unión Fenosa and the government held differing understandings of the term 'investment'. While the former viewed it as the replacement of street-lighting bulbs (essentially maintenance work), the latter perceived it as the construction of new distribution posts and connections. Interviewees argued that the lack of investment continued beyond the initial years of private ownership. The inability of the energy sector regulator to intervene during the sale of the electricity distributor and its subsequent incapacity to enforce the contract terms raises significant concerns about the INE's capacity to regulate the electricity sector.

Persistent lack of investment in the distribution system has arguably contributed to the maintenance of high levels of technical and non-technical losses in the system (McGuigan, 2007). While the aim of the reforms in Nicaragua was to reduce such losses, Figure 17 demonstrates continued high losses post-privatisation, compared to the regional average.

Figure 17. Distribution losses in Nicaragua and Central America 1990 – 2010



Source: CEPAL (2011a)

While all electrical systems experience a degree of technical losses (in transmission), non-technical losses can be attributed to electricity theft. The level of unmetered electricity is in part connected to the surge in *asentamientos humanos* (discussed in section 5.1.2), which lacked adequate infrastructure and commercial set ups with service providers to collect payments. The early part of the new millennium also saw continued deterioration in the social and economic wellbeing of the population: 69.3% of the population were living in poverty and there had been little change in levels of inequality since the upheavals of the late 1980s (Hammill, 2007). These conditions did not incentivise a profit-driven private distributor to expand coverage into informal or low-income areas. According to a consumer rights campaigner, these factors contributed to electricity thefts:

> 'Electricity is a basic need, not a luxury, and so the people that need it, say 'if they won't supply it to me, if they won't sell it to me, I'll take it for myself'... that is what the people think… So they go and they connect themselves to the electricity... but it is not because they want to steal from the distributor, but that they [the private distributor] do not want to invest in the poor neighbourhoods because this investment won't be recouped in one year, but in five or six years, and this is no good for them' [Expert interview 1 – Founder, consumer defence organisation in Masaya]

Despite specific investment clauses stipulated in the distributor's contract (e.g. the *Normativas de calidad de servicio*; INE, 1999), the private company had little financial incentive to enter areas where consumption would be low and where the initial investment would potentially take years to recoup. Respondent 32 echoed this idea when describing the situation in an *asentamiento humano* where his consumer defence organisation worked in the capital city, Managua:

> 'Los Martinez is a really poor zone and right across the street from this settlement is a [grid connected electricity] generator, yet none of these people have access to grid electricity. They themselves have put up poles made out of trees they have cut down and put up their own illegal artisan grids, using barbed wire, whatever metal they can find. I know of 1,400 houses that do not have a legal connection here and they are really poor houses, houses made from small sheets of cardboard, plastic and with these artisan grids, the cables reach very high temperatures and what tends to happen in many of the houses is that fires are started, or someone dies' [Expert interview 32 – Campaigner and energy specialist, consumer defence organisation]

Some communities in close proximity to major electricity infrastructure remain excluded from service provision leading to a situation where households 'help themselves' to electricity.

Dissatisfaction with the (lack of) service in some areas has become a deep cause of contention. Cupples (2011) considers that the privatisation of electricity has coincided with the emergence of consumer citizenship in Nicaragua. Expert interviewees 1 and 32 explained that increasing moves towards privatisation in Nicaragua had given rise to a number of active consumer rights groups seeking to protect vulnerable populations (with little knowledge of electricity issues) from what they view as unscrupulous companies and inadequate regulation or safeguards:

> 'Our struggle... our headline issue has always been against privatisations....' [Expert interview 32 – Campaigner and energy specialist, consumer defence organisation]

> 'We have shown all governments that we have fought against privatisation and against all the companies that come here to swindle Nicaraguans' [Expert interview 1 – founder of consumer defence organisation]

Such organisations hold deeply ideological positions about the role that the private sector should play in the provision of basic services; indeed private participation is regarded with deep suspicion. This contrasts to the positions outlined by the officials who considered that privatisation was a 'necessary' move given the deteriorated state of the sector.

Wide discontent and dissatisfaction with the distributor, according to expert interviewee 4, reinforced what he termed a *cultura de no pago* (non-payment culture); indeed he traced this culture's historical roots in Nicaragua as a form of political protest:

> 'There is a non-payment culture which is quite strong in Nicaragua from the revolution or before, even during the Somoza period where non-payment was a form of protest and then after the Revolution it became a thing of, 'well the government is paying for it, it is free'… and really it has become quite a political act… then with Fenosa being a private firm that everybody believes bought the system very cheaply and behind closed doors, therefore there is a lot of resentment about paying for Fenosa...and then there is the sort of multiplier effect of the fact that people know there are lots of illegal connections so why should they pay?' [Expert interview 4 - fundraiser, NGO operating SHS programme]

The combination of consumer mistrust, the distributor's apparent lack of interest in low income consumers and their unwillingness to invest, results in what interviewee 11 (official at the Instituto Nicaragüense de Energía, energy regulator) views as a vicious cycle: households refuse or are unable to pay for their electricity, which exacerbates non-technical losses, resulting in the private distributor being even less likely to make investments in infrastructure or new connections, feeding into further consumer dissatisfaction, mistrust and losses.

Consumer discontent also related to the price increases experienced post-privatisation, which saw Nicaragua's electricity prices consistently the highest in the region. McGuigan (2007) analyses consumer bills pre and post-privatisation and concludes that the tariff increased by 51% between 2000 and 2005, and further to this, other charges were added to the bill (e.g. for street lighting where there was no provision). Perceived high prices and poor service further fed into consumer dissatisfaction and mistrust, as interviewee 32 explained:

> 'There is a triangle of mistrust... the distributor says 'I don't trust the users because they steal from me and connect illegally', the users distrust the company because 'they steal from me by charging too much and give me terrible service'. So when the users complain to the company and get no response they go to the regulator, who doesn't trust the consumer either, and thinks that they're lying... when the consumer is right and the regulator complains to the distributor, the [distribution] company protects themselves with a barrage of lawyers, and so everyone mistrusts everyone...but we must break this cycle' [Expert interview 32 – Campaigner and energy specialist, consumer defence organisation]

The result of this cycle - consistently high distribution losses - seriously impacted on the financial performance of Disnorte-Dissur. At their peak, distribution losses reached nearly one third of electricity injected into the grid, which raises the question why the company was unable to make the investments necessary to halt such significant losses. An interview with a finance official at Disnorte-Dissur argued that the company's financial position was linked to external pressures (i.e. high oil prices), which were out of their control:

> 'The country's oil dependent energy matrix, alongside the increasing price of oil over recent years meant that the cost of system losses – either not recognised in tariff rates, or not recuperated through consumers paying their bills - caused a huge problem for us…it created a serious hole in the company's accounts...' [Expert interview 33 – finance official, Disnorte-Dissur S.A]

When oil prices began to rise exponentially in 2004, it meant that the cost of electricity lost in transmission or through theft became increasingly expensive for Disnorte-Dissur. This, according to expert interviewee 33, hindered the company's potential for making profits and investments in the system. Some tariff adjustments were made post-privatisation to accommodate rising oil costs, however Mostert (2009) finds that the energy regulator prevented the full coverage of system losses, which led the company to slide into a precarious financial position. In addition to this, the government did not immediately establish a law to criminalise electricity theft, which illustrates to Mostert (ibid) that an inappropriate enabling and regulatory framework was in place. It is important to note that when the difficulties facing electricity distribution came to light, the government in power was that of Enrique Bolaños; whose administration, according to Walker and Wade (2011), was politically paralysed, which meant that enacting change and implementing laws, specifically in the area of electricity, was incredibly difficult (expert interviewee 20 - MEM official). The administration was also operating with a state apparatus which, according to Walker and Wade (2011:72), had been 'stripped to the bone' through the severe structural adjustment policies of the previous decade. This severely affected its capacity to resolve the issues facing the electrical subsector. Having examined the specific challenges and consequences of privatisation related to good governance, consumer mobilisation and urban connection levels, the section turns to the challenges of increasing electricity coverage in the post-privatisation era.

An area where investment in the distribution system was anticipated and greatly needed was in increasing electrical coverage. In 2000 when Unión Fenosa bought the two distribution companies, only 46.2% of the population had access to electricity (CEPAL, 2011a). When the liberalised electricity sector framework was approved the *ley de la reforma del sector eléctrico* (law 272) established the responsibilities of the state and distribution company in relation to electrifying unserved populations. This law decrees that any household located within a concession area is entitled to an electricity supply (article 35), and this falls within the responsibility of the distributor if it is within 150 metres from any point of the distribution network (Electricity Service regulation 4.3.1) (INE, 1998; 2000). For 'rural areas or areas where new connections show insufficient levels of return for the concessionaire', the law states that the government should provide subsidies (article 38) (INE, 1998). The *Fondo para el Desarrollo de la Industria Eléctrica Nacional* (FODIEN) was therefore created to promote rural electrification in remote areas, using some of the proceeds from the sale of the distribution network (World Bank, 2001).

In 2001, the *Comisión Nacional de Energía* (CNE) enlisted the support of the World Bank in the formulation of a national rural electrification strategy (World Bank, 2001). At the time, the World Bank estimated that 40% of the population without electricity were in areas suitable for grid extensions, which they considered would be best served through the existing distribution companies (i.e. Disnorte-Dissur). The remaining unelectrified populations were considered to lie within 'uneconomic' distances from the grid to warrant extension. The World Bank therefore recommended that Bank resources be focused on the electrification of remote populations in the concession zones (further than 150 metres away from the grid network) and areas outside of the concession zone.

By 2003, however, it became clear to the World Bank (2003) that Disnorte-Dissur had failed to increase electricity connections within its concession zones. The lack of a clear regulatory framework hindered this. While law 272 defined the general rules of Nicaragua's electricity sector, the lack of fine-tuned regulations made it difficult to interpret, implement and enforce the private distributor's obligations with regard to electrification (ibid, 2003). This is reflected in Barnes and Waddle's (2004:40) observation that: 'like many other recently privatised distribution companies in Central America, Unión Fenosa is primarily concerned with improving its commercial and administrative systems and with ensuring that it can make a profit from the areas it already serves... it views the task of rural electrification as risky and as offering little prospect of achieving reasonable rates of return on the investment required'. In the period 2000 to 2005, overall electricity coverage increased only slightly from 46.2% to 50.1% (CEPAL, 2011a).

It was in this context that the World Bank approved the programme Proyecto de Electrificación Rural para Zonas Aisladas (PERZA) in 2003 which sought to address low electrification levels through implementing private sector-led, off-grid electricity service provision models (World Bank, 2003). A major component of PERZA was the 'Solar Photovoltaic Market Development Programme' which sought to 'establish the beginnings of a sustainable local PV industry structure and fill a gap in remote electrification plans' (World Bank, 2003:32). According to expert interviewee 13 (technical advisor, large donor funded solar programme), PERZA was the first programme of its kind in the Latin American region which sought to commercialise small scale decentralised solar energy (solar home systems) on a large scale. It is unsurprising that PV market development was proposed in the context of the market-led energy paradigm. Indeed, in an environment that saw private distribution companies with little interest or ability to make investments in increasing electricity coverage as well as limited public funds for grid extension, it is predictable that consumer-funded solar home systems would emerge as a solution for electricity access (Jacobson, 2004; 2007; Chapter Two). It was in this context that the commercialisation of solar home systems became an important strategy for electrification.

As emphasised in Chapter Three, progress in increasing electricity connections in rural and low-income areas was slow post-reform within the wider Central American region due to the lack of 'natural incentives' for the private sector. Rural electrification was not made a priority during the reform process; instead, it was included as an afterthought once key decisions about the utilities had already been made (Ripley, 2010). The MEM argues that between 1990 and 2007, the Nicaraguan state virtually 'disappeared' from projects promoting rural electrification, and only in 2005 was a rural electrification policy actually formulated[46]. In the post-privatisation era, it was assumed that the market would fulfil the sector's needs for increased electricity connections, however the World Bank recognised this failing and stepped in to finance a programme to fill the gaps where the market was unable to.

This section has argued that the expected benefits of private sector participation in electricity distribution did not materialise in the form of reduced distribution losses or increased electrical coverage in the Nicaraguan case. When discussing this with a finance official at Disnorte-Dissur, he perceived that despite some of the failings, privatisation still presented the only viable option available to the sector at the time. He questioned the extent to which the situation would have been any better had the sector remained in public hands:

> 'If we had to compare electricity distribution with another company, not the same, but one comparable with electricity distribution, it would be the water distribution company, ENACAL... Today ENACAL lose half of the water that they pump, of this, only half is actually billed... so what you have is a company which is only billing 25% of the water it pumps, so you have a company that is practically bankrupt... The government is constantly subsidising this company for it to be able to make payments to providers like us, who provide them with electric power... If the distributor had not been privatised it would have similar sorts of indicators... the fact that the government is running a public utility company makes its management very difficult especially when you need to take strong measures against non-payment, high energy losses and theft... The government knows that it is very difficult to distinguish between a client and a vote... this conflict of interest is the main reason why public service companies cannot make any improvements' [Expert interview 33 – finance official, Disnorte-Dissur S.A]

Interviewee 33's use of a comparison between the electricity and water sectors connects to the arguments made by privatisation advocates within academic debates that assert the state is inefficient, and that its activities inherently become politicised (McKenzie and Mookherjee, 2003). In Nicaragua, discontent with the privatisation of distribution activities led to serious opposition that meant that full sector privatisation was never achieved (i.e. not all electricity generation companies

[46] http://www.mem.gob.ni/index.php?s=3&idp=351&idt=2&id=267

were privatised), and the state water utility became protected from privatisation (expert interview 1 - founder, consumer defence organisation in Masaya). The IMF (2004) acknowledges the potential failings of privatising all components of the Nicaraguan electricity sector; principally that not only would there have been a distribution monopoly, but there would also have been a generation monopoly. Furthermore the IMF acknowledges the important role that the remaining state generators played in subsidising the favourable PPAs negotiated between generators and distributors in the 1990s.

These debates raise really interesting questions about the role of the state and market in governing the delivery of basic public services. Chapter Three emphasised that generalisations about public and private roles in electricity utilities are unhelpful; indeed, challenges brought about by reforms often bring into question the pertinence of a particular governance mode. According to Djankow (2003; cited in Millán, 2007), either a state or market-led approach could guarantee the satisfactory operation of an industry, however it is ultimately dependent on having the appropriate institutions to regulate and steer it. A common theme of discussion in this section has been the apparent lack of institutional capacity and the regulator's inability to enforce the electricity distributor's contract. Indeed, Ripley (2010) argues that the very lack of institutional oversight in the Nicaraguan case resulted in most of the promised benefits of privatisation failing to materialise. Poor governance of the sector had implications in terms of national energy security as conceptualised by Sovacool (2012a); not only were there large segments of the population without access to electricity (and unlikely to be served), but the electricity sector had become highly vulnerable because of its dependence on imported diesel for electricity generation. The consequences of these arrangements were highly detrimental to Nicaraguan society and culminated in the energy crisis which plagued the country during 2006 and 2007 to which our discussion now turns.

5.3. Convergence to crisis: the energy shocks of 2006-7

The first cracks in the electrical system became evident during the first years of Unión Fenosa's ownership of the distribution company Disnorte-Dissur in Nicaragua, when it began to fall into financial difficulty. As the country's electricity situation worsened, the private distributor became the focus of popular discontent and anti-privatisation sentiment (Cupples, 2011); this coincided with a series of complex inter-linked factors, not entirely attributable to the distribution company, which culminated in the 2006-7 energy crisis. These factors included: dependency on imported oil; the highly favourable PPAs and incentives established in the 1990s for private participants in the sector;

lowered electricity reserve margins; the distributor's inability to reduce system losses; and general financial illiquidity in the sector.

According to Miranda-Urbina (2006) by late 2003, the first difficulties with high oil prices began to be experienced. In response, the government passed the *establecimiento de la política energética nacional* (establishment of a national energy policy) (GoN, 2004). The document recognised the dangers of Nicaragua's dependence on petroleum for electricity generation and the low contribution from renewable resources. It called on the *Comisión Nacional de Energía* to 'establish the policies and specific strategies of the different energy sub-sectors to promote sustainable development and investment in the sector, guaranteeing optimal exploitation of… native energy resources' (ibid, 2004:2).

This law was approved with several others, including the 2005 rural electrification policy (GoN, 2005), the law incentivising the development of renewable energy (law 532) (INE, 2005a) and the energy stability act (law 554) (to penalise electricity theft) (INE, 2005b), however, little happened. According to Mostert (2009), a political power struggle (which as discussed previously, characterised the administration of Enrique Bolaños) led to the paralysis of the regulatory agencies' work, thus creating uncertainty in the sector. Mostert (2009) argues that by late 2005, the high prices of imported fuels revealed the macroeconomic and social costs of a society which had been unable to prioritise and promote renewable energy policies.

By this stage, a series of technical, financial and social factors were at play, which together contributed to bring about the collapse of the sector in 2006-7. As emphasised in section 5.1.3, favourable deals made with generators had led to generating capacity being locked into oil, and a wider sector starved of maintenance and investment. Between 1998 and 2006, the MEM notes that only 142MW was added to installed capacity, but that overall effective capacity had declined significantly. By 2007, this had caused a generation deficit in the order of 150MW (MEM, 2008). At the same time, the sector was suffering from liquidity problems; despite several adjustments in electricity tariffs, the losses being made by Unión Fenosa could not be recovered, causing a precarious financial situation. With rising oil prices, high levels of non-billed electricity contributed to a 'hole' in Unión Fenosa's finances and, by 2007, the MEM reports that Unión Fenosa owed US $32.8 million mainly to state generators (MEM, 2008). In the period leading up to the crisis, Herrera-Montoya (2005a) argues that financial resources had literally been 'bleeding' from State generators to subsidise the ailing distributor.

Although as discussed, popular discontent with the distributor had contributed to a culture of *no pago*, the financial circumstances of the general population had also worsened. The MEM (2008), for example, argues that the rise in fuel prices and the cost of the *canasta básica* [47] meant that low income households could not afford electricity bills, leading to an even lower level of recuperation for the electricity distributor.

Some electricity plants reduced production or stopped producing altogether due to spiralling debts from Unión Fenosa. The state owned hydroelectric plant, Hidrogesa, was forced to continue production at full capacity to cover the deficit. The generators blamed Unión Fenosa for not paying them for their output; they claimed they could not cover their costs and so refused to operate (McGuigan, 2007). The result was rolling blackouts of up to sixteen hours a day for approximately eighteen months. Having discussed some of the consequences of a poorly governed sector, the following section examines the ways in which the crisis was managed, which saw the reestablishment of a prominent role for the state in steering development of the electricity sector.

5.4. From crisis to stability?

Rolling blackouts plagued the 2006 electoral year. Prior to the presidential election, the FSLN's candidate Daniel Ortega had conversed with Venezuela's Hugo Chávez regarding Nicaragua's energy problems, and had arranged an aid package in the form of generating plant and cheap oil (Staten, 2010). This relationship arguably provided credibility to Ortega's campaign promises of easing the energy crisis, and could have been one of the determining factors behind the return of the Sandinista government. Meanwhile, electricity rationing had dire consequences for Nicaraguan society:

> 'Nicaragua faced severe electricity rationing, this means that around 20% of maximum demand was rationed up to 10 hours daily. At that time we were striving to impact as little as possible on the productive and social activities of the country, but rationing did adversely affect the economy'[MEM, 2011[48]]

Electricity rationing indeed had disastrous macroeconomic impacts on Nicaraguan society, and severe socio-psychological effects on the population (Cupples, 2011). By the time of the presidential election in November 2006, Nicaragua's energy problem had become a key campaigning issue and

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[47] This translates as 'basic basket', which refers to the cost of basic services and goods for a household

[48] This document was provided by the MEM in November 2011; it is a reference guide used by the Minister of Energy and Mines, Emilio Rappaccioli, during interviews, speeches and public appearances and reflects official information gathered by the MEM.

arguably saw the FSLN enter office in early 2007. This represents a significant watershed in the sector's history. Since the inauguration of the FSLN government, the country's 'energy problem' has been a high priority, illustrated by the CNE's promotion to 'Ministry' at the beginning of the new administration in January 2007:

> 'Energy has had a higher priority in this [Sandinista] administration... With this one we have policies that actually work, before there wasn't the political will to do things... yes they worked in rural electrification, yes they worked in generation, but on a very low profile... You can see the different interest this government had when it came into power, the national energy commission rose to the rank of Ministry of Energy and Mines, with this you have a very favourable advantage, as a ministry it has more power to direct the sector as it should... with the ministry clearly there is more support and the government has given full support to develop projects that broaden electrical coverage, to have renewable energy generation and provide a better service to the population' [Expert interview 13 –technical advisor to a large donor funded solar programme at the MEM]

The quote reflects how the change in government engendered a shift in political will and priorities; promotion of the CNE to Ministry status provided the mandate to tackle Nicaragua's energy crisis with greater resources and ambition. The ambition to 'transform' the electricity sector is frequently emphasised by the MEM:

> 'A core mandate is to initiate a path towards the transformation of the energy sector to create one that is consistent with the interests, needs and possibilities of our population. Providing safe, quality and low cost energy is fundamental for economic and social activities in the country, as well as for economic and social development.' [MEM, 2011]

Communications from the MEM (e.g. Perez, 2012) frequently articulate sectoral transformation along three strategic axes: the conversion of the energy matrix to predominantly renewable based energy; increased electricity coverage; and energy efficiency.

The first job of the newly elected government was to put a stop to the blackouts that had been plaguing the country. The government leveraged assistance from Cuba and Venezuela to install emergency petroleum based generators and, within three months, had installed the first 60MW of generating capacity (Morris, 2010; MEM, 2011):

> 'In conjunction with the solidarity of Cuba and Venezuela [power] generators arrived... These generators brought us out of the dark... Daniel Ortega inherited these problems when he came into power... but now we don't have such problems of the deficit in capacity.... And this is good, but oil does have a cost... But how much does it cost not to generate? How many lives are lost because there isn't electricity to operate on them? How much money is lost in the factories where they can't produce? [Expert interview 22 – government official, rural electrification department, MEM]

The involvement of Cuba and Venezuela in resolving Nicaragua's energy crisis highlights the regional geopolitical dynamic of Nicaragua's energy crisis. Ortega's strong alliances with the Latin American political left partially eased the crunch - which itself was a product of interacting layers of governance, i.e. shifting global energy paradigms, transmitted through IFI policy-tied assistance, and internal domestic politics and unrest. This emergency assistance led to a formalised 'Agreement of Cooperation and Mutual Assistance with Venezuela', which meant that Nicaragua could import oil at an attractive price and on favourable terms (GoN, 2009). Morris (2010) explains how a condition for supplying oil at this price is that certain revenues are earmarked for social programmes under Nicaragua's inclusion into the 'Bolivarian Alternative for the Americas' (ALBA) (discussed in more detail below). Assistance in the form of cheap oil and generating plant was the quickest, cheapest (in terms of upfront costs) and least risky means to solve the supply deficit (as discussed in Chapter Three):

> 'the generation capacity of the system in Nicaragua, was reaching its limit with respect to the demand there was... So at the time the Nicaraguan government had to contract a number of thermoelectric generation systems to mitigate these difficulties and these are basically emergency systems to get the country out of the hole it was in... the energy level was below the required standards, so in 2007 the first response was attending to the most essential - restoring electrical power' [Expert interview 29 – official at Inter-American Development Bank (IDB)]

The emergency diesel based generators were considered a 'short term' solution to overcome the immediate supply deficit, whereas in the medium to long term, the goal was transformation of the energy mix towards renewables-based generation [Expert interview 22 – government official, rural electrification department, MEM].

In the period following the instalment of the new administration, relations between the state and the private distributor deteriorated, evidenced by the threat of legal action on both parts. The

Nicaraguan government initiated arbitration following an audit which revealed the distributor's non-compliance with the concession contract (expert interview 32 - campaigner and energy specialist, consumer defence organisation). Unión Fenosa later claimed against their political risk insurance from the World Bank's Multilateral Investment Guarantee Agency (MIGA) (INE, 2009). While the discourse of Ortega's campaign speeches was to renationalise the distribution companies, one expert explained how this was a largely unrealistic ambition:

> 'when the elections were on, one of the campaign speeches of the current President [Daniel Ortega] was that he was going to expel the transnational corporation [Unión Fenosa]... but then you have a reality check - you cannot just nationalise a country's energy sector overnight... instead they had to make a deal to satisfy both the private company and the Nicaraguan people because we could not take on nationalisation nor could we keep Nicaragua switched off for more than twelve hours every day' [Expert interview 32 – Campaigner and energy specialist, consumer defence organisation]

Ortega's impassioned campaign speeches did not reflect the reality of expelling a company backed by MIGA; Unión Fenosa was seeking US $53 million in compensation for the damage it claimed had been done to its investment (McGuigan, 2007). Instead of arbitration therefore, a cooperation agreement to resolve the energy crisis was brokered by the King of Spain (El Nuevo Diario, 2007). Decree 70-2007 (INE, 2007), the 'creation of an inter-institutional commission for negotiation with Unión Fenosa International' recognised the negative impacts the energy crisis on the social, economic and productive sectors of Nicaragua. In 2008, the state and Unión Fenosa agreed to presidential decree number 5557, the *protocolo de entendimiento* (memorandum of understanding). The memorandum contained articles relating to electricity theft and fraud, specific investment clauses, agreements on the *asentamientos humanos*, promises to suspend arbitration processes, and finally the part-renationalisation of the distribution companies through the transfer of 16% of shares to the state, in exchange for cancelling the debts accrued by Unión Fenosa with state-owned generators (INE, 2009). One interviewee explained the main elements of this agreement:

> 'In 2007 when Daniel Ortega took office, there was energy rationing over 12 hours a day, a reality of the fact that the sector was collapsed, broken by bad policies… the distributor had no money to pay the generators, and the generators had no money to pay their oil suppliers, so the market and all of its chain had collapsed and the distributor's losses oscillated around 30%, shared between technical and non-technical losses… so there was a great quantity of millions that they lost… so what did the Government do? They signed the memorandum of

understanding with the distributor, saying that 'we are going to support them until 2011, but with the condition that they will reinvest around 30 million dollars [in the system]'... the government promised to give economic stability to the electricity sector by guaranteeing monthly cash flows… which would allow the distributor to have income to pay the generators... we are conscious of the *asentamientos humanos*, the areas that are not profitable… the government decided to work in these areas through the Ministry [of Energy] and FODIEN … the idea is that we should be working hand in hand with the distributor' [Expert interview 22 – government official, rural electrification department, MEM]

The memorandum dealt with the main causes of contention between the state and distributor: the complex issue of the informal settlements and the distributor's poor record of investment. The memorandum resulted in law 661, the *Ley para la Distribución y Uso Responsable del Servicio de Energía Eléctrica* (law on the distribution and responsible use of the electricity service), which established electricity theft as a criminal offence, whilst also re-iterating the obligations and social responsibilities of the distributor to serve users with an efficient and high quality service (INE, 2008). The memorandum also decreed that the government and distributor should work closely to improve service to those in low income urban areas (GoN, 2009). Having discussed the steps taken to address Nicaragua's energy crisis, this section has traced the beginnings of an increasingly interventionist state in governing the electricity sector.

5.5. 2007 onwards: from market-led to an interventionist turn?

The energy crisis saw the new government step in to provide liquidity or 'oxygen' (Expert interview 22 - government official, rural electrification department, MEM), to kick-start a collapsed system. According to the MEM (2011), the government's rapid resolution to electricity rationing and the signing of the memorandum of understanding represented a 'powerful message to the country and domestic and foreign investors to continue normally with productive and social activities and undertake new projects in all sectors of the economy' (MEM, 2011). This represents a significant shift in the sector's governance, reflective of Goldthau's (2012) energy paradigm thesis. The interventionist turn has seen increased levels of state involvement in the sector because of unease with its pro-market direction and increasing recognition of the crucial importance of energy in a society's development. Indeed, interviewees from across the sector expressed the view that the state has a key role to play in guaranteeing national energy security, which has a positive multiplier effect on the entire national economy:

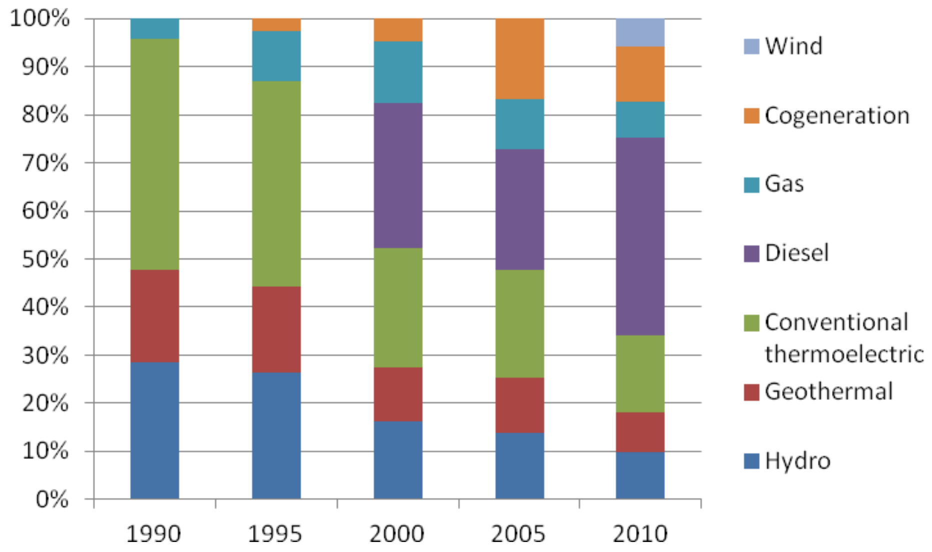
> ‘The first thing an investor looks for when he comes to evaluate the investment climate, is the guarantee of an electricity supply... any industry, factories principally require energy... so to have electric energy is a fundamental element, not only for investment projects in production, but also in tourism... If an industry comes, a factory, the first thing that they need is the guarantee of electricity. And so, energy is an important part of the economy and for the future no? In order to facilitate the country’s development, logically, Nicaragua requires investors’ [Expert interview 31 – former official of the state electricity company]

This actor’s comment reflects the crucial role of any country’s electrical sector to drive economic growth and inward investment. This reflects the findings of studies that identify major macroeconomic growth drag as a result of power outages (e.g. Andersen and Dalgaard, 2013; Diboma and Tatietse, 2013) or the disastrous effects that insecure electricity supply has on the productivity, growth and competitiveness of businesses (see Deininger et al., 2007; Dinkelman, 2011) or broader social and political stability (Varigonda, 2013). The insecurity created by the lack of a reliable electrical system was perceived as extremely negative for inward investment. In particular it was seen as non-conducive to any form of investment in electricity generation, specifically renewable electricity generation:

> ‘The government is certainly interested in supporting the distribution company and looking at how it can reduce its losses and become financially stable... Why? because if you want to change the country’s energy matrix, if you want to have renewable energy or energy that is cheaper than depending on oil, you need to be able to attract investors...but certainly no investor will invest in a power plant when he sees that the distribution company’s profits are so weak, because it is the distribution company that gives security to a generator because at the end of the day, it is the distributor who is going to pay for their output’ [Expert interview 33 – finance official, Disnorte-Dissur S.A]

A financially unstable distributor does not create confidence for potential investors. For renewable electricity generation in particular, perceived risks are heightened because of the relatively high upfront costs associated, long lead times, lack of knowledge about RE, the novelty of RE in a particular context, and in a country like Nicaragua (which had previously expressed the intention to expel a transnational company), political risk (see Chapter Three). This raises questions about whether the more interventionist approach of recent years has created the right conditions to incentivise investment in generation capacity. Since the FSLN came to power, installed generation capacity has undergone significant growth, increasing by 34%, with growth largely consisting of diesel-based capacity, due to the emergency plant installed to resolve the energy crisis. While installed capacity remains dominated by diesel (41% of the total), the generation mix has become more diversified with the introduction of wind power for the first time in 2008 (Figure 18).

Figure 18. Installed electrical generating capacity by source (MW) in Nicaragua 1990-2010



Source: adapted from CEPAL (2012)

While at present renewables-based electricity represents 35% of installed capacity, ambitious plans have been unveiled to completely transform the country's installed generating mix. Of the 932MW addition to the system that is planned during the period 2010 to 2017, 100% is projected to be renewables based, utilising hydro (602MW), geothermal (212MW) and wind (118MW) (DGERR-MEM, 2010). Such goals are highly ambitious; not only will generation capacity be nearly doubled within seven years, but expansion will be entirely renewables based. According to the MEM (2011), the government has been successful in harnessing investment for generation programmes:

> 'The other great achievement [of this government] has been advancing with steady steps in the process of transforming the energy matrix, from high oil dependency towards harnessing the potential of renewable energy available to the country... In this transformation process exists significant participation of private investors, who can take on the technical, economic and commercial risks at an international level. That is to say, Nicaragua as

a country has managed to mobilise large financial and technical resources required for this type of transformation '[MEM, 2011][49]

The Nicaraguan Human Development Plan 2010 (GoN, 2011) emphasises that energy matrix transformation is being promoted through the approval of new projects to be carried out by private enterprise and public-private partnerships, with a projected US$2.5 billion spend on new renewable electricity generation projects between 2012 and 2016. Some of the projects have benefitted under the Clean Development Mechanism (CDM)[50], financing from ALBA, regional banks and support from public-private partnerships.

As discussed in Chapter Three, the IDB Climatescope index report (IDB, 2012) indicates the current significant levels of interest in the Nicaraguan energy sector from multiple stakeholders. Indeed, Nicaragua is highlighted as Latin America's top destination for clean energy investment from international donors. The largest and most recent energy programme to launch in Nicaragua is called PNESER (*Programa Nacional de electrificación sostenible y energía renovable* – National Sustainable Electrification and Renewable Energy Programme), which aims to 'transform [Nicaragua's] energy matrix and expand electricity access'[51]. PNESER is a multi-donor programme coordinated by the IDB that will provide up to US$381 million in loans and technical cooperation to Nicaragua in conjunction with other donors and IFIs[52]. The objectives of this programme are to: increase rural electrification to cover 85% of the population within four years (mainly in concession zones), to 'normalise' 164,000 households currently with illegal electricity connections; to increase electrical coverage in off-grid areas using renewable energy technologies and extend renewable electricity generating capacity; to install 214km of new transmission lines; to promote a national

[49] DGERR-MEM's (2010) 'Investing in Nicaragua's electricity sector' sells the sector as a favourable site for investment, possessing the suitable institutional and legal framework, a competitive business environment and 5000MW of renewable electricity resource potential. The document displays the areas for investment, indicating zones of the country under investigation for their feasibility in geothermal, hydropower, biomass and wind potential. The report indicates that significant private sector interest has been attracted thus far, and that the IDB is supporting further RE feasibility studies.

[50] The CDM allows emission-reduction projects in developing countries to earn certified emission reduction (CER) credits, each equivalent to one tonne of CO2. These CERs can be traded and sold, and used by industrialised countries to meet a part of their emission reduction targets under the Kyoto Protocol, see: http://cdm.unfccc.int/about/index.html

[51] See the IDB website for more information on the PNESER programme:
http://idbdocs.iadb.org/wsdocs/getdocument.aspx?docnum=35280898 and
http://www.iadb.org/en/news/news-releases/2010-07-08/sustainable-electrification-and-renewable-energy-in-nicaragua-idb,7416.html

[52] Participants include: the World Bank, International Finance Corporation, Spanish Agency for International Development Cooperation, the Korean Exim-bank, Latin America Investment Facility, European Investment Bank, Central American Bank for Economic Cooperation, Climate Investment Fund and the Nordic Development Fund

energy efficiency programme and strengthen the agencies responsible for isolated generation systems outside of the concession area[53]. The IDB's aim is to support the Nicaraguan government's agenda, which is currently focused on energy sector transformation (expert interview 29 - official at IDB). The IDB has taken a leadership role in attracting other donors and investors to the programme, in what appears to be a highly ambitious and transformative partnership programme.

Interestingly, the funds loaned from multiple PNESER donors will be used to fill the gaps that the arrangements made under neoliberal sector reforms were unable to address; for example, US $44.9 million of the budget will be spent on the 'normalisation' of illegal connections in the *asentamientos humanos*, which means creating a fortified grid that will be both difficult and dangerous to access illegally (expert interview 28 – distribution engineer, Disnorte-Dissur, S.A). The question of the Nicaraguan state obtaining loans to tackle the long-seated issue of electricity losses, and therefore enabling Disnorte-Dissur to become financially viable, is highly contentious. The IDB official explained:

> 'I think we have exceptional circumstances, we're talking about segments of the population that are difficult to finance through the current distribution schematic, so what is required is an extraordinary amount of money... So this is where the Bank enters with an extraordinary contribution to support the Ministry... so it will be the Ministry in charge and executing these projects... once the projects are implemented they will be transferred to the control of the distributor... So this is the extra effort required to formalise these users - this has been beyond the scope of natural growth that could be obtained with only the efforts of the distributor' [Expert interview 29 – IDB official]

The official emphasised the incredible amount of financing required to reduce electricity losses, and consequently improve the viability of electricity distribution activities in Nicaragua.

The second largest component of the PNESER programme is to facilitate electricity to unserved populations (US $132 million of the budget). This chimes with the government's envisioned sector transformation, and is an area arguably omitted from past Nicaraguan energy policy concerns regardless of state or private ownership. In fact, CEPAL (2011a) indicates that there has already been accelerated growth in grid connections between 2007 and 2010, increasing from 61.5% to 74.6% of the population. More up to date figures from the MEM reveal that by 2011, grid

[53] See footnote 51 and also the MEM website for further information:
http://www.mem.gob.ni/index.php?s=4&idp=352&idt=2&id=269

connections had reached 78.6% of the population[54]. Connections increased by 27.8% between 2007 and 2011, compared with 3.6% (1990-2000) and 24.1% (2001-2006). These data do not, however, take into consideration the off-grid populations that have been reached by the ever-expanding distributed renewable energy technology market – especially solar – which, as discussed in section 5.2, emerged to fill the vacuum in electricity coverage activities. While for some scholars the expansion of off-grid renewables markets cements the 'impossibility of large scale publicly funded energy infrastructure' (Cross, 2012: n.p; see Chapter Two), the PNESER programme is designed to adopt a two-pronged approach, consisting of both aggressive grid electrification activities, alongside the deployment of small scale solar energy technologies in the most remote areas.

The current level of support from donors and regional banks in the rural electrification arena is striking. Recent programmes promoting electricity access in off-grid zones (either through renewable energy technologies or grid extensions) are worth over half a billion US dollars (see Chapter Three, Table 7 for a partial listing of recent solar energy initiatives). An analysis of the websites of IFIs involved in energy sector financing reveals a shift in lending activities; from the 'restructuring' loans of the 1990s (section 5.2.3), to lending in areas where it had been assumed that the private sector would play a key role[55]. This provides evidence of the failure of the market-led approach in meeting energy sector needs in Nicaragua, and further support for Goldthau's proposition that globally a new 'energy paradigm' has emerged, in which a turn towards increasing 'interventionism' is seen as the only way to address the energy challenges currently facing nations (Goldthau, 2012; see Chapter Two).

Aside from the large international donors, and public-private partnerships, the proliferation of national energy interest groups demonstrates the prioritising of the 'energy issue' in Nicaragua. One example is the *Asociación Renovables* (Renewables Association) which was launched in 2010, a partnership between 30 organisations whose aim is to promote the 'equitable and efficient use of renewable energy... for a sustainable energy future'[56]. Civil society groups, NGOs and universities are also engaging in rural electrification activities, particularly with renewable energy (e.g. financing hardware programmes, providing training, etc.), albeit on a small scale.

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[54] Personal communication with official at the MEM, August 2011

[55] For IDB's recent energy-related loan portfolio see: http://www.iadb.org/en/projects/advanced-search,1301.html?query=energy&ProjectNumber=&Status=&Country=NI&Topic=&Sector=&SubSector=&Fund=&Cofinancing=&FinancialProd=&ProjectType=&YearFrom=&YearTo=&FinancingOver=&FinancingUnder=&FinCurrency=&adv=true

[56] For information on *Asociación Renovables* vision and mission, see: http://renovables.org.ni/www/index.php?option=com_content&view=article&id=50&Itemid=69

What has been driving this turn of events? Within a relatively short amount of time, transformation from a sector seemingly starved of investment to one which is harnessing programmes ranging from large-scale multi-million dollar interventions to small scale-local projects has occurred. The key actors involved in financing energy related programmes point to the country's long standing 'energy problem' and in particular the crisis in 2006-07 acting as a catalyst or 'turning point' for sector improvement. The following quotes highlight these perspectives:

> 'In 2006 when the [energy] system in Nicaraguan began to show signs of difficulty simply in supplying electricity to users .... It sought support from donors and the Bank [IDB] was available to assist, to take the lead and put lots of effort in to develop [energy] programmes...the programmes that you see now are a response to the sector's breakdown' [Expert interview 29 – IDB official]

> 'This country structurally needed it, we desperately needed a huge energy boom... Companies could not produce without energy [during the crisis] so they really needed that [boom in investment]... Ironically Nicaragua has a pretty developed industry - we're talking about the western side of the country... when it has energy it is productive, very productive... they build a lot of stuff, they grow a lot... they're also involved in the transformation of rural products... so really Nicaragua was dying to get a decent electricity solution and rural electrification solution... we were just waiting for that to boom' [Expert interview 7 - founder of NGO with off-grid RE initiative, convenor of national renewables association]

> 'Maybe that the awareness of the important economic role of electrification has been realised and now there is a political conjuncture between the issues of renewable energy sources, making [electricity] generation more sustainable and energy access... Prior to [our] programme starting, Nicaragua had serious energy problems - worse in Managua and other parts of the country' [Expert interview 30 - coordinator of large donor funded SHS programme]

These quotes suggest that there was a shared recognition that the time for profound change had arrived for Nicaragua's electricity sector. Interviewee 30 in particular hints at the important intersection of the climate, energy security and energy access agendas – the facets of the energy trilemma discussed in Chapter Two (see section 2.1) in the rapid developments that have occurred. Several interviewees related the current momentum and influx of funding to Nicaragua as reflecting broader 'trends' in energy financing:

'**EI30**: this conjuncture between the different issues, these types of projects at the moment are selling well with the regional banks, renewable energy is in everything, all institutions and also the banks ....the IDB is talking about renewable energy, never before had they spoken of renewable energy

DG: Would you say that it is fashionable?

EI30: It is fashionable, this joining of issues, it is the awareness of the need for more sustainable electricity generation. In fact I'd say that it is more than fashion because for many years we've known that oil is becoming scarcer, this is already known, the truth that oil is not infinite, the price will ultimately go up...so we have institutions that get behind these issues and drive it in countries like Nicaragua' [Expert interview 30 - coordinator of large donor funded SHS programme]

'I do feel that it has trendy for a while, maybe a year or two, and even since the Al Gore movie and the IPCC got the Nobel Prize... the climate change propaganda has kicked in and people are now listening to this new scripture... so that inevitably translates into financial opportunities here in Nicaragua' [Expert interview 7 - founder of NGO with off-grid RE initiative]

The idea that energy programmes, especially those promoting renewable energy and/or those providing off-grid electricity, are currently 'selling well' with the IFIs is an interesting postulation. This helps to think through the ways in which current global debates on 'sustainable energy for all', are transmitted into national contexts such as Nicaragua. It also reflects the conjoining of three global policy drivers (climate change, energy security and energy poverty), and the changes in governance patterns and the finance available to address them (e.g. Goldthau, 2012).

At the same time, in addition to global policy drivers, there is evidence of national level political-economic drivers behind the recent energy transformations in Nicaragua. An official from the MEM argued that emphasis on electricity demonstrates the government's commitment to programmes supporting the most vulnerable populations:

'It was a dream of the young people of this time, who had overthrown the dictatorship, to bring wellbeing to the *pueblo* [people]... many of our leaders today, for example our *Comandante* [Commander] Daniel [Ortega], lived in the rural areas, this was where the war to end the dictatorship took place... And through this coexistence, this is where our leaders

> discovered all of the necessities that the rural population had... Health, education, energy needs... People were dying from simple illnesses, that already had cures....children weren't able to walk properly because they had suffered from polio, yet the vaccine already existed... There wasn't electric energy, communications, roads... This is a promise made by that generation with the Nicaraguan people... it was a dream that is going to be realised now... It was a promise that the *Comandante* could not achieve in the 80s because there was a war, and in a war obviously, all of the resources are destined to defence... So now in the second stage of the revolution, where there is no war, we are taking many of these dreams, these projects and promises to make them realities... And if we are talking about development, we necessarily have to talk of electricity' [Expert interview 22 – government official, rural electrification department, MEM]

This quote evokes the notion of the 'second stage of the revolution'[57], where aspirations that were unable to be met during the first term of Sandinista government (1979-1990) could now be realised. According to the MEM website, the goal of FODIEN is 'rural electrification without exclusion', with electrical service counting as a 'universal right', and act as a 'motor of progress'[58]. The extent to which the ambitions of the interventionist turn can be achieved is the focus of the following section.

5.6. End of the rolling blackouts and towards a 'renewable energy revolution'? An era of politicised electricity

According to Walker and Wade (2011), under the first period of the second Sandinista administration (2007-11), economic policy was not dissimilar to other post-1990 governments, except that Nicaragua was now the recipient of millions of dollars in aid and low interest loans from ALBA. At the end of this period, the Nicaraguan economy had grown by 4.5% (CEPAL, 2011b). This growth has been described as the country 'recovering the road towards expansion', which had temporarily been disrupted by the international financial crisis (ibid: 5). Walker and Wade (2011) however argue that despite economic growth, rising fuel costs and growing unemployment threatened to undermine these gains.

The administration has been characterised by its focus on social programmes, something that had been overlooked by the previous three governments. These include *Hambre Cero* (Zero Hunger),

[57] In Daniel Ortega's presidential inauguration speech of 2007, he claimed that his government would represent the 'second stage of the Sandinista Revolution'; see the Council on Hemispheric Affairs: http://www.coha.org/nicaragua-under-daniel-ortega%E2%80%99s-second-presidency-daniel-style-politics-as-usual/

[58] See: http://www.mem.gob.ni/index.php?s=3&idp=351&idt=2&id=267

Plan Techo (Plan Roof) and *Usura Cero* (Zero Usury), which are all programmes aimed at reducing poverty in Nicaragua; at the same time electricity provision has arguably also come under the government's social mandate, in particular the expansion of electricity services to remote communities. Fieldwork experience suggests that electrification in particular has become a highly politicised activity; both field trips coincided with a presidential election year, and the election itself took place during the second phase of fieldwork in November 2011.

Two weeks prior to the presidential election in 2011, a visit was made to a remote (non-grid electrified) community in the department of Estelí, for survey work related to this research. Several of the respondents revealed that FSLN Ministers had recently visited their community to promote the party for the upcoming presidential election. Community members were promised prompt connections to the electricity grid if they were to unite and '*votar en la casilla dos*'[59]. Two unnamed officials at the MEM corroborated that electrification had become a highly politicised process in the electoral year. According to one official, *El Consejo Liderazgo Sandinista* (Sandinista Leadership Council) had cells in every public institution to promote the party. Prior to the elections, the MEM cell had instructed officials to visit undecided voters, and remind them that it was the Sandinistas who were bringing electricity to unserved populations. He suggested that electrification projects were politically motivated i.e. by the desire to win a further term in government rather than related to any concerns regarding human development needs. This echoes Walker and Wade's (2011) observation that the government has come under criticism for the proliferation of clientelistic, paternalistic and populist development programmes that in some cases, it is alleged, have involved political favouritism in the choice of recipients. Envío-Nitlapán (2011) also criticises the government for investing in a wide range of 'aid' style programmes, with the intention of 'vote-buying' (p. 5).

A further concern is that the financing for many of the social programmes derives from 'the Venezuelan cooperation's abundant petrodollars' (Envío-Nitlapán, 2011:5). As previously discussed, a condition of receiving cheap oil is that certain revenues be saved for social programmes. A complex and opaque system of oil sales and revenue transfers between PETRONIC (semi-private Nicaraguan petroleum conglomerate), PDVSA (Venezuela's state-owned oil enterprise) and ALBANISA (a part state, part private Venezuelan-Nicaraguan firm), result in reduced oil prices, and income for social programmes in Nicaragua and the wider ALBA social fund[60]. Concerns over government corruption and lack of transparency in the uses of these funds are rife, however, for example, the funds received through ALBANISA are not obliged to face the scrutiny of the national

[59] 'Vote in box number 2', this refers to the ballot paper on which, box 2 represents a FSLN vote.
[60] See the Council on Hemispheric Affairs: http://www.coha.org/nicaragua-albanisa-the-privatization-of-venezuelan-aid/

assembly. Interviewee 11 (official at the energy sector regulator, INE) argued that these complicated arrangements do not favour good governance in the sector.

ALBANISA is becoming a big player in the energy arena – not only are ALBANISA investing in electricity generation plants (El Nuevo Diario, 2011), but they are also cushioning users from further price hikes in electricity tariffs by subsidising electricity bills[61]. However, there are also rumours of an ALBANISA takeover of the private distributor (Interviewees 28 - distribution engineer, Disnorte-Dissur, S.A, and 32 - campaigner and energy specialist, consumer defence organisation). The future of the sector, however, in a post-Chávez Venezuela is now increasingly uncertain.

Aside from concerns about good governance, while interruptions in supply have been reduced, there are persistent issues which are seemingly unresolved despite the memorandum of understanding signed between the government and Unión Fenosa. According to interviewee 1, approximately 80% of complaints received everyday at his consumer defence organisation still relate to the electricity distributor (complaints include the inconsistency of electricity billing, dubious meters, overcharging and intermittent supply). Interviewee 11, an official at the energy sector regulator, corroborated this assertion. In his role which involves investigating claims made against the electricity distributor, he found consistent flouting of the law, resulting in the regulator almost 'asphyxiating' the private distributor with fines related to violations against consumers (including overbilling, failure to respond to requests for electrification[62], consumer injuries as a result of obsolete infrastructure and irregular metering).

Despite these concerns, it is clear that the sector has undergone significant transition, and was recently hailed as the 'ideal laboratory' or 'exemplar' for how countries can make the transition towards low carbon futures (Rogers, 2012: n.p.). Despite some of the concerns voiced about populist policies and a lack of transparency, most actors whose views were sought during the research agreed that the strong political will and support from the international financial institutions

[61] Until new generation projects go online, electricity prices remain the highest in the region (CEPAL, 2011a), however the government are seeking to cushion users from increased costs, especially low consumption users (under 150 kWh/month), by subsidising the electricity tariff. The Electrical Energy law (272) was amended to authorise the INE and MEM to seek financing to subsidise energy rates for consumers until energy becomes cheaper through the entrance of new renewable electricity generation projects in 2016 (El Nuevo Diario, 2012). In June 2011, electricity tariffs increased by an average of 41.8%, however this increase was financed by ALBANISA, the joint Venezuelan – Nicaraguan, part state, part private company that imports oil from Venezuela (INE, 2011). It is likely that ALBANISA will be the main financer to subsidise electricity tariffs until 2016.

[62] A meeting with a key informant at the MEM (March 2011) revealed that there are some 443 communities (100, 632 individuals) within 150 metres of the grid who have requested electricity and are waiting (some for many years) for a response from the distributor.

and the donor community meant that the objectives of sector transformation would most probably be achieved within the next decade.

5.7. Conclusion

This chapter has provided a detailed examination of national energy governance in Nicaragua, tracing the ways in which the sector has been shaped by shifts in global energy paradigms, but also national political economic frameworks over recent decades. This chapter provides evidence that supports Goldthau's energy paradigm thesis as discussed in Chapter Two. With the origins of the electricity sector tied to the expansion of industry in the early twentieth century, a state-led mode of governance then dominated the sector from the 1950s to the 1990s. This was a particularly turbulent period of Nicaraguan history, in which political-economic (both internal and external) factors contributed to shaping an electrical system characterised by high levels of inequality and vulnerability. The statist model of energy governance largely gave way to neoliberal reforms in the 1990s and early 2000s, initiating the privatisation of state-owned enterprises and market liberalisation processes. This shift was rooted in wider economic policy shifts and transmitted through policy-tied assistance from IFIs. The years following these reforms witnessed ongoing energy challenges, related to the increasing dominance of fossil-fuel based generation and limited progress in the expansion of electrical coverage – cementing the inequitable and vulnerable nature of the energy system.

Poor governance of the energy system meant that the potential benefits of reform failed to materialise, most notably culminating in the Nicaraguan energy crisis of 2006/07, in which national energy security was severely threatened. This energy crisis represents a turning point in the sector's history. After eighteen months of intermittent electricity supply, a change in government saw the elevation of Nicaragua's energy problem to the top of the political agenda. At the same time, shifts in the global energy arena saw significant financial flows and support from the international community to address the 'energy trilemma' faced by countries of the developing world. Aggressive policies to reduce oil dependence and increase access to electricity illustrate the interventionist turn in governance. While concerns have been raised about the politicised nature of electricity and poor governance in the Nicaraguan context, experts agree that an 'energy revolution' is underway.

A key element of the so-called energy revolution is the high level of commitment to increasing electricity coverage amongst unserved populations. Over recent years frequent crises in the electricity sector (e.g. underinvestment or generation deficits) have diverted attention from the 'other' energy crisis – that of the vast proportion of Nicaraguans living without access. The privatisation process served to further reinforce inequitable access. It was in the aftermath of electricity sector privatisation - in a context where both the private distribution company and the state demonstrated limited will and ability to extend electricity access with conventional grid extension activities - that decentralised solar energy technologies emerged as a mainstream solution to providing access. Thus, the early 2000s saw the birth of the solar PV market, and the subsequent commercialisation of small scale solar technologies in areas of the country unserved by grid electricity. As the following chapter discusses, the market grew exponentially in a matter of a few short years.

This chapter contributes to the thesis and broader literature in two key ways. Firstly, it embeds analysis of the Nicaraguan energy sector within global energy debates and the national political-economic context (e.g. Büscher, 2009). Secondly, it extends previous analyses of the sector to consider contemporary developments (post energy crisis) and their interactions with these global debates. This chapter has also prepared the ground for profiling the emergence and propagation of decentralised applications of solar energy in off-grid areas of Nicaragua, which is outlined in the next chapter.

Chapter Six. The Rise of Solar Energy in Nicaragua

Within the broader political-economic framework of electricity established in the previous chapter, this chapter aims to analyse the growth of the off-grid solar energy market in Nicaragua during the last decade, and discuss the implications of its trajectory. The launch of the World Bank *'Proyecto de Electrificación Rural para Zonas Aisladas'* (PERZA) in 2003, saw technologies such as the solar home system (SHS) become the favoured option to address gaps in rural electrification and the off-grid populations previously overlooked in energy policy considerations. Since PERZA, the off-grid solar energy market segment has experienced significant growth, with the number of actors and active programmes burgeoning.

Chapters One and Two indicated this thesis' emphasis on energy governance and the political-economic power structures of electricity access. This chapter therefore emphasises the actors, decision makers, institutions and regulations integral to the promotion of solar energy in off-grid areas of Nicaragua. Critical to understanding the practices of solar energy is to embed analysis within the complex agendas of the international community and national political-economic frameworks (as discussed in detail in Chapter Five). The 'solar actors' belong to various actor groups (see Chapter Four, Table 16), ranging from private sector SHS providers to grassroots development organisations, and have adopted a diversity of approaches to the delivery of solar energy technologies within Nicaragua. They also operate in various regions of the country, including the Atlantic coast region, considered to be one of the poorest regions in Latin America, as well as the comparatively 'well off' Pacific and Northern mountain regions. Analysing the positions, motivations and expectations of these key actors enables the complex practices and politics of distributed solar energy technologies in Nicaragua to be unravelled. Interviews with solar actors draw out the perceived challenges and barriers to the sustainable deployment of distributed solar energy technologies within Nicaragua.

This chapter is structured as follows: section 6.1 begins by analysing PERZA and is followed by a discussion of off-grid solar energy market development from the perspective of the actors instrumental to its growth. Section 6.2 specifically addresses research question two, namely to explore the practices and visions of those involved in off-grid solar energy in Nicaragua by examining the positions of these different actors. Through the investigation of three 'project organised' solar programmes introduced in Chapter Four (Table 8), the variety of delivery mechanisms, and the often competing motivations, objectives and narratives of the actors promoting solar energy interventions, are analysed. Section 6.3 addresses research question four, by examining key challenges facing solar energy interventions in the Nicaraguan context, from the perspective of the stakeholders integral to their delivery. Finally, section 6.4 draws conclusions about the outlook of the off-grid solar energy market, and points forward to the local level focus of the following chapter.

6.1 PERZA and the establishment of the off-grid solar energy market segment

Chapter Two provided a detailed discussion of the global evolution of PV as a major component of strategies for addressing low levels of energy access in the Global South. The discussion there suggested that technologies like SHS are 'vital' in the efforts of international financial institutions (IFIs) to curb energy poverty (Sovacool et al., 2011: 1534). Indeed, IFIs have played a particularly important role in the development and growth of viable off-grid PV markets in countries of the Global South, for instance, through creating demand, providing training and financing systems (Acker and Kammen, 1996; Corsair and Ley, 2008). As well as the support of IFIs, the literature examining the dissemination of PV identifies other drivers behind the emergence and growth of PV markets for off-grid electricity provision. Off-grid solar energy technologies emerged as important tools for rural electrification in the wake of market-led energy policies, which had overseen a decline in public sector financed grid electrification programmes (Jacobson, 2007). Socio-economic factors, such as the household incomes of potential users of solar energy technologies (particularly the rural middle classes), are also considered to be highly influential on PV market growth (Jacobson, 2004; Bawakyillenuo, 2012). Finally, political-structural factors, for example the presence of proactive donors and stable political contexts, are also identified as drivers of PV dissemination (Ondraczek, 2013) (see broader discussions in Chapter Two).

In the case of Nicaragua, the off-grid solar market was consolidated by the launch of the World Bank supported PERZA in 2003. This programme emerged in the immediate aftermath of electricity sector reform, which, as discussed in Chapter Five, had failed to increase national levels of electrification. PERZA emerged during a relatively stable period of Nicaraguan history (compared to the significant upheavals and political crises of previous decades), when IFI assistance had returned and growth was being witnessed in the agriculturally productive regions of the country (CEPAL, 2005). These factors arguably contributed to the growth of the off-grid PV market, which has matured over the decade since then.

During the Nicaraguan power sector reform process (from the mid-1990s to early 2000s), the World Bank's Public-Private Infrastructure Assistance Facility (PPIAF) began to support the *Comisión Nacional de Energía*. In particular, it supported the Commission to elaborate a national rural electrification strategy, specifically 'the design and implementation of innovative, private sector-led off-grid electricity service provision models that would provide sustainable solutions for off-grid users' (World Bank, 2001:5), thus filling a 'gap' in remote electrification plans (World Bank, 2003:32). This strategy was PERZA.

In 2003, after a series of preparation studies, PERZA was approved (Ley et al., 2006). The programme's overall aim was to 'support the sustainable provision of electricity services and associated social and economic benefits in selected rural sites in Nicaragua, and strengthen the Government's institutional capacity to implement its national rural electrification strategy' (World Bank, 2003:3). PERZA's coordinator (2003-2006) stated that the programme represented an 'innovative' way of approaching electrification in the Latin American region, wherein various sectors collaborated to try and guarantee 'sustainable' electricity provision:

> 'In all electrification projects you have to think about it being sustainable…so the objective should always be to guarantee this, because otherwise you are going to have piles of abandoned systems that are unusable… The PERZA is a project which was the first pilot project of its kind at the Latin American level where several components converged... it was no longer seen simply as a rural electrification project where you just put the technology and that people have lighting full stop. No. Instead it was addressed from a more holistic viewpoint… PERZA was a programme that worked with all the aspects necessary for sustainability, including business development, extending access to micro credit, forming the policies and strategies necessary for rural electrification, communication and also social promotion' [Expert interview 13 – technical advisor, large donor funded solar programme]

PERZA incorporated a variety of rural electrification components, including grid extension, small hydroelectric plants and solar battery charging stations. The main interest of this chapter is in the role that the 'Solar PV Market Development Programme' component of PERZA played in stimulating the market for small scale residential solar energy technologies in areas unserved by the national electricity grid[63]. This particular programme was designed to achieve widespread commercial

[63] While the focus of this thesis is the residential off-grid solar market, it is important to note other solar market segments that have also grown in recent years: e.g. solar energy for off-grid schools and health centres (e.g. see Programa EuroSolar, http://www.programaeuro-solar.eu/); telecommunications, broadcasting and

dissemination of SHS and to 'establish the beginnings of a sustainable local PV industry structure and fill a gap in remote electrification plans' (World Bank, 2003:32). As discussed in Chapter Five, while Nicaragua had 'successfully' unbundled its power sector and privatised distribution activities by the year 2000, the vast majority of the rural population were still without access to electricity. SHS emerged as an important technology in a context where state funding for rural electrification was curtailed and where the interests of the private sector electricity distributor did not extend to remote areas. SHS were therefore considered important technologies for Nicaragua, since they provided a least cost option for supplying basic electricity services to dispersed populations (World Bank, ibid).

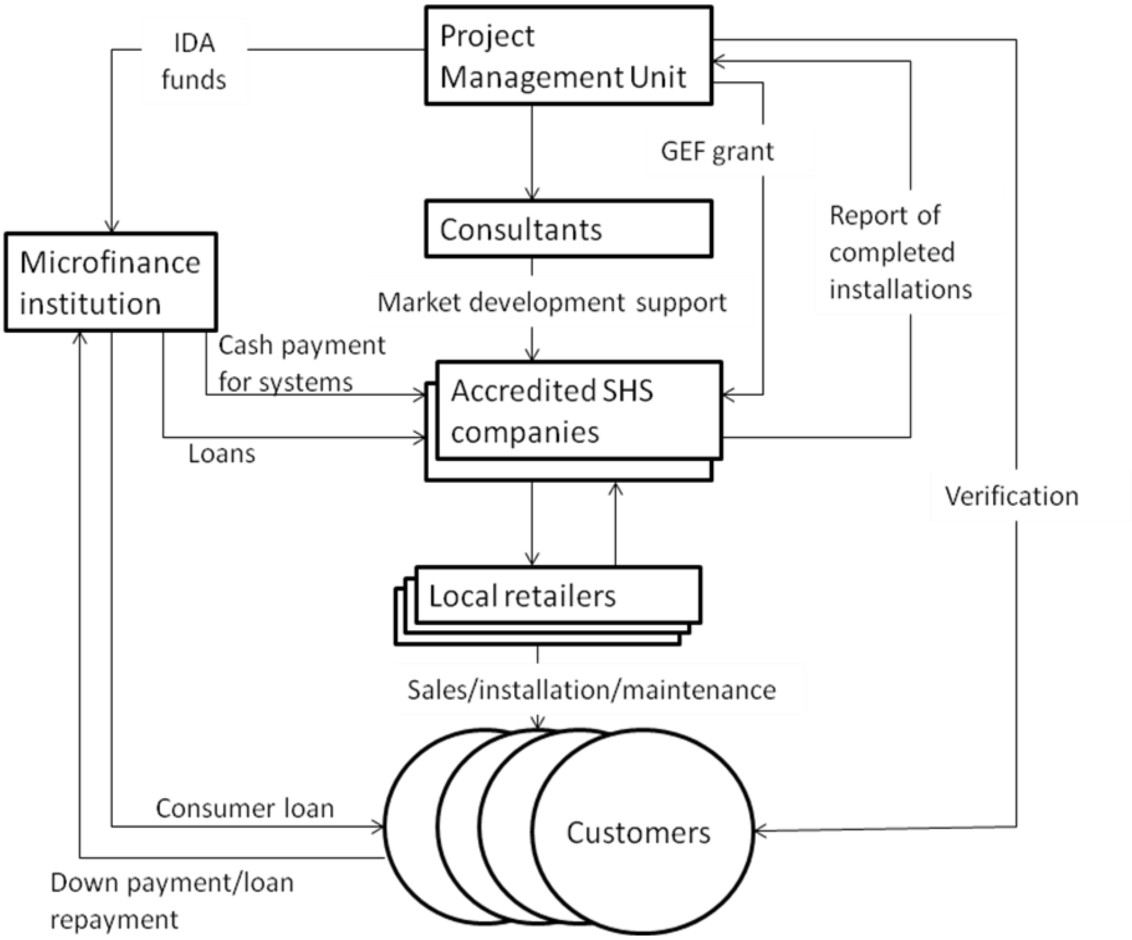
Through the formation of the national '*linea de credito solar'* (solar credit line) in 2004, microfinancers were financially supported to lend to households wishing to access SHS. The vision of the programme for the development of the sector was that the government would act as market enabler, providing subsidies, while the private sector would take the investment risks and deliver electricity services (World Bank, 2003; see Figure 19 for an outline of the programme structure). Interviewees generally suggested that PERZA had some success in developing the market infrastructure necessary for commercialising SHS in Nicaragua. The programme sought to strengthen private sector providers of both SHS and microfinance, and to achieve coordination between them, as the following quote explains:

> 'one of the objectives was to achieve a synergy between suppliers of solar panels and micro financers, so it was perfect, because many people wanted them [SHS] but had no purchasing power to buy solar systems outright, they were cash-strapped…' [Expert interview 9, private sector SHS provider]

The initial programme revolved around a subsidy which was channelled to users through the coordination of micro-finance institutions and private sector SHS providers. According to the product manager of Nicaragua's largest micro-credit institution, lending for SHS peaked in 2005-6 for a variety of reasons, including the subsidy available, the fact that SHS were 'novel' products, and the absence of planned grid electrification programmes (expert interview 14 - loan product manager, large Nicaraguan micro finance institution). For this particular micro-credit institution, the majority of those who took advantage of the solar credit line were pre-existing customers, who had already taken out 'productive' loans (for instance, to improve agricultural production) and arguably with the capacity for repayment. Growth in Nicaragua's agriculturally productive regions during this period

tourism; grid-connected PV is the most recent market segment to be developed (see CADE, 2013; Dolezal et al., 2013) (see CEPAL, 2005) also meant that some farmers were in a position to take out loans for items like SHS, therefore driving growth in the SHS market (e.g. Jacobson, 2004). The supportive environment provided by PERZA enabled micro-financers to establish their own loan products; one lender, for example, launched a SHS 'green package' loan (see FDL, 2008).

Figure 19. Flowchart of solar market development element of PERZA



Source: adapted from World Bank (2003)

The private sector infrastructure necessary to commercially disseminate SHS was clearly expanded geographically and strengthened as a result of the programme, as the following quotes show:

> 'The solar market grew magnificently, such that there are not just [SHS] providers in Managua… the providers now have a branch in pretty much every municipality of the country… this is the success of the solar market' [Expert interview 22 – government official, rural electrification department, Ministry of Energy and Mines]

> 'What I experienced with PERZA was through [name of small private sector SHS provider] and I saw that the PERZA programme had this mechanism… to provide the link between the client

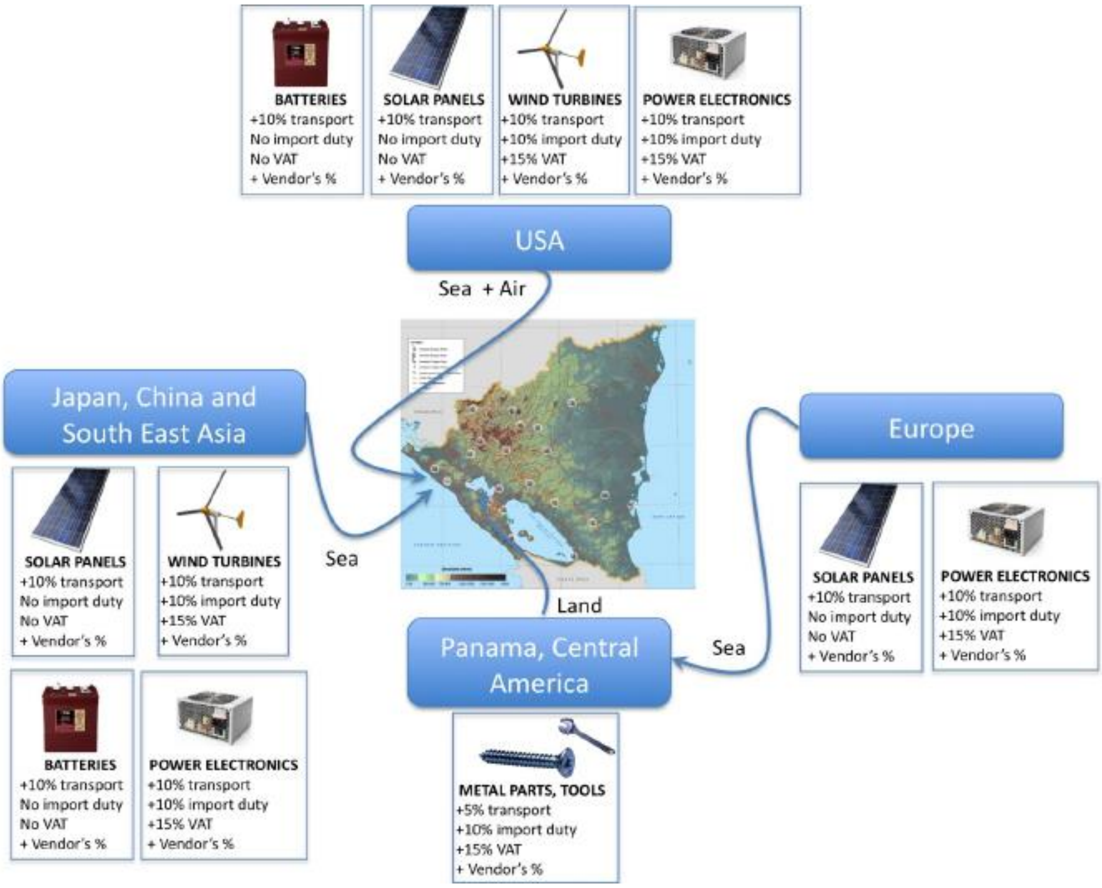
that has no money and the small [SHS] company that doesn't have the capacity to provide micro-credit... a lot of people who wanted panels could therefore approach a [SHS] company with credit and the company could provide for them... Thanks to PERZA [name of company] grew... it didn't make a lot of money but it did extend practically across the whole of Nicaragua… there are a great many people who now know about solar energy and have access [to a SHS]' [Expert interview 15, founder of organisation promoting solar energy in Nicaragua]

The PERZA programme, therefore, served to link and to coordinate potential SHS users with micro-credit facilities and SHS providers. As the interviewees above suggest, the solar industry in Nicaragua was developed significantly as a result of the programme. While prior to PERZA the sector had been dominated by just one company, two smaller companies were also strengthened through their participation in PERZA and recent years have witnessed the emergence of other new companies. Through PERZA, the quality of solar products provided by such companies was improved through the introduction of codes, standards and an extensive training programme to 'certify' vendors (see Ley et al., 2006; Corsair and Ley, 2008). The solar value chain established was relatively short; SHS components were imported from other world regions due to the lack of national or Central American manufacturing capacity (with the exception of artisanal (non-certified) production of PV arrays by an NGO in the north of the country). The supply chain of various RETs is illustrated in Figure 20, and highlights the implications of the lack of indigenous production capacity on the pricing of SHS components.

The expansion and strengthening of private SHS firms in Nicaragua arguably led to the widespread dissemination of knowledge about SHS among the general populace. The founder director of Nicaragua's leading solar firm stated that this had profound effects, particularly in the rural regions of the country:

'Ten years ago, not many people knew about solar energy here in Nicaragua… but now knowledge is widespread… people in the countryside know more about solar energy than people in the city… the people in rural areas, they handle it very well… At least 75% of all those who talk about solar panels say [the name of our company], or they say 'I know solar panels because they are in such and such a community'… I know that almost all [Nicaraguan] communities have at least one solar panel… and there are communities that have 100% solar panels' [Expert interview 27, private sector SHS provider]

Figure 20. International supply chain of renewable energy technologies and impact on prices



Source: Marandin et al. (2013)

The geographical expansion of solar companies meant that knowledge of solar energy became widespread. According to the product manager at the country's leading micro-lending institution, increased knowledge stimulated demand for solar products. He stated that when PERZA was launched, demand for SHS was 'contagious' - as a household in one community gained access to a SHS, requests for credit from nearby communities and households followed (expert interview 14 - loan product manager, large Nicaraguan micro finance institution). By the close of the PERZA programme in 2011, a total of 6,863 SHS had been sold through the credit line, providing the means for electricity access to approximately 41,000 Nicaraguans (World Bank, 2011).

In addition to the SHS commercialised directly through PERZA, the programme strengthened the solar energy sector in Nicaragua in a much broader sense. Actors from the SHS companies were convinced that a robust solar sector had been created, one with the capacity to service the needs of both 'self-organised' private clients and also 'project organised' solar programmes (see also van der Vleuten et al., 2007 and the general discussion of solar delivery models in Chapter Two). The manager of one private SHS provider argued that thanks to the PERZA programme, his company was in a position to work with large donors to execute solar energy projects with off-grid populations, as this quote highlights:

> 'PERZA helped the company to grow and move into other projects that require working capital… Now we are running major projects such as projects with the municipal governments, with international organisations such as the World Bank, and the European Commission and countless other organisations… We have been able to successfully execute these projects' [Expert interview 26, private sector SHS provider]

For government officials and private sector actors, PERZA represented a catalyst for the proliferation of the off-grid residential solar energy market segment in Nicaragua. While PERZA specifically promoted the commercial dissemination of SHS, actors explained that other delivery models also emerged to address different market segments (e.g. donated systems or fee-for-service models to target lower income groups), with the funds derived from an increasing suite of aid agencies and multilateral financial institutions. Expert interviewee 26 (private sector SHS provider) for instance, suggested that the majority of his business activities in 2010 and 2011 were related to the projects of international donors and aid agencies, rather than the 'self-organised', private or commercial sales that PERZA had sought to stimulate. While this can in part be attributed to a more recent retraction in microcredit lending due to changing financial[64] and political[65] situations, actors also highlighted the changing landscape of electricity access governance and the potential problems that it may bring. As discussed in Chapter Five, the interventionist turn sees Nicaragua's 'energy problem' attracting increasing flows of finance from IFIs and development agencies. In the case of solar energy programmes targeting off-grid areas, actors pointed to increasing intervention from large multilateral financial institutions and increasing numbers of 'donation-style' programmes, which operated through various channels to deliver electricity access to the unserved.

[64] A personal communication with an official at Nicaragua's leading micro finance institution (November, 2011) suggested that the global financial crisis contributed to a retracting loan portfolio (including SHS loan products) and that the economic status of Nicaraguans had generally worsened (due to enormous agricultural losses witnessed in 2010 as a result of heavy rains - see UNICEF, 2010), therefore meaning that less households had the capacity to undertake a SHS loan. The official argued that incredible demand for SHS loans still existed but that the institution could not finance these requests in the current economic and political climate.
[65] Discussed in section 6.4.1

The scale at which solar energy is being disseminated and promoted is unprecedented, as one Ministry of Energy official described:

> '[solar] panels are not that new… they have existed during many years here in Nicaragua… but not on such a massive scale… The success of the PERZA programme is the huge scale in which they are being delivered… the solar market that has been catalysed' [Expert interview 22 – government official, rural electrification department, Ministry of Energy and Mines]

Indeed, according to Foster and Cota Espericueta (2005), the use of PV technologies in Central America dates back to the mid-1980s. The novelty of PV from 2003 onwards however is the speed and scale at which it is has been disseminated. According to expert interviewees 21 (renewable energy expert – Ministry of Energy and Mines) and 26 (private sector SHS provider), since 2002 SHS have become a technology of choice for rural electrification due to the 'ease' of installation, their non-site specific nature and comparative advantage over other decentralised electricity generating technologies (e.g. pico-hydropower), where issues of cost, wider infrastructural and local governance issues are considered prohibitive[66]. For two government officials interviewed, the emergence of off-grid applications of solar energy signalled a significant shift in the way that rural electrification is thought about and executed in Nicaragua:

> '[For rural electrification] previous governments were only interested in line extensions and kilometres... how many kilometres of cables do I need to bring electricity here?' [Expert interview 35 – social promoter, PERZA programme, Ministry of Energy and Mines]

> 'when they privatised energy in 1998, with the 272nd law, they only thought in the large scale...they thought in Disnorte - Dissur, they thought in the Western generator, the central generator… large generators of 56MW, which are quite big for our energy system... But what they didn't do is think in the small scale... they didn't think about people with small PV systems, they didn't think in PCH [pequeños centrales hidroelectricas - pico-hydro plants], they just didn't think in the micro-scale' [Expert interview 22 – government official, rural electrification department, Ministry of Energy and Mines]

[66] Difficulties include the site-specific nature of pico hydropower, the community-level management required (of both the technology and the watershed) and the technical capacity required to plan and construct the plant. See Maher et al. (2003) who detail the complexities of installing pico hydro systems in Kenya, and Smits and Bush (2010) who discuss the 'universal applicability' of SHS as a barrier to the deployment of pico-hydropower in Laos.

This represented a shift from a focus solely on centralised electricity provision to one that also incorporated distributed micro generation technologies. Government officials envisaged an important role for SHS in the future national electrification strategy which, as outlined in Chapter Five, is undergoing significant transition due to the multi-donor financed energy development assistance programme, PNESER. In some ways, the legacy of PERZA lives on in the PNESER project with many PERZA staff redeployed to the latter programme and distributed renewables in off-grid areas forming an element of the programme. However, the programme's large budget of over US $400 million, combined with a political commitment to reach 85% electrical grid coverage (IDB, 2012), means that the scope for off-grid solar energy in the longer term may now be much more limited (e.g. Ondraczek, 2013). The following quote from a senior official at the Ministry of Energy and Mines highlights the vision for solar energy in the future rural energy mix:

> 'We have contemplated that in many places where we have already installed photovoltaic systems, we're going to put in grid electricity [through the PNESER programme]… we're going in with panels of 50 watts where we think we will enter with grid electricity in the next five years… and panels of 30 watts where we are going to arrive in the next two years… In the areas we can't get to with grid electricity… there are many [communities] for example next to the *Rio Coco*[67]… around this area, where there are no roads, no transport… where the only way to arrive is by the sea or by river, here we will arrive with photovoltaic systems…a basic system for houses, a more robust system for the school, another robust system for the health centre, for vaccines, so that they can have a refrigerator' [Expert interview 22 – government official, rural electrification department, Ministry of Energy and Mines]

This suggests a shift from a focus solely on grid extension to a two-pronged approach where aggressive grid electrification is preferred to take advantage of the 'lowest hanging fruits' (Expert interview 7 - founder of NGO with off-grid RE initiative and convenor of national renewables association), while for the most remote areas, distributed technologies, such as SHS, will remain the long term solution[68]. For the government, therefore, SHS represents a 'pre-electrification' or 'transition' technology (e.g. Foley, 1995; IEA PVPS, 2013) for those areas that will eventually be reached by grid electricity under electrification plans, while for those areas where it is considered unfeasible to extend the distribution network, SHS represents a permanent alternative to grid connectivity.

[67] The Coco River is located on the Nicaraguan-Honduran border

[68] PNESER programme documentation (IDB, 2012) outlines that 117,390 households will be electrified through grid extension activities while 3,820 households will be targeted with off grid renewables, such as solar photovoltaics, over the life of the programme (2012-2016).

While the ministry official quoted above presents a rather unproblematic vision for off-grid solar energy, the Nicaraguan government's aggressive large-scale pursuit of grid expansion may reduce the desirability and/ or profitability of acquiring a SHS from the perspective of households (e.g. Sovacool and Drupady, 2012). Indeed, as discussed in Chapter Two, tensions may arise between grid-based and off-grid solar-based rural electrification strategies. Empirical evidence suggests that SHS owners often prefer to use their systems for more services than they are able, in many cases, users prefer to have a grid connection because it allows them to draw more energy per day (Wamukonya and Davis, 2001; IEA PVPS, 2013). Nicaraguan households aspiring to have a grid connection may therefore undermine efforts to deploy alternatives, such as SHS (see Rehman et al., 2012). These tensions are especially important to consider in light of Chapter Five's discussion of the current politicised nature of grid expansion activities and key questions arise about the potential sustainability of solar energy interventions in this context. These challenges are discussed in more detail in section 6.3.

On the whole, the solar actors engaged in shaping the off-grid solar energy market shared similar accounts of its growth and the way in which the sector's formation played out in the Nicaraguan context. However, there were also some critical viewpoints and dissenting voices on the topic. The founder director of one of the private sector renewable energy companies, for example, argued that solar energy had become 'big business' with 'huge cash flows and transactions' over recent years. Furthermore, he argued, rural electrification had 'degraded into a big business where corruption and bad practices have become engrained' (expert interview 6 – director, renewable energy technology company). He went further, claiming that his company had declined to participate in the PERZA programme due to these discrepancies. It is difficult to ascertain if this is the dissenting voice of a disgruntled director, whose company was not accredited to participate in PERZA, or whether it is the voice of a private sector actor who took a genuine stand against a sector he described as an 'enormous fraud'[69]. It does, however, echo the concerns raised in Chapter Five regarding the potential implications of poor governance in the Nicaraguan electricity sector.

[69] In response to this statement, the theme of corruption in the solar energy sector was explored in the research. Detecting corruption is inherently problematic however. The majority of private sector actors and government officials interviewed were directly involved in the deployment of solar energy technologies and were therefore benefitting from the emergence and growth of the off grid solar energy market segment. The private sector providers of SHS benefitted through increased sales, and the government through the financial flows associated with the increased currency of 'sustainable energy' and the political favour gained as a result of expanding access to electricity (e.g. Chapter Five, section 5.6). As discussed in Chapter Two, 'good governance' in energy terms means that energy is supplied to those who need it most in an affordable, secure and environmentally sustainable way. Although, it is not within the scope of this thesis, corruption in the Nicaraguan energy sector warrants further research (see Lemaire, 2013).

An official from the Ministry of Energy and Mines expressed other concerns regarding the proliferation of the off-grid solar energy market, questioning *who* the real beneficiaries of the PERZA programme were. He explained:

> 'Frankly speaking, this programme [PERZA] was a way of filling the pockets of those who sell panels… they were the ones who gained… [name of company X] and [name of company Y], those were the ones who made all the money…. But what about the people who bought [SHS], what happened to them? Yes they bought them, yes they used the subsidy, but I have no idea who they are, where they are, how they are doing with them [SHS]. I only promoted the solar market, and at the end of the day, I can only say for sure that the main beneficiaries were the [SHS] providers' [Expert interview 22 – government official, rural electrification department, Ministry of Energy and Mines]

This official argued that it was the private sector SHS providers who benefitted most from the advent of the market rather than the users who were sold systems and left without any follow up. This echoes other country experiences with IFI-funded solar programmes; for instance, in the case of the World Bank/GEF funded 'Energy Services Delivery' project in Sri Lanka, Sovacool and Drupady (2012) found that the selection of SHS over other technologies like solar dryers, cookers and lanterns or cookstoves was 'to build industry, not help poor households' (p. 177). In Laos, Smits and Bush (2010) found that, despite the enormous potential of pico-hydropower for rural electrification, this technology was neglected because of a combination of interests of international and national actors - namely the desire of the World Bank for a single rural electrification model (using SHSs), and the government's interests in centralising power production. These examples suggest that the selection and deployment of off-grid solar energy technologies in Nicaragua is bound up in the interests of national (e.g. industry, government) and international (e.g. IFI) actors. The second part of interviewee 22's quote suggests that there was little follow-up with the users of the technology; indeed, this was a sentiment echoed by many of the actors who were integral to Nicaragua's solar infrastructure. Very few of the actors interviewed were able to provide detailed information on user experiences (beyond anecdotes) with solar energy technology over time or on the continued functioning of installed SHS. The question of *who* benefits from the proliferation of SHS in Nicaragua is a recurrent theme throughout the remainder of this chapter, and that which follows.

6.2 Deciphering the Nicaraguan solar energy landscape

Having discussed the emergence and development of the off-grid solar energy market, this section now turns to an examination of the positions of the various actors involved in the delivery of solar energy. Through an analysis of the motivations, visions and narratives of key actors involved in promoting and implementing solar energy, an evaluation of the state of Nicaraguan solar energy governance is provided. In particular, the ways in which the practice of solar energy in Nicaragua is influenced by the political economies of national and international actors is assessed, including a focus on who ultimately benefits from the propagation of solar energy technologies. However, the discussion begins by providing an estimation of the number of actors and programmes active in promoting solar energy, including the number of systems installed, in order to provide a picture of the current situation of SHS in Nicaragua.

In the post-PERZA period, the actors interviewed noted a large implementation space in which activities to promote and implement off-grid solar energy had flourished. Table 7 provided the details of a number of solar energy initiatives active or recently active in the Nicaraguan context. As discussed in Chapter Three, this data was difficult to obtain; no inventory existed that detailed the number of systems installed, the full range of programmes established and/or the organisations engaged in promoting solar energy. There are a number of possible explanations for this; firstly, programmes promoting solar energy tend to be short-lived - simply put, technologies are installed in people's homes and then organisations leave. Secondly, because SHS are installed in people's homes or land, permission is not required from government agencies, in comparison to the planning required for a hydroelectric plant for instance. Finally, there are multiple structures and means of channelling funds for off-grid solar energy programmes; for example, while some donors operate centrally through the Ministry of Energy and Mines' Rural Electrification Fund (FODIEN), others operate through local, municipal or regional governments, others directly through private sector SHS providers, and still others through NGOs. There are multiple scales of delivery: from small SHS programmes, which fundraise to purchase individual SHS for households, to larger programmes, such as the European Union's ZONAF Programme (Central American Border Zone Development Programme) which recently donated approximately 1,000 SHS to communities in the north of Nicaragua. Thus, in Nicaragua there is a vast 'implementation space' (Bazilian et al., 2010b: 5410) filled with a variety of contrasting initiatives to promote energy access using distributed solar energy technologies.

As part of this research, efforts were made to ascertain how much the market had grown in the post-PERZA period (i.e. 2003 onwards), including an estimation of how many systems had been installed. This turned out to be an extremely difficult task: while the Ministry of Energy and Mines provided a rough estimate of 10,000 systems installed in total (expert interview 22 - government official, rural electrification department, Ministry of Energy and Mines), interviews with the 'big three' solar companies offered competing estimates with each company stating that they had each installed a total of between 10,000 and 40,000 systems[70]; data from the Directorate of Customs suggested that a minimum of 45,000 systems had entered Nicaragua since 2002 when records began (Dirección General de Servicios Aduaneros, 2011), while Cárcamo-Ruiz et al. (2012) estimated that approximately 30,000 systems have been installed. All these estimates contrast with the REN21 (2012) estimate of just 6,000 systems installed. Even with detailed investigation of individual case programmes (see Chapter Four, Table 8), it was difficult to verify the exact number of systems. For instance, in the case of the GED programme (case programme B), 400 SHS were allegedly installed during its first phase; however, officials could not locate the paperwork to prove or disprove this figure, and used the opportunity to raise their concerns about 'good governance' (see Section 6.1). It therefore proved incredibly difficult to estimate the number of programmes in operation, let alone provide an estimate of how many individual systems were still functional. That there is no entity to coordinate the many programmes promoting solar energy, and that little data exists on the activities of organisations, illustrates that the approach taken to deploy solar energy technologies in Nicaragua, as elsewhere, has been extremely fragmented.

6.2.1 Solar energy: an agent of multiple objectives

Having discussed the size and scope of this fragmented sector, this section adds detail to the practice of off-grid solar energy in Nicaragua and the ways in which this is influenced by the motivations and priorities of the actors driving it. Through focusing on the three case programmes introduced in Chapter Four (Table 8 and Figure 10) - Project Solar, the Global Energy Development (GED) Programme and Project Santa Clara – this section illustrates the often divergent motivations of actors involved in the design and delivery of solar energy.

The case programmes are indicative of the variety of programme types that operate in Nicaragua. While these three cases do not provide an exhaustive set of examples of all programme types found in Nicaragua, they do provide a range of examples of the programme models documented in the wider literature on decentralised energy systems in the developing world (as discussed in Chapter Two). All of the programmes examined are 'project organised'; that is they derive from the planned effort of an organisation to facilitate access to solar energy (van der Vleuten et al., 2007). This mode of organisation is illustrative of the wider solar landscape, one heavily influenced by the presence of

[70] Each of the 'big three' firms were accredited to sell SHS under the PERZA programme, and the estimations given include the 6,863 SHS sold through PERZA.

donors. Each programme, however, operates different delivery mechanisms (e.g. in financing, implementation, accompaniment and follow-up), carrying out activities in different regions of the

Table 17. Comparison of three case study programmes

	A - Project Solar	B - Global Energy Development (GED): phase I	C - Project Santa Clara
Locations	Masaya and Managua	Estelí, Madriz, Nueva Segovia	RAAN
What?	50 Wp SHS, installed in approximately 200 homes in rural areas.	50-85 Wp SHS, installed in approximately 400 homes of rural Estelí. Subsequent phases of the programme have reached more than 2,000 homes in different locations of the country.	Five 2.4 kWp solar PV battery charging stations (SBCS) with household lighting kits in five indigenous communities of the RAAN.
Institution and financing	Implemented by a community development NGO, financed through small donations provided by UK-based housing associations amongst others.	Implemented by a large European development agency, financed by the German and Dutch governments. In addition to SHS, the GED programme also finances grid extension, grid densification and micro hydroelectric projects in Nicaragua. Programme operational in 22 countries worldwide	Implemented by the Ministry of Energy and Mines' Rural Electrification Fund, financed through government subsidies and a major multilateral financial institution.
Year initiated	2005	2006	2005
Programme details	Programme operates a revolving fund, where loan repayments finance SHS for more users. Donations and revolving fund are used to purchase SHS from private sector providers, which are then installed by the NGO.	Development agency operates an 'output based aid' approach[71] to programme, coordinating local institutions and private sector SHS companies to deliver systems. No direct involvement of the development agency in delivery.	Capital costs of programme entirely subsidised due to the nature of the region (poorest in Nicaragua). Local NGOs contracted to assist in the implementation of the programme.
Financing mechanism	'Dealer' model: long-term (6-7 year), interest-free micro finance provided by	'Dealer' model: subsidised SHS are offered by the agency, users pay cash for	'Fee-for-service' model: users pay a fee (~US$ 1) per battery recharge which

[71] According to the Global Partnership on Output Based Aid (GPOBA, 2009), output based aid (OBA) links the payment of aid to the delivery of specific services or 'outputs.' OBA is used in cases where poor people are being excluded from basic services because they cannot afford to pay the full cost of user fees such as connection fees (e.g. connection of poor households to electricity grids or water and sanitation systems, etc). Service delivery is contracted to a third party (usually a private firm), which receives a subsidy to top-up the user's contribution. The service provider 'pre-finances' the project and the subsidy is awarded by the donor only once the outputs have been delivered and verified. This approach is considered to improve the effectiveness of aid.

	NGO to enable users to purchase SHS. Users make monthly loan repayments equivalent to US$10.	the remaining balance. No micro finance offered to users through the programme, however, in some instances coordinating local institutions extend credit or facilitate the sale of users' agricultural produce to enable them to pay for the SHS.	goes to a community sink fund for future system maintenance costs. Initial project design stipulated that users would only recharge batteries when income was available to them (and this was the case during the first two years of operation). Concerns over the financial sustainability of this model were subsequently raised by the Ministry of Energy and Mines. A minimum number of battery recharges per month/user have since been implemented (~US$ 4). The fund is managed by a locally-elected committee.
Target population	Low-income households with capacity to service monthly loan repayments (~US$ 10).	Organised households belonging to institutions such as agricultural cooperatives and with capacity to finance upfront capital investment for SHS (~US$ 400).	Poor subsistence households on Nicaragua's Atlantic coast.
Programme accompaniment	A local entrepreneur collects monthly repayments on behalf of the NGO and provides technical assistance where necessary. Users assume responsibility for all operational and replacement costs after the initial warranty period.	In some communities local technicians are trained in the operation and maintenance of SHS. There is no official follow-up or post-sale element to the programme, however users can approach the local institutions that coordinated the programme or the private sector SHS provider directly. Users assume responsibility for all operational and replacement costs after the initial warranty period.	Users provided with technical assistance and business development training by the Ministry of Energy and Mines until programme end in December 2011. Users assume responsibility for all operational and replacement costs after programme end in December 2011.

country and targeting different market segments. Table 15 illustrates the diversity in approaches to delivering off-grid solar energy in Nicaragua in terms of technology, type of institution and target population.

For the organisers of Project Solar, the programme meets their organisation's mission by responding to the needs of households in rural areas within the communities where they work. It also adds to the NGO's strand of work on 'alternative infrastructure' by fomenting environmentally sustainable community development (expert interviews 3 and 4 – director and fundraiser from NGO operating SHS programme A). This fits with the donor institutions' attraction to financing the programme, principally the environmental credentials of the technology, with some of the donor organisations even using the programme as part of their carbon off-setting activities.

The project originated in the absence of reliable grid electricity in a community local to the NGO during a period of crisis in the Nicaraguan electricity distribution sector (see Chapter Five):

> 'The idea of working with solar energy originally came from the electricity problem in this community... so we developed the idea of having a solar panel project which might initially start here as a viable alternative to the electricity grid...' [Expert interview 3, director of NGO operating SHS programme A]

The idea of creating an alternative to grid connectivity was the key rationale behind this programme. In addition to addressing the lack of electricity provision, the programme sought to offer low-income households an alternative way of accessing and affording electricity, as the programme fundraiser described:

> 'One of the problems with [Unión] Fenosa obviously is that you have to keep on paying each month, and if you get into difficulties you'll eventually get cut off, whereas with our scheme you're not paying for your consumption because in a sense your consumption is free...you're just paying for the [SHS] equipment… and with our tolerant attitude towards payments then it is an altogether different experience...and I have heard people talk about comparisons between dealing with us [local NGO] on the panels project and dealing with Unión Fenosa and obviously it is entirely different... they have a commercial concern to not sustain any losses…' [Expert interview 4, fundraiser, NGO operating SHS programme A]

Project Solar was initially about offering an alternative to purchasing grid electricity from an unreliable electricity distributor with commercial interests. This approach later evolved however, as explained by expert interviewee 4:

> ‘we quickly realised that it [solar] wasn’t going to work in the [original] community because of the fact that there was intermittent supply from the grid... where the installation was being done close to the electricity grid there was the risk of illegal connections… so [name of NGO] suggested that we spend the bulk of the money in areas that didn’t have the grid... And we’ve learned the lesson now that it’s much better to install panels in those remote communities [away from the electricity grid]’ [Expert interview 4, fundraiser, NGO operating SHS programme A]

The presence of the nearby electricity grid undermined the initial installations. It was explained that users were unwilling to repay loans on SHS because of illegal connections to the electricity grid which provided free – albeit poor quality - access to electricity. Indeed, the tension between grid access and solar-based access has already been noted above and in Chapter Two.

By way of contrast, the Central American coordinator of GED stated that the programme was motivated by donor governments’ international cooperation commitments. In particular, the need to provide a political message to the taxpayers financially supporting the programme ‘back at home’:

> ‘This programme was driven by an idea from the Dutch cooperation ministry… And they said they wanted to have something which is very concrete, a programme in which each taxpayer – which at the end of the day is where the money for international cooperation comes from – is aware of what it is being spent on… and that every taxpayer participates in providing energy access to poor people who do not have access… they kind of support, in an almost personal way towards achieving the Millennium Development Goals... So the idea was to create something very concrete with a specific political message, one which was very simple and clear’ [Expert interview 30, coordinator SHS programme B]

Being accountable to the taxpayer meant that facilitating electricity access at the lowest cost per capita was crucial for the GED programme. In this case, SHS technologies offered a cost-effective addition to the programme’s wider electrification activities in Nicaragua (which also included micro-hydro plants, grid extension and grid densification). The reduction in global PV prices over recent years meant that SHS became a particularly attractive component of the GED programme, as the programme coordinator explained:

> ‘we are a programme that provides access [to energy] and we always have to be looking at the areas in which we work, and which projects we engage in… what we have to achieve is the lowest [connection] prices per capita, that is the bottom line… At one time solar projects were really expensive… let’s do the calculation, eight hundred dollars [per system] between six people [in a household] is really high… We used to subsidise half of that amount… But now as the price of the products [SHS] has reduced we have also been able to reduce our subsidy significantly… SHS is therefore less expensive for us’ [Expert interview 30, coordinator SHS programme B]

As a result of a reduction in global SHS prices, the programme was able to reduce the subsidy provided to users, meaning that more ‘heads’ could be electrified per allocated euro. SHS therefore offered a means of achieving defined indicators set by the global programme in a cost-effective way, and importantly, provided a strong political message to European taxpayers supporting the programme.

By contrast again, Project Santa Clara was motivated by a combination of donor interests and the Nicaraguan government’s interest in piloting a new electricity access business model for potential application in the poorest regions of the country. The project formed a component of the wider PERZA programme (discussed above), aiming ‘to ensure the efficient use of scarce public subsidies, maximise private sector participation in service provision, share investment risk and improve the chances for long-term sustainable operation in technical and financial terms’ (World Bank, 2003:16). The idea was that lessons learned from this pilot would later inform the development of Nicaragua’s rural electrification strategy. According to the project’s former business development manager (expert interviewee 20 – Ministry of Energy and Mines official) and project documentation, solar energy provided the ‘least cost’ option to pilot the business model, given the extreme remoteness of the project location, which made ‘traditional’ solutions (e.g. grid extension or diesel generation) economically unviable (World Bank, 2003: 34). Furthermore, extreme poverty in this region was considered an obstacle to cost recovery; solar battery charging stations (SBCS) over SHS were therefore selected as the ‘best’ option for low income households, where users could potentially pay for battery recharges only when income was available to them (ibid: 76). The SBCS were seen as an ‘important alternative… for the decentralised, mostly indigenous population of the Atlantic Coast’ (ibid: 111).

Table 18. Comparison of three case study programmes: donor priorities, motivations, metrics for success and key challenges

	Project Solar	Global Energy Development (GED) Programme	Project Santa Clara
Donor priorities	Environmental: SHS as clean energy which allows the donors to off-set carbon emissions	Development cooperation: Energy access (particularly access to clean lighting) contributes towards achievement of the Millennium Development Goals	Formulation of electrification strategy: Piloting sustainable electricity provision business models
Programme motivation	SHS as alternative to unreliable/unavailable grid electricity	SHS as cost-effective means for programme to support wider electrification activities and development targets	Solar battery charging station (SBCS) as least cost technology (cf. to diesel generators or individual SHS) for donor and users, and novel delivery model
Metrics for success	Positive impacts wrought on the lives of users: increased levels of comfort, security and greater opportunities	Achieving lowest cost per capita electrified	Achieving a delivery model that is operationally sustainable, enabling users to sustain the SBCS beyond the life of programme/institutional support
Perceived challenges	Users defaulting before loan is recovered (key SHS components have a shorter useful life than the 6-7 year loan period)	Further reducing the subsidy provided to users	Designing a suitable 'exit strategy' from SBCS communities; e.g. implementing income generation projects to help users to financially sustain the SBCS; building coalitions with local NGOs which will continue to accompany SBCS communities

Discussion of the three case study programmes illustrates the divergent motivations of actors designing and delivering solar energy in the Nicaraguan context (see Table 16 for a brief comparison of the three programmes). The comparisons made between the motivations underlying three programmes suggests, as discussed in Chapter Two, that solar energy is an 'agent of multiple objectives' and priorities (Hunsberger, 2010). Not only does solar energy appeal to those concerned with the environmental dimensions of the energy trilemma, but the provision of off-grid energy technologies is also seen as a means to meet internationally agreed human development targets. At the local level, solar energy is framed as an alternative means of accessing electricity, where access to the electricity grid appears unfeasible. Solar energy therefore appeals to actors with varying priorities, and responds to various organisational objectives or 'needs' (e.g. the development agency's need to satisfy European taxpayers, the donors' need to offset carbon emissions, contribute to the UN development agenda or pilot new off-grid electrification models) or perceived end user 'needs' (which are discussed in greater depth in the next section). Discussion of the three programmes highlights the critical importance of understanding the influence of the global and national political economies within which such programmes are embedded. These more distal forces influence the way in which programmes are framed and delivered with implications at the programme and local levels. The next section turns to examine the varying narratives and expectations attached to solar energy.

6.2.2 Multiple expectations and visions of solar energy

A plurality of visions for solar energy was articulated by the actors engaged in delivering it to off-grid populations. As discussed above, distributed solar energy can be described as an 'agent of multiple objectives' and priorities at various scales. There are multiple perceptions of what technologies like SHS can 'do', the impact that access has on users, and also varying assumptions about the compatibility of small scale solar energy technologies with basic user 'needs'. What 'needs' constitute is however highly contested, especially in light of the vested interests and motivations of the multiple actors involved. Multiple narratives of solar energy in Nicaragua were articulated. On the one hand, SHS were frequently linked to 'progress' and to social improvement. Actors suggested that the energy services SHS provided were sufficient to result in significant benefits for households, such as health promotion, income generating opportunities and even lower birth rates. On the other hand, actors linked SHS to potentially negative impacts, with some suggesting that the energy services provided were insufficient to cover user needs. This clearly illustrates a disparity in opinion, which is also evident in the academic and grey literatures reviewed in Chapter Two. Indeed, while solar energy technologies are often framed as 'win-win' solutions, for instance simultaneously addressing energy poverty and climate change objectives, scholars question the suitability of the wide scale push for SHS in developing world settings (e.g. Karekezi and Kithyoma, 2002; Wamukonya, 2007), as well as the pervasive view that SHS is able to satisfy basic energy needs (e.g. Mala et al., 2009).

For many of the actors interviewed, small scale solar energy technologies provide sufficient electricity to cover what they considered to be the most basic energy need of households in off-grid areas - illumination. Replacing contaminating or low quality lighting sources, such as kerosene lamps or candles, with solar electricity, represented improved health for users and their families, as highlighted by one private sector SHS provider:

> 'Well the principal impact that I see is illumination because people before [access to a SHS] would use candles or oil lamps, and of course the drawback to this is that it seriously affects the health of children, for example, those who are studying at night, they use an oil lamp to be able to see and to read, which affects their vision and damages their health' [Expert interview 26 - private sector SHS provider]

This sentiment was echoed by most actors, who shared the view that SHS were critical to improving household air quality and promoting health (particularly of women and children). For example, one government official explained that she envisioned SHS making users' lives easier (for example, when caring for children in the night). She also argued that SHS were able to cover 'basic' needs, which represented a 'start' for households previously without access to electricity:

> 'The main thing I think is lighting, which is the most basic, as it means that mothers can attend to their children if they are ill in the night, if somebody gives birth for example, it means that the newborn can be looked after, or if there are animals to be cared for… while they'd normally get up early with an oil lamp, with the [SHS] system they'll no longer be inhaling fumes. Above all illumination covers their basic need, there are other things [needs] that cannot be covered… for example water could not be pumped with this system [SHS], but I think that it [SHS] is a start' [Expert interview 19, government official, coordinator of solar programme]

While emphasising the health benefits of access to SHS, several actors were critical of the limited number of energy services provided by the technology. The coordinator of a large SHS programme, for example, commented that the limited nature of solar technologies was their main disadvantage, but recognised that they were a means of promoting health and represented significant 'progress' for users:

> '[SHS] is the means to achieve a basic electrification, lighting in homes, and it is a means of replacing oil lamps. Oil lamps are a very important factor for health in the countryside, when you replace oil lamps, houses are less smoky and it has a direct relationship with family health, for children and women especially but it has its limits. That's the main disadvantage of photovoltaic systems, that they are so limited… many people think that having a photovoltaic system means having the same as a mains connection in the house but it is not... despite this I would say that having basic electrification… is huge and important progress' [Expert interview 30, coordinator SHS programme B]

While the systems typically available through programmes observed in the Nicaraguan context are 'limited' (ranging from 50 Wp to 80 Wp), this is usually adequate to power small devices. The use of SHS to satisfy the 'connective' needs of users (e.g. Jacobson, 2007), for example, through powering devices such as mobile telephones, radios, or televisions, was therefore also emphasised by actors. SHS were thought to be able to satisfy users' needs to be entertained, connected and informed:

> 'Through being able to charge cell phones, powering a television, being able to listen to the news, having access to entertainment, those are basic needs that can be achieved with a solar panel system' [Expert interview 26, private sector SHS provider]

> 'They can also inform themselves using a television, also they can have access to a radio, improving their basic living conditions… they will have a better standard of living as a result' [Expert interview 27, private sector SHS provider]

Implicit in these interviews is that the electricity provided by SHS is sufficient to cover the basic needs of rural users, as one actor commented: 'it [SHS] covers the high priority needs for users in rural areas' (EI26). In addition to covering basic needs, other suggested benefits included: the potential to 'transform' users' lives (EI19), for example by facilitating the generation of additional income (both directly through users selling services requiring electricity and indirectly through extending working hours (EI4, 26)); halt migration flows from rural areas to the cities (EI26); reduce birth rates (EI15, 26 and 27); and offering users savings in time and money (EI27). The vision of SHS as an 'enabler' of opportunities for rural users was pervasive amongst actors, which is summarised in a quote given by the fundraiser of one solar programme:

> 'If people haven't got electricity then they're really kind of forced into a very basic sort of lifestyle... at night time they can just about cook, eat and sleep and that's it... so with solar you're providing them with an opportunity, a possibility that their kids can study or that they can do other things in the evening...even do things like having a church service in their house or something... I guess what [SHS] is doing is changing a certain modality...we are changing one of the factors which would otherwise be a limiting factor for families' [Expert interview 4, fundraiser, NGO operating SHS programme A]

Other actors also emphasised these less tangible impacts, arguing, for example, that solar electricity offered the opportunity for its users to become 'actors' of their future. This less tangible impact is highlighted by the following quote:

> ‘There exists a chance for people to plan their life more, to take control of their own future, to think that their child may go beyond not only primary school but also to secondary school or college... also that they can have their own production, that they can sew, cook, make cheese, repair shoes and all the other things they used to have to finish before it went dark’ [Expert interview 15, founder of organisation promoting solar energy in Nicaragua]

The expectations attached to solar energy in the preceding paragraphs are diverse. However, it is worth noting that the assumptions made about what solar energy can ‘do’ are related to the culture of the organisation promoting and implementing the technology. Interviewee 15 for example, promoted solar energy with a small cooperative of just twenty families, where solar energy formed an element of a wider vision that promoted ‘integrated energisation’ (e.g. harnessing solar energy for productive, income generating activities; see Chapter Three). In contrast, interviewee 30 coordinated the GED programme, which had installed over 2,000 SHS in Nicaragua; this programme focused on delivering the technology, and supporting the growth of a robust market, such that users would be able to source replacement parts and technical support without further assistance from the development agency. Understandably therefore, the visions that each actor had for solar energy differed.

By way of contrast to those who emphasised positive aspects, several actors expressed concern about the potentially negative implications of small scale solar energy technologies on users. The founder director of a renewable energy company (expert interviewee 6) argued that as a result of users being able to power small devices like televisions, he saw ‘social and household networks deteriorating’, and changes in culture, values and attitudes. Similarly, interviewee 15 explained:

> ‘when I first arrived in Nicaragua practically no one had access to a television… families used to talk a lot between themselves and now I often hear people saying ‘shut up!’ to a child who is talking because the TV is on…’ [Expert interview 15, founder of organisation promoting solar energy in Nicaragua]

Interestingly the views of three actors involved in supporting solar programmes on the Atlantic coast[72] were markedly different from the other actors. All three shared reservations about the compatibility of distributed solar energy systems with user needs. The president of one development organisation in the Atlantic coast region described solar energy as a ‘palliative’ measure. He questioned why the region had not harnessed its significant hydrological resources to establish large power generation projects, such as

[72] The three organisations were providing technical assistance and related development assistance programmes to communities engaged with a large-donor funded solar programme in Nicaragua’s Autonomous Atlantic Region (RAAN).

those typically concentrated in more developed regions of the country[73]. As Chapter Five (Figure 16) highlights, there are stark differences in socio-economic development indicators (particularly in relation to the existence of infrastructure) between the Pacific, Central and Atlantic regions. As he went on to explain:

> 'we don't need these things [pointing to a solar panel display in the office]… we have five or six huge rivers in the Atlantic coast region, why can't we have five large hydroelectric plants?' [Expert interview 23 - president of development organisation supporting an off-grid solar programme on the Atlantic coast]

In the opinion of interviewee 23 only large scale, centralised electricity generation and extended grid access would solve the Atlantic coast's 'energy problem'; small scale solar energy technologies were framed as second rate, providing only limited energy services, insufficient for user needs. This linked with his opinion of wider 'development' assistance activities taking place in the region (for instance, projects promoting access to education, sanitation, etc.), which he viewed were equally palliative and only able to make populations more 'comfortable' in their poverty, rather than lift them out of it (EI23). A similar view was shared by the director of another development organisation on the Atlantic coast. She argued that while access to solar electricity - in particular lighting - did have positive impacts on households, this was insufficient to meet 'real user needs', which she argued were the ability to harness power to generate incomes:

> 'To have energy for lighting, clearly it has a big impact, in other words people feel happy, when somebody arrives, 'look, I have electricity'. But in terms of the amount of energy they get from it, it isn't enough for them to set up a business, it isn't enough for them to sell frozen items, it isn't enough for them to process materials… in other words it is basically for lighting.. It is only for illumination at night time and so that they do not need to depend on pine wood [for lighting]' [Expert interview 17, president of development organisation supporting an off-grid solar programme on the Atlantic coast]

[73] Interestingly, since this interview took place a concession has been awarded to the Brazilian conglomerate Quieroz-Galvão-Electrobras to build a new dam to exploit significant hydroelectric power potential in the southern Atlantic coast (RAAS). The Tumarín dam will generate 253MW of electricity (which accounts for a staggering 23% of current installed electrical capacity, CEPAL, 2011) and is a cornerstone piece of infrastructure in Nicaragua's electricity generating mix transformation (MEM, 2011). However, the communities that surround Tumarín claim they were not consulted about the project and environmentalist groups argue that the project will negatively impact the watershed (Eguizábal, 2011). Tumarín is located in a region in which the majority of the sparsely distributed population do not have access to conventional electricity connections – the extent to which these populations will benefit from the creation of this plant (in terms of electricity connections) is unlikely.

The view that solar energy is insufficient to address 'real' priorities was also expressed by another Atlantic coast actor (EI5). This view echoes the sentiment expressed by Velumail (2011; cited in Sovacool, 2012b), who critiques current energy access programmes for adopting 'minimalist' approaches i.e. those that provide basic lighting or new cook stoves, but do not contribute towards real poverty reduction or improvements in standards of living. In other words, programmes which 'keep people where they are', but do not 'make them better off' (p.279) (see also Wamukonya, 2007; Karekezi and Kithyoma, 2002). Expert interviewee 5 expanded this view, suggesting that the 'need' for electricity was created and imposed on users by external development agencies. He described this as a form of 'colonisation', which echoes the 'post-development' perspective discussed in Chapter Two (see Escobar, 1995; Willis, 2005). This perspective is highlighted in the following quote:

> 'So they [development agencies] say the *Miskitos*[74] need electricity… 'let's give them electricity'… but solar electricity? With what purpose? Just to have lighting at night? Or with other objectives? What use do we get from it apart from being able to put on the radio, listen to music or have light in the evening?... They think [development agencies] 'I'm going to colonise this *indito*[75] with my ideas and not with the *fusil*[76], not like in the 1500s, but with modern things… the *indito* will feel the need to have a computer or a cell phone….to be complete' [Expert interview 5, president of development organisation supporting an off-grid solar programme on the Atlantic coast]

This quote emphasises that the 'need' for electricity assumed by development agencies may not match the realities of populations, and moreover, may have been created and imputed to 'needy' populations (Illich, 1992). For Illich, the 'needs discourse' provides legitimacy for intervention in the form of aid or technical assistance. The imposition of external (Northern) norms and expectations onto other societies sees indigenous ways of living rejected as inferior (see Shrestha, 1995; cited in Willis, 2005).

As Chapter Two highlighted, defining the quantities of energy necessary to satisfy 'human needs' is difficult (e.g. Krugman and Goldemberg, 1983; Goldemberg et al., 1985; Goldemberg, 1990; Pachauri et al., 2004), which helps to explain the current conceptual difficulties of defining 'energy poverty' and basic minimum access thresholds (see Chapter Two). In Nicaragua, actors engaged in the solar sector have distinct understandings of energy needs. For some, the solar technologies typically deployed are compatible or sufficient to meet the needs of users in off-grid areas, while for others, they are

[74] The Miskitos constitute the largest ethnic minority group in Nicaragua; 57% of the population in the RAAN identify with indigenous or ethnic communities (INIDE, 2005a).
[75] This translates as 'little Indian' and was used in a patronising way by the actor
[76] This translates as 'rifle' and is an historical colonial reference to the presence of British forces on the Atlantic coast of Nicaragua in the 1600s. In exchange for Miskito loyalty to the British crown, British forces provided inhabitants with gifts such as firearms (Tijerino, 2008)

incompatible or insufficient and, at its most critical, necessities imposed by external organisations who are satisfying their own view of what basic energy needs constitute. The following quote from a government official sums up the difficulty of defining 'needs' specifically in the context of SHS. She argues that 'needs' are in constant flux and that once users have access to the first 'teaspoon' of electricity provided by a SHS, user perceptions of need change:

> 'When you have access [to SHS] for the first time, your needs change, so people suddenly say, 'I don't just want lighting, I also want communication'… then all of a sudden they say that they want to pump water and it's probable that the system they have isn't powerful enough to do that, or they say 'I want to run a business', 'I want to buy a refrigerator', so the system [SHS] isn't useful for this anymore... in other words I think that the needs of people are always changing, they want to connect to a television, to have a DVD for films… this is the major challenge that a solar project faces… what can we do once the basic needs are covered? Because there are other needs that are also important, which a small system will not necessarily cover' [expert interview 19, government official, coordinator of solar programme]

This quote highlights the limitation of the majority of SHS deployed in the Nicaraguan context. Since most SHS have limited outputs (most are sized with panels of 50-85 Wp), they are restricted to level one of the 'incremental levels of access to energy services' (outlined in Chapter Two). This supports Pielke Jr.'s (2012) view that while solar energy applications have worked well to provide the first step of lighting and running of small appliances, they do not scale well to address cooking or the running of major appliances, such as refrigerators. While SHS capacity can be increased (through adding further panels and batteries), expert interviewee 19 pointed to the financial unviability of adding capacity to achieve other uses (e.g. water pumping for productive use). The changing needs of users are therefore not necessarily compatible with solar technologies and present significant challenges to those implementing the programmes.

While it is not the aim of this chapter to examine in detail the user perspective, which is the focus of Chapter Seven, there is evidence to suggest that there are conflicts between the assumptions of those promoting the technology and the off-grid users ultimately adopting, maintaining and sustaining them. One actor elaborated on the case of the GED programme, where the aim was to facilitate a clean source of lighting. An inverter that enabled the use of AC devices was not included in the package because it was 'not a policy of the organisation to finance the panel for TV use, but for basic lighting' (expert interview 30 - coordinator SHS programme B). As discussed in section 6.2.1, this agency's key priority was promoting energy access in order to meet the donors' commitments to the Millennium

Development Goals. A follow-up study on the programme revealed that for users however, a key priority was being able to power a television set, and that on acquiring a SHS, users had purchased inverters separately or creatively added components/ adjusted their systems to enable it to power AC devices (Wheelock-Horvilleur and Gent, 2011).[77] This reveals the polemical nature of SHS programmes which have to balance the conflicting viewpoints of donors, end users and engineers, (IEA PVPS, 2013; see also Chapter Two) which in this case resulted in the prioritisation of the donor perspective. Kumar (2013a) discusses the 'emotional appeal' of the lighting agenda in current discourses of the international energy for development community, and questions whether lighting is necessarily the most important aspect to end users. As several studies have demonstrated, TV use rather than lighting has proven to be a significant driver of historical SHS sales (see Acker and Kammen, 1996; Jacobson, 2007). From the perspective of the international community, would providing the funds for equipment to charge 1,000 mobile phones or power 1,000 TVs prove to be as acceptable or 'bankable' to providing 1,000 lanterns? These tensions emphasise the importance of user consultation in defining 'needs' and how to go about satisfying them, including questions such as: what type of energy?, how much of it? and what type of kit?

Continuing this theme, one actor expressed his surprise at the 'needs' sometimes manifested by users, and acknowledged the discord between what he, as a private sector provider of SHS, saw as fundamental user needs and the priorities often conveyed by users (this was a perspective also presented by expert interviewees 6 and 16). This is highlighted in the following account:

> 'Once we went to carry out an inspection in a community where we were going to install solar panels and what caught my attention was that the first thing that the *señora* [female of the household] asked me was 'will I be able to use my iron?' and I said 'you can't'… I mean we went there to put electricity in so that she wouldn't have to use an oil lamp anymore and she just wanted to ask me about ironing her clothes… I mean this lady lived in the mountains, hours away from civilisation and all she asked me about was if she could use the iron' [expert interview 9, private sector SHS provider]

The IEA PVPS (2013) report recounts a similar story wherein an African lady had bought a SHS at the same time as an iron. While the Nicaraguan or African lady might be ridiculed, it demonstrates what these users wished to achieve with an energy system: to iron clothes. As the IEA PVPS (2013) report states, 'the difference between a 1,000 watt iron and a 1 watt radio seems obvious for an engineer, but for most people (even in developed countries, it should be mentioned) it is simply irrelevant' (p. 12).

[77] The programme has subsequently changed its policy and included an inverter in the standard SHS package offered

This evidence illustrates a gap between which energy services are considered important by rural users and those assumed to be important by the actors (and financers) engaged in the dissemination of solar energy technologies.

In light of these debates, expert interviewee 9 went on to argue that it was time to rethink what 'basic needs' constitute:

> 'I started to think, perhaps there is a need to redefine what we mean by basic need… it is a term that is really complicated… because what I see as basic [need] is to have access to lighting, drinking water, education, health services, but that term can mean something completely different to other people' [expert interview 9, private sector SHS provider]

This echoes the current call made in relation to the SE4All objective by civil society – the clarification of ambiguity surrounding the initiative's stated aim of facilitating 'universal energy access' including defining what levels of access? what types of energy services? (e.g. FOEI, 2012) and what 'development benefits'? (Garside, 2012).

In summary, the Nicaraguan solar energy landscape is difficult to decipher; no official information about the penetration of distributed solar technologies exists and there appears to be little coordination between the actors engaged in 'project organised' solar interventions. Programmes range from large-scale donor-funded to very small-scale and informal activities. There are also many different programme types and actors engaging in the sector. Analysis of three specific solar programmes (as well as interviews with other actors from across the sector) reveals that solar energy is an 'agent of multiple objectives', here addressing climate goals, European taxpayer needs and/ or institutional demands. Indeed, those involved in solar energy interventions each have their own motives, which are not always clear or coordinated with the motivations of other actors. The following example quoted from Barley (1986) captures precisely the complex interplay of vested interests, multiple objectives and 'needs' inherent in the delivery of solar energy technologies that this section has conveyed. The following excerpt discusses the motivations of various stakeholders involved in the delivery of a community water project in Cameroon:

> 'The doctor hoped quite reasonably to eradicate at a stroke the major component of his case load. Most of the endemic fatal diseases derived either from impure water sources or else these sources so debilitated local inhabitants that otherwise mild infections proved fatal. He had despaired of treating villagers who promptly became re-infected when they returned to their homes. Pure water was the only way to break the cycle.

> The man from the Peace Corps quite clearly needed a large project with a budget, thereby justifying his own existence and endearing himself to his superiors. As a source of money and employment, he would also have power.
>
> The missionaries certainly had the material improvement of the locals at heart but were doubtless aware that by controlling the water they would be breaking the power of the rain-chief and so eroding pagan beliefs' (Barley, 1986: 89-90)

Different actors converge around development assistance interventions with multiple objectives, and attach different meanings and expectations to the product of the intervention. In the case of this research, a range of different 'problem narratives' (Smits and Bush, 2010: 125) are articulated in which perceptions of the role of solar electricity compete with different understandings of needs, in which vested political interests vie with international donor interests and local NGO interests, while the heterogeneous mass of rural households ultimately adopting, using, maintaining and sustaining technologies are largely without a voice in the policy making process.

Competition between different visions of distributed solar energy has the potential to confuse future developments in the sector. This connects to the critique of energy access activities that '…are not often well linked to each other, are framed under different assumptions and goals, and are, ultimately, insufficient' (Bazilian et al., 2010: 5410). This section has demonstrated the cacophony of approaches to the dissemination of solar energy in Nicaragua, and echoes the fragmented 'patchwork' of governance arrangements referred to in Chapter Two.

Having examined Nicaragua's solar landscape and the various actor groups instrumental in its function in considerable depth, the final section of this chapter considers another key thread of actor interviews to address research question four – to examine the key challenges facing the continued dissemination, sustainability and growth of distributed solar energy technologies in the Nicaraguan context. The following section builds on the analysis presented in previous sections and highlights the politics and complexity of the practice of off-grid solar energy in Nicaragua.

6.3 Barriers to the effective delivery of distributed solar energy in Nicaragua

All actors recognised common challenges to the effective delivery of distributed solar energy, some well documented in the wider literature and others more specific to the Nicaraguan case. The findings point to a series of barriers to sustainable electricity access through distributed solar energy technologies in Nicaragua, which broadly fit with Benjamin Sovacool's typology of barriers to the alleviation of energy poverty (see Sovacool et al., 2011; Sovacool, 2012b) and echoed in other scholarly work (see Watson et al., 2012). These include technical, economic and financial, political and institutional, social and cultural obstacles. In this sense 'sustainable' refers to the on-going viability of the system (a system that continues to work or will be replaced) or the programme promoting it, primarily in organisational, financial, technical and social realms (e.g. Corsair, 2009; Nieusma and Riley, 2010). Sovacool (2012b) notes that barriers often transcend technical, economic, political, and socio-cultural domains, making them particularly tenacious and difficult to overcome without coordinated action (see also Lysen, 1994; Foley, 1995). This section will examine two broad categories of barriers: the institutional and political, noting the interconnectedness of issues, which also incorporate financial, social and cultural aspects. A common thread evident in the analysis of the actor interviews was the perceived inability of key stakeholders engaged in the solar energy sector to fully engage with and understand the households or users ultimately intended to adopt, use and maintain the technology. This illustrates the importance of examining interventions from the perspective of the user, which will form the focus of the following chapter.

6.3.1 The project-centred approach: institutional and structural barriers

Institutional and structural challenges to the long term effectiveness of solar energy interventions were highlighted by actors from each actor group interviewed. These views were often framed within actors' experiences of previous 'development assistance' programmes (although not always energy-related interventions) in Nicaragua, which were described as lacking in vision, insufficient, short lived and at worst, designed to fail. Actors were critical of broader development assistance in Nicaragua - one even referred to it as an 'industry' – which they claimed produced interventions designed on the basis of donor interests, limited to short project lifecycles (i.e. the 'project' or 'briefcase' approach), which see organisations arrive, implement and leave (Morris 2013). For some of the actors interviewed, this approach did not aid 'development', rather it satisfied the 'need' of the implementing institution to secure funding. Two actors went so far as to state that such organisations in Nicaragua were 'mercenaries of development' (expert interviews 18 and 23) and invested in projects that did not necessarily address the most 'pressing needs' of inhabitants (expert interview 17 - president of development organisation supporting an off-grid solar programme on the Atlantic coast). Actors referred to numerous examples of 'failed' development interventions in the Nicaraguan context; expert interviewee 17 for example, highlighted a project in which 'dignified bathrooms' were installed in people's homes, in an area where water supply was not guaranteed. Other interviewees recounted similar experiences, wherein development assistance programmes had failed to adequately consider the local context in which they were operating (expert interviews 18, 15, 22, 23). Expert interviewee 17 emphasised that the structure of development assistance meant that organisations were limited in their ability to enact programmes as 'processes', or to respond to the vision of the organisation handing out the funds rather than to the needs of the target populations (see also Dichter, 2003). Several of the actors interviewed therefore considered that decades of development assistance had achieved little in Nicaragua, especially in the most impoverished Atlantic regions of the country. This damning indictment of development assistance in Nicaragua again highlights the importance of analysing interventions from the perspective of the users.

The design of solar energy interventions is crucial. However, according to one actor, the organisations delivering solar energy programmes are out of touch with the realities of the users ultimately intended to use technologies:

> 'Technological things can be difficult, they can be complex, but there is nothing so complex as social processes… You have to have patience and support users [of solar technology in rural areas] and follow them up over time. You need to listen a lot, and know how to interpret what is said. The large organisations who want to finance rural electrification, they have the buzz words of 'community participation', but what they do [when designing programmes] is formulate a questionnaire and even sometimes they hire sociologists, they go in, do their interviews and then look at how they can work with the results… but there are differences, it's not a simple translation between Spanish and English, it's about different ways of seeing the world…sometimes they [the donor or financial institution] do not have enough of this knowledge… and are in a hurry… they want to have quick successes and results… And while it is important that they have taken an interest in delivering solar energy… the problem is that they always want things done by certain dates, with rules and targets that do not necessarily fit with the reality of the countryside' [expert interview 15, founder of organisation promoting solar energy in Nicaragua]

The 'reality of the countryside' – which, for this actor, included issues such as different world views and extreme poverty – contrasts with the 'reality' of the institutions promoting energy access programmes, whose methods, haste, imperatives and designs were, in her view, incompatible with the realities of the areas in which they operate. This critical perspective is not exclusive to energy-related interventions and echoes scholarly critiques of 'development' interventions more broadly (e.g. Dichter, 2003).

The experience of a marketing director at a private sector SHS company also supported this view. He recalled supplying SHS kits to a project supported by an overseas development agency, wherein the SHS were donated to low-income households. On installation of the systems, company employees were shocked to find that many beneficiaries did not have adequate housing to which to attach the SHS components. For this actor, the experience demonstrated how solar energy interventions were often 'out of touch' with the reality of the populations they targeted:

> 'they [the SHS company installers] returned astounded by the poverty of the people participating in the project… in some cases there was nowhere to even attach the panel or the light bulbs because their homes were made of plastic… that is to say that the people receiving them [donated SHS] were clear that the [SHS] system was worth more than their homes and land put together… once they were set up, some people immediately sold the systems' [expert interview 9, private sector SHS provider]

Given that the SHS were immediately sold indicates that this programme was not sustainable in terms of the definition provided by Corsair (2009) and Nieusma and Riley (2010) above. The poor housing conditions and financial difficulties that faced households described above reveal that users had more pressing concerns than gaining access to electricity. Furthermore, even if the users had retained the systems, this raises questions about how long the systems would have remained functional. Indeed, SHS are often sold as a technology that does not require costly operation and maintenance investments, yet significant capital investment is required every two to three years to replace expensive components, such as the battery (Corsair, 2009). The extent to which families facing such extreme poverty would be able to finance costly replacements is doubtful. Inappropriate design in this case resulted in a programme likely to fail.

The notion that the intended users of the technology may have more fundamental pressing concerns than access to electricity, particularly those users facing extreme poverty, was also articulated by other actors. Interviewee 23 (president of development organisation supporting an off-grid solar programme on the Atlantic coast) suggested that from his experience as a development practitioner in the RAAN over several decades, food security, housing and access to water and credit were key priorities across the rural sector that were rarely considered or integrated into the design of (solar) energy access programmes, despite the clear crossovers between issues (e.g. using electricity to pump water, process food or generate incomes) (EI23). He suggested that the lack of a cross-sectoral or integrated approach contributed to the lack of sustainability in such programmes. He went further, arguing that it was therefore necessary for projects to be integrated into local development plans, which delivered electricity as part of a wider package of complementary infrastructure. A government actor with many years of experience in rural electrification argued that the Ministry of Energy and Mines had learned that without considering such intersecting issues, for instance, income generation, programmes were unlikely to be sustainable in the long term:

> 'The experience of the CNE [predecessor to the MEM], was only ever concerned with extending the grid... we saw the necessity to connect every house to the grid...so we were charged with this mission, to connect them up....but to bring electricity or energy to the house, also brings extra costs to the family.... because you have to pay the bill, right? It was good in that we generated 'development', and we could say X amount of Nicaraguans benefitted from electricity… but in reality this didn't work, people did not know how to make use of it... so what we now also do is promote the productive uses of energy…. To make it more sustainable… to make it pay' [Expert interview 22 – government official, rural electrification department, Ministry of Energy and Mines]

These experiences emphasise the necessity to create programmes which are self-sustaining or self-reinforcing i.e. making solar work 'beyond the light bulb' to power income generation (e.g. Clancy, 2001; 2003; Clancy and Dutta, 2005) or extending access to micro-finance in order to improve productive capacities alongside users' participation in a solar programme (e.g. Wong, 2012). This ties in to debates on so-called 'integrated energisation' discussed in Chapter Three.

Actors also recognised that local capacities need to be built to ensure the longer term sustainability of SHS. The notion of users needing to be 'prepared' or 'ready' to use distributed solar energy technologies, i.e. through behaviour change and internalising its uses, was commonly expressed by actors. This implies that successful programmes require adequate awareness raising, capacity building and training. Actors pointed to this as having frequently been an oversight in their experience of solar interventions in the Nicaraguan context, arguing that the project-centred approach tended to limit interventions to providing 'hardware and finance' (see also Byrne et al., 2012; Watson et al., 2012), without crucial elements such as awareness raising, training or follow-up. This echoes Nieusma and Riley's (2010) criticism, that the imperative of energy development assistance programmes is too frequently simply to make the technology 'work' technically, without considering the social and economic conditions that need to be established in the local environment to sustain such changes. Two actors that had engaged with donors on solar programmes argued that sufficient funding for these crucial elements was not always available:

> 'An obstacle is that often you have little resources for training, the donors, the [development] agencies say 'we're going to help you, we'll give you the funds', so they donate all the equipment… but money for monitoring and training to ensure that people are strengthened and

trained to be able to look after the equipment, well... the funds for this are always minimal…for the [development] agencies the technology is really important, but I think that it is also important that people know how to manage it… In the case of this programme, it has required strong counterpart [government] funding for these elements' [expert interview 13, technical advisor, large donor funded solar programme]

'There is no perspective of project sustainability… how can there be when there is no financing for post-sale [visits] or training?' [expert interview 6, founder director, private renewable energy company]

These quotes echo the arguments made by Sovacool (2012b) that energy access interventions are 'minimalist' or 'insufficient', as well as those of Byrne et al. (2012) who argue that the narrow 'hardware and finance' approach neglects the fact that successful technology transfer also requires knowledge and skills.

Another barrier to the sustainability of the programmes that was frequently mentioned was the lack of post-sale or follow up visits, which are generally difficult and costly, especially when people live in remote areas. One of the main SHS providers explained that his company now incorporated a US $20 charge in to the cost of the SHS to finance one post-sale visit. He also recommended the following for programme designers:

'you normally have an allocated budget per person, say if I have a thousand dollars per person, I wouldn't spend it all just on the kits… we'd spend around seven hundred dollars per system and the other three hundred dollars we'd spend over the next three years to follow up and support users.... This type of accompaniment, accompanying users to ensure sustainability is not something that I see happening here, many organisations fulfil their indicators [installations] and then they leave… as a private company I see this, but as much as I want to support or comment, we basically have to adjust to the conditions of the tenders and our responsibility only goes so far' [expert interview 9, private sector SHS provider]

This actor recognised the failings of the way that current programmes are designed and delivered, however he also expressed the view that it was not his role as a private sector firm to correct this. Again the questions of, 'who benefits from solar interventions?', and 'whose responsibility is it to guarantee sustainability?' arise. A government actor similarly recognised past failings in this sense:

> 'In Nicaragua we're good sellers, but not very good with the post-sale… that is why so many programmes have failed' [Expert interview 22 – government official, rural electrification department, Ministry of Energy and Mines]

Interestingly, government actors agreed with the private sector views that a major problem was that key donors rarely include funding for post-sale follow-up within the resources dedicated to executing the project. During an informal conversation with a group of officials at the Ministry of Energy and Mines, they recounted that approximately 1,000 solar home systems had been donated and installed in the Nicaraguan RAAN in the mid-2000s, and today estimated that a small fraction of the systems would still be functional (or even present) in the homes where they were originally installed. The officials insisted that nobody in the MEM wanted to follow-up on the programme, because of embarrassment and reluctance to admit to the donor that the programme had been a failure. This raises questions about the potential for good governance, but also presents the danger that actors engaged in the provision of solar energy will get caught in the same traps again and again (Schäfer et al., 2011: 325), highlighting the need for transparent, independent monitoring and evaluation of interventions (Brass et al.; 2012; Watson et al., 2012).

In one case, dissatisfaction with the project-centred approach to electricity access has encouraged an NGO to transform its financial model; instead of being dependent on funds for specific projects from donors, the organisation has chosen to rely on the income generated by international volunteers who paid to intern at the NGO's field office in Nicaragua. Expert interviewee 7 argued that donor funded projects often sought 'results' and 'impacts' in terms of the number of users electrified or the rate of expansion into new geographical areas. By contrast, this NGO has sought to concentrate activities within the communities where they were already working in order to improve the quality of energy services, provide power for homes as well as community centres, and increase the number of local leaders engaged in managing energy systems. This illustrates that other models for the delivery of (solar) energy services exist, however that a shift in the structure of organisations and sources of finance are required.

This section has focused on the broad category of institutional challenges facing the effectiveness of solar energy interventions in the Nicaraguan context, which incorporates political, financial and technical challenges. The chapter now turns to examine a series of political obstacles.

6.3.2 Political challenges

In addition to the institutional challenges discussed above, actors also revealed a number of broadly political challenges related to the continued development of the solar market and programmes promoting distributed solar energy in Nicaragua. The issue of *no pago* (non-payment) in Nicaragua was identified in Chapter Five as a political and socio-cultural phenomenon with deep roots in Nicaragua (see Arenas, 2009). Interviews with solar actors concurred that the *no pago* culture has been cultivated via a history of political parties attempting to gain favour with voters. Recent politically motivated statements regarding *no pago* (including the government's apparent endorsement of it) have, for example, seriously impacted the microfinance sector, putting into jeopardy the lending infrastructure for solar products that had been established through the PERZA programme (discussed in section 6.1). From another perspective, actors from the NGO sector promoting SHS and off-grid renewables, explained how the politicisation of the electricity sector and political interference in energy access initiatives have made their work difficult in several key areas, for instance, where government electrification plans have undermined the dissemination of distributed solar energy. The proliferation of donated or subsidised technologies (as highlighted in section 6.2) – whether they are government-led or not – has the potential to flood the market with solar products and create tensions between organisations promoting different delivery models. Connected to this, actors perceived that in some cases households had come to expect 'freebies' to enable their access to electricity, and that a form of dependence had been nurtured, posing potential threats to the local sustainability of SHS programmes.

The *no pago* movement has undergone a recent resurgence in Nicaragua, partly galvanised by President Daniel Ortega who told debtors that they should 'stand firm' and 'reclaim their rights' against the usurious practices of microfinance institutions in Nicaragua (El Nuevo Diario, 2009). The product manager of a leading microfinance institution explained the evolution of this movement:

> 'The president's discourse was 'go and put yourself in front of the [micro credit] institutions', and so the people understood this as, 'great we have the government's blessing to go out and protest' and so the problems escalated to where the police had to get involved.. they were going to burn down our office, our institution… and so the president came out and said 'no, nobody is going to dissolve the debts, nobody is giving anything away, everything must be paid for'…but now we are in an electoral year and politicians from both sides are trying to seek favour from the voters by saying that people do not have to pay their debts' [expert interview 14 – leading micro finance institution]

While the President ultimately backtracked and urged debtors to continue servicing their debts, expert interviewee 14 argued that the *no pago* sentiment had re-emerged in the wake of the presidential election campaign of 2011. For some of the actors interviewed, the *no pago* sentiment impacted on the commercialisation of solar energy products. The marketing director of a private sector SHS provider argued that a knock-on effect of the *no pago* movement was a decline in lending, and therefore SHS sales:

> 'The *no-pago* movement has obviously hit our sales hard… it [the *no pago* movement] put Nicaragua's credit portfolio at risk and as a result there was a retraction in the credit made available to people, that is to say that none of the micro financers would release more credit for solar panels because the *no pago* movement left much of the lending portfolio unstable' [expert interview 9, private sector SHS provider]

The market instability caused by this movement has led to a decline in the funds available for individuals to access products such as SHS. This sentiment was also articulated by the manager of another SHS company, who suggested that a reduction in the offer of credit due to high levels of loan defaults meant that the 'self-organised' or private sales of SHS had 'stalled'. This had resulted in his company predominantly focusing on the business opportunities provided by the changing financial landscape of energy access programmes (as discussed in section 6.2), i.e. the SHS programmes of international donors which either facilitated donated/highly subsidised systems (therefore not requiring micro credit services) or provided financial backing to micro credit lines (expert interview 26 – private sector SHS provider).

As Chapter Five (section 5.6) elaborated, the FSLN government has become associated with the proliferation of 'aid-style' development programmes, with cases of alleged political favouritism in the choice of recipients (see Wade and Walker, 2011; Envío-Nitlapán, 2011). In particular, this was highlighted with regards to the politicisation of grid electrification activities in the run up to the 2011 presidential election campaign (see Chapter Five). This is not an issue which is unique to Nicaragua, politicisation of grid electricity has created significant barriers to the dissemination of distributed RETs such as SHS in other cases too; for instance, Rehman et al. (2012) find in Bangladesh, China, India, Indonesia and Pakistan that politicised grid extension activities have provided 'hope' that grid-supplied electricity will be delivered to deprived sections of the population, therefore reducing the desirability of adopting solar energy (see also Kirubi et al., 2009; Sovacool and Drupady, 2012; Groh, 2012). The co-founder of an NGO promoting renewable energy programmes on Nicaragua's Atlantic coast argued that the political motivations behind electrification made it difficult for organisations like his to plan and execute their work:

> 'The electrification plan… it's not even a plan… it's more of an electrification project where it's mostly based on political interests, buying votes and stuff... so that makes our life very, very difficult… we were designing projects for isolated rural electrification in areas where it was already agreed that the grid would come in the space of months... quite often we had no idea what was coming and no one on the coast was even aware of electrification projects… in some cases we had to refinance...we had to cancel entire initiatives because we were isolated from that information' [Expert interview 7, founder of NGO with off-grid RE initiative]

Politically motivated and uncoordinated grid electrification caused this particular NGO to abandon initiatives that were nearing implementation. Again this not only highlights the fragmented approach to the delivery of electricity (solar or otherwise) to off-grid households, but also underlines the consequences of political interference in energy access programmes.

In a similar vein, the coordinator of a SHS programme at another NGO argued that the increased politicisation of electricity was problematic for his work. The widespread notion that the government 'rewards' voters meant that the implementation of SHS programmes that required users to make monetary contributions (e.g. to system acquisition, maintenance or replacement), was becoming more difficult. He argued that significant challenges had been faced by his NGO, particularly entering into the electoral year. Some communities, for example, assumed that the NGO was aligned with the government and was therefore handing out 'freebies' (expert interviewee 36, coordinator, NGO SHS programme). This resulted in problems given that this particular NGO's business model was to offer long-term credit for household access to SHS.

The 'politics' of donors is equally worrying however. A donor programme operating in the north-west of the country distributed subsidised SHS on a large scale. The private sector SHS provider involved in programme delivery argued that it had been clear at the time of installation that the electricity grid would enter some of the communities receiving SHS – almost certainly affecting whether or not the systems would ultimately be used – however that the policy of the executing donor had been to fill 'quotas' and achieve volume, rather than to foresee whether SHS would be operational in the future (expert interviewee 6 - director, renewable energy technology company). This again provides a damning indictment of the practice of solar energy in Nicaragua and raises some serious questions about 'who benefits' and 'whose sustainability?'. This experience suggests that some projects were simply designed to fail.

The changing financial landscape of energy access programmes meant that multiple organisations operating different types of delivery models could potentially be working in neighbouring communities. Interviewee 34, the president of an agricultural cooperative, who had helped two major organisations to coordinate SHS programmes – one with entirely donated kits, the other offering subsidised kits – experienced this tension. This reflected not only the tension that this caused between communities who were offered different electricity access 'packages', despite sharing similar socio-economic characteristics, but also the danger that households would decline to participate in programmes or abandon systems altogether. The political economies of development cooperation, which see organisations donating systems (and potentially flooding) or disturbing the market with subsidies has implications for the work of other actors engaging in these endeavours. This echoes the call made by Bellanca and Wilson (2012) for greater coordination between programmes, and for actors to better understand the markets they are engaging with (and potentially distorting).

The politics of how electricity access is 'done' – government-led or not - has created what some actors term a 'donor mentality', a culture of 'dependence' or 'over-assistance' in Nicaragua. Expert interviewee 7 for example argued that certain regions of the country (particularly the Atlantic coast) have been the foci of much development assistance over recent decades. The 'donation' approach to development assistance he argued, had nurtured a culture of entitlement, which made his work - promoting distributed renewable energy - particularly difficult. The following quote highlights this view:

> 'We're faced with a region that has been hit by so many development projects that there is definitely a culture of being assisted, of being aided and they are becoming.... they have become experts at luring you and always looking for the biggest short term interest and being able to secure more than they would need... and that's because development in that region has been done like it's been done anywhere else in the world... in the 70s and 80s, just upside down. They thought that just giving stuff away out there was the way to help… and it has created that culture... communities are actually very inventive and astute in taking advantage of development assistance so that's a huge cultural challenge [for an organisation] to face..' [expert interview 7, NGO with off-grid RE initiative]

This sentiment was similarly echoed by other actors:

> 'when communities receive a lot of NGO assistance, they fall into what we call dependence, in other words they come to depend on the funds from aid agencies… And so their capacities become self-limited... the communities that are less assisted for example, they are creative in

> ways that other more assisted communities are not' [expert interview 17, president of development organisation supporting an off-grid solar programme on the Atlantic coast]

> 'when there is a donation culture or donor mentality they think, 'I'm going to wait for another project to come along to take care of this' or if something breaks, they are not capable of buying a new part or taking it to be repaired… many organisations instil the idea that people can't [do things for themselves]… It almost becomes a way of life for people to depend' [expert interview 13, government official, coordinating large donor- funded solar programme]

According to the actors interviewed, a legacy of the 'development assistance' industry in Nicaragua is a culture of dependence. This has potential consequences for the future of the solar market and programmes promoting this type of technology in areas that grid-supplied electricity will never reach. Solar energy technology is costly – whether in its acquisition or long-term maintenance - and requires users to make investments in replacement parts. This set of challenges raises further questions about what this culture implies for the sustainability of current and future solar energy interventions within the Nicaraguan context.

6.4 Conclusion

Since the launch of PERZA in 2003, Nicaragua's off-grid solar energy market has grown significantly. During this time, the infrastructure required to commercialise distributed solar energy technologies and to establish a robust solar sector has been assembled. Private sector SHS providers, micro finance institutions and the state have converged to facilitate access to SHS on a large scale. The use of solar energy represented a significant shift in how electrification was 'done' in Nicaragua i.e. there was a shift from a centralised to a distributed approach. Further, despite the ambitious national grid electrification targets, small scale solar energy technologies remain important transition technologies or longer-term alternatives for electricity provision in the country's most remote areas. Whilst a commercialisation approach to the dissemination of solar was promoted through PERZA, donors were seemingly making use of the solar infrastructure established (e.g. increased geographical penetration of solar companies, increased knowledge of/capacity to install off-grid solar energy systems) to roll out solar programmes that involved the adoption of a variety of delivery mechanisms. Solar company actors interviewed agreed that servicing the emerging programmes of international donors and local NGOs had become a large part of their business activities. This is indicative of the wider paradigm shift occurring wherein there are a greater volume of institutions responding to the new global scripture of 'sustainable energy' and providing financing for the execution of programmes to target different income groups (as discussed in Chapters Two and Five).

PERZA's 'successes' were framed around the establishment and strengthening of the solar infrastructure, rather than from the perspective of the households ultimately using the technology. Indeed, key actors were unable to provide detailed information on user experiences with solar energy technology over time (beyond anecdotes) or even the extent to which installed technologies continued to function. Unsurprisingly therefore, little information existed about the penetration of distributed solar energy technologies. Furthermore, ostensibly low levels of coordination existed between actors engaged in the delivery of solar energy. Deciphering the solar energy landscape was therefore incredibly difficult. Identifying and analysing three specific solar programmes (combined with interviews of other actors engaged in the sector) provided some insights into the drivers and practices of solar energy interventions. Analysis revealed that solar energy was an 'agent of multiple objectives' (Hunsberger, 2010:959), a flexible technology that seemingly addressed climate goals, the normative needs of European taxpayers and institutional demands. Solar energy therefore appealed to actors with varying priorities or mandates, and responded to various organisational objectives or 'needs'. This highlighted the critical importance of understanding the influence of global and national political economies within which such programmes are embedded; distal forces influence the way in which programmes are ultimately framed and delivered, with implications at the local level. This raises critical questions about *whose* needs are addressed and which actor groups ultimately benefit from the advent of the off-grid solar energy market.

Varied perceptions about the implications of solar energy technologies for households were articulated by actors. On the one hand, the technologies typically deployed within the Nicaraguan context were framed as 'progress', or as compatible with the basic needs of rural households (particularly for lighting or connective purposes). While on the other hand, critics suggested that technologies were insufficient to meet 'real user needs' (namely income-generating activities) and, at their most critical, imposed by external organisations satisfying their own institutional needs and perceptions of basic household energy needs. These more critical perspectives originated from actors most familiar with the types of off-grid households that were targeted by such programmes. However, that solar energy technologies delivered local level benefits (or otherwise) relied on the on-going viability of individual systems or programmes promoting them, primarily in organisational, financial, technical and social realms. As later parts of the chapter discussed in depth, a significant number of institutional and political obstacles to this were identified and emphasised by the actors engaged in delivering solar energy. This related to the project-centred approach often dictated by the funds available for implementing programmes; while actors delivered on development industry 'recipes' for interventions, in some cases they did so doubting its sustainability from the outset. Dominant implementation methods were identified as narrowly focused on the provision of hardware and finance, which omitted crucial elements such as user training or follow-up. In other words, they were inadequate to establish the appropriate conditions for the long term sustainment of solar energy technologies. The political economies of donor assistance also interacted with the specificities of the national political economic framework. As elaborated in Chapter Five, the *no pago* movement combined with the increasingly politicised nature of grid electricity access, may serve to undermine the efforts of organisations delivering perceived 'second best' technologies. These findings raise important questions about whose role it is to coordinate activities, to ensure the sustainability of energy access interventions, and thus determine the 'winners' and 'losers'.

Given the somewhat dismal picture of the 'project organised' solar energy arena portrayed by this discussion of the views of actors integral to its operation, it is important to note Wamukonya's (2007) concern that some of the SHS programmes of international donors are not always 'free' to host governments. In the case of PERZA, GEF grants covered 18% of total project costs, with the remainder loaned to the government from the International Development Agency (IDA) and provided as counterpart funds (World Bank, 2003). This therefore raises the question of whether scarce government resources could be better allocated to other 'development' priorities.

This chapter has highlighted the highly complex, fragmented and uncoordinated nature of (solar) electricity access programmes in Nicaragua. The chapter cast light on the practices and politics of these interventions, an area largely overlooked in the literature and particularly in the Nicaraguan context. This analysis points to the necessity to examine the role of technology users, who are ultimately intended to adopt, use and sustain technologies in the long term. The end user perspective forms the focus of the following chapter.

Chapter Seven. Local Energy Realities: The Perceptions and Experiences of Solar Energy Interventions

This chapter addresses the local level implications of solar energy interventions, which as examined in Chapter Six, are shaped through the interplay of domestic and global political economies. Through drawing on field research conducted across three solar energy programmes (as described in Chapter Six), this chapter addresses research questions three: 'from the perspective of users, what are the implications of solar energy technologies?' and four: 'what are the challenges facing solar energy interventions in Nicaragua?'. The detailed analysis that follows presents the perspective of the households adopting, using and sustaining solar energy technologies, and the challenges they face in doing so.

Chapter Six revealed that in Nicaragua, the 'success' of the off-grid solar energy market has largely been framed in terms of strengthened market infrastructure, rather than from the perspective of the households that had purchased SHS. Indeed, the actors integral to the *Proyecto de Electrificación Rural para Zonas Aisladas* (PERZA) revealed a general unawareness of the longer-term implications of solar energy interventions on users, and also the extent to which systems installed were still functioning. This view was particularly apparent during an interview with a high ranking official of the Ministry of Energy and Mines' rural electrification department, who claimed that PERZA had revolved around 'filling the pockets' of the companies accredited to sell solar home systems (SHS), and that little was known about what happened to users that had purchased SHS (see Chapter Six, page 161). This sentiment was echoed by many and is repeated in other geographical contexts. Indeed, more than a decade ago Nieuwenhout et al. (2001) highlighted the dearth of information relating to the actual lived experience of users with solar home energy technologies over time. As Cherni (2008) argues, there is an urgent need for greater ex-post evidence on the experiences of renewable energy technology interventions to determine whether technologies fulfil the practical energy needs and priorities of users. Understanding these perspectives is of vital importance; Schillebeeckx et al. (2012) for instance argue that a better understanding of users is likely to increase the long-term sustainability of rural electrification projects, thereby increasing the effect of limited governmental resources (p. 695).

However, as highlighted by numerous scholars and as revealed in interviews conducted for this research, negative experiences with technologies are seldom narrated, and as such there is an urgent need for critical, objective evaluations (Nieuwenhout et al., 2001; Schäfer et al., 2011; Sovacool and

Drupady, 2012; Watson et al., 2012). This is even more critical in light of the discussions in Chapter Two, which highlighted the recent explosion in the deployment of solar energy technologies across the Global South as a 'keystone' technology in the international community's efforts to secure universal energy access. Ensuring that ambitious targets - such as the SE4All universal energy access by 2030 goal - can be achieved and maintained (and indeed, judged on their appropriateness) requires an in-depth understanding of user experiences and perceptions of such technologies. Through placing users at the centre of analysis - something that Bond et al. (2012) argue is overlooked in typical impact evaluations - this chapter responds to these calls and builds on and adds new empirical insights to the debate on end-users' experiences with small scale solar energy technologies in rural areas of developing countries.

The chapter draws on interview, focus group, participant observation and survey data collected with households in off-grid communities associated with the three solar energy programmes introduced in Chapter Six. The coding of these data (as explained in Chapter Four) was used to draw out the key themes and those themes have influenced the structuring of the chapter. The chapter is therefore organised as follows: the first section, divided into three parts, presents the three solar programmes (Project Solar, GED Programme and Project Santa Clara), and provides in-depth data on the communities within which they were implemented. Section 7.2 presents the 'energy realities' of households prior to participation – their expectations of electricity, and perspectives on life without it. Section 7.3 presents user experiences of solar energy in the post-adoption period; in particular, whether user expectations of solar energy were met, the perceived impacts and benefits wrought, in addition to the challenges facing users as solar energy technologies are incorporated into their everyday lives. The final section concludes by highlighting the breach between users and implementers in terms of their perceptions about basic household needs, priorities and circumstances. While users discussed the delivery of significant 'non-monetary lifestyle benefits', the limited capacity of the solar technologies combined with its relatively high cost, may ultimately result in the abandonment of the technologies.

7.1 The solar energy programmes

The three solar energy programmes investigated for this research were 'project organised'. That is, they derived from the planned effort of an organisation to facilitate access to solar energy; this approach, as discussed in Chapters Four and Six, is illustrative of the wider Nicaraguan solar landscape. All programmes were designed on the premise that the 'user pays' for energy services (see World Bank, 2008), on the basis that households often already dedicate significant amounts of income to poorer quality fuels for lighting and operating appliances. All programmes shared the objective of making solar electricity accessible (financially) for households living in off-grid areas of the country. However, as

Chapter Six established, the programmes were driven by different mechanisms and ultimately, objectives. Delivery models varied from programme to programme: Project Solar used long-term micro-credit to enable purchase of SHS, GED provided a large subsidy to enable purchase, while Project Santa Clara donated community solar systems with 'pay-as-you-go' use of solar electricity. Each programme offered support for users to acquire and use systems. However, once installed, the responsibility for future costs and maintenance was assigned to users. As outlined in Chapter Four, a total of 38 respondents were interviewed, 152 households surveyed, and four focus groups were conducted at the local level. The majority had participated in the three case programmes for a period of three months to five years, although some respondents were interviewed as they were shortly due to participate in a solar energy programme. In order to add context and depth to this chapter's analysis of the local or user perspective, the following sections add significantly to the data presented in Chapter Six. The subsequent sections provide detailed information on the nature of the communities where the programmes were implemented and the views of participants.

7.1.1 Case Programme A: Project Solar

Project Solar installed SHS in approximately 200 homes in rural areas of Masaya and Managua. The programme was implemented by a community development NGO and financed through a range of sources, especially through relatively small donations provided by UK-based housing associations, which used the programme to off-set carbon emissions. The programme was initiated in 2005 during the early stages of the off-grid solar energy market. As discussed in Chapter Six, the NGO operated in locations unlikely to be grid-supplied with electricity in the near future, typically offering SHS packages consisting of a 50 Wp solar panel feeding a 12 V battery, three lightbulbs, a charge controller and inverter. The business model used to disseminate the technology can be described as a 'dealer' model in which users purchase the system with finance provided by the organisation (World Bank, 2008). The implementing NGO offered a unique service through extending interest-free finance to households over a six to seven year period, in a context where long-term lending (i.e. greater than two to three years) for goods like SHS did not exist[78]. Once a US $20 deposit was paid, the SHS installation was arranged. Finance was loaned in US dollars, and users repaid the full amount in monthly installments in local currency equivalent to US $11. To reduce the programme transaction costs, users were originally expected to pay their monthly instalments directly to the organisation in Masaya; however a local entrepreneur[79] had begun collecting payments, charging users a small fee (typically US $1 – 1.50) to do so. Beyond the system warranty period, users assumed responsibility for all operational and replacement costs. While

[78] An official at Nicaragua's largest micro-finance institution confirmed the uniqueness of this loan product in the Nicaraguan context.
[79] The entrepreneur acted on behalf of the NGO, but was not employed directly by them.

the entrepreneur and NGO staff were trained in system installation, installations were of a variable quality, which was considered to have negative implications in terms of long term technical functionality (e.g. UCA, 2012 identified problems with panel and battery siting). In terms of maintenance, the entrepreneur could source new components and install as necessary (for a small fee); however, interviews and personal observations revealed that this process was inconsistent.

The long-term lending agreement between the NGO and user established a relationship for a period of up to seven years. While visits could be regular, the influence of weather conditions and personal commitments of the entrepreneur meant that participants were sometimes not visited for periods of up to seven months. This meant that not all users made regular monthly repayments, and some were left without electricity altogether if their SHS experienced technical problems (although there were other sources of technical assistance that users could draw on, for instance that of private companies). The entrepreneur performed general maintenance activities for a small fee; however, users were often unaware of the necessity of these activities and were untrained in dealing with this aspect of SHS ownership. This delivery model was based on a revolving fund, where loan repayments were used to finance the provision of further SHS to other households; the future success of the programme rested therefore on the recuperation of loans, or on the ability of the NGO to harness more donor funds. Since the programme was initiated in 2005, fifteen SHS had been purchased through recuperated loans.

The departments in which Project Solar was in operation - Managua and Masaya - are amongst the more developed departments of the country in terms of the socio-economic development indicators presented in the national census (INIDE 2005a; 2005b). According to the MEM[80], these departments also display the highest levels of electricity coverage nationally. Masaya and Managua are industrial and commercial centres of Nicaragua, with major industries including footwear and clothing, furniture, *artesanías*, and tourism. The population is predominantly urban (Managua, 90%, Masaya 57%), while secondary and tertiary sectors dominate in terms of employment.

7.1.1.1 La Quebrada, Chiquistepe and El Rosario

The land on which the three *caseríos* are located used to belong to the state-owned sugar refinery, *Victoria de Julio.* This land had been privatised and the area had become the site for several large haciendas that produced rice and sorghum. La Quebrada, Chiquistepe and El Rosario were relatively small *caseríos*, populated with 24, 15 and 38 households respectively. Despite census data for the wider Masaya and Managua departments illustrating relatively favourable socio-economic development

[80] See: http://www.mem.gob.ni/index.php?s=3&idp=351&idt=2&id=267

indicators compared to the rest of the country (INIDE 2005a; 2005b), residents of the *caseríos* faced conditions of extreme poverty[81] and marginalisation, related to income poverty/insecurity and lack of access to basic services (water, sanitation, electricity, land security, adequate housing, education and health facilities). All three communities were characterised by a lack of political consciousness, community leaders and organisational structures, which residents stated was one of the main barriers to lobbying for improved basic services.

The haciendas provided the largest source of employment in the area; men living in the *caseríos* were employed on an irregular basis (as *jornaleros* or day labourers), where wages averaged US $5 per day. Some of the women were also employed as *jornaleras* (day labourers) or undertook *chambas* (informal paid work undertaken by women, usually clothes washing), with the remainder caring for children and carrying out domestic work. None of the *caseríos* were cultivated for subsistence production (e.g. beans or maize) due to a lack of formal land rights (residents of the three *caseríos* shared the problem of insecure land tenure), lack of technical assistance, finance and available water resources. While the haciendas themselves were served with water, sanitation facilities and grid-supplied electricity, these services were not extended to the surrounding communities. Residents therefore relied on the goodwill of the hacienda owners to provide access to water or mobile telephone battery charging, for instance. The precarious nature of housing in the *caseríos* (houses were predominantly made of plastic, scrap metal, wood, with corrugated zinc roofs and dirt floors), combined with low population and income levels, and the uncertainties about land tenure, made the communities a very low priority for the private electricity distributor in terms of considerations over the location of new grid connections.

[81] A meeting with a social *promotor* at the local *alcaldía* (mayor's office) who had experience of working in these *caseríos* confirmed this point.

Figure 21. Project Solar participants, Chiquistepe

Source: author's own photographs

7.1.1.2 Guanacaste, El Amatillo, La Concha and Sabaneta

Compared to the precarious situations of households located in the *caseríos*, Project Solar participants in the communities of Guanacaste, El Amatillo, La Concha and Sabaneta, were relatively 'well off'. Respondents interviewed in these areas generally owned land, lived in well-constructed homes and were engaged in employment as *jornaleros* (day labourers) or had smallholdings which produced basic grains (for subsistence) or cash crops/livestock (or a mixture of both subsistence and productive activities). While residents in these communities expressed concern about their lack of access to basic services, compared to the *caseríos*, they were generally less isolated from markets and transport infrastructure, and in some cases had access to potable water and sanitation facilities.

Common to all the Project Solar communities visited was the lack of grid electricity; residents claimed to have requested household grid electricity connections from the electricity distributor Disnorte-Dissur (the grid network runs in relative proximity to each of the settlements, especially in La Quebrada, Chiquistepe and El Rosario). After repeated requests, however, residents claimed that they had received no response from the company. In the case of La Quebrada for example, a MEM official confirmed that the *caserío* was one of 443 Nicaraguan communities located within 150m of the electricity distribution network, which by law should be connected by the private distributor.

7.1.2 Case Programme B: Global Energy Development (GED) Programme

The programme was implemented by a European development agency, which since 2006 has facilitated access to over 2,000 SHS across various off-grid areas of Nicaragua. The research conducted for this study focused specifically on the first phase of the programme (2006- 2007), during which time 400 subsidised SHS were installed in rural areas of the North Central Mountain Region (NCMR) of Nicaragua. This programme emerged in the initial growth years of Nicaragua's off-grid solar energy market, during which the geographic reach of companies and popularity of solar as an option for decentralised electricity access increased significantly (see Chapter Six, section 6.1). The programme facilitated access to a SHS consisting of a 50 or 85 Wp solar panel feeding a 12V battery, three lightbulbs and a charge controller[82]. The development agency operated an 'output based aid' approach to project implementation (see GPOBA, 2009), which involved coordinating local agricultural cooperatives and private sector SHS companies to channel a subsidy towards the initial cost of the SHS, therefore making the technology financially accessible for end users. Households that were part of organised communities, with the capacity to finance the subsidised SHS (approximately US $400) were approached to participate in the programme. Local intermediary organisations (agricultural cooperatives) collected payments from households willing to participate on behalf of the private company, and once installations had been verified by the development agency (i.e. presence of SHS and quality control), the remaining subsidy was paid to the private SHS company. In the post-installation period, users assumed (financial) responsibility for system maintenance and replacement of components. While in some communities, a few local technicians received training on the operation and maintenance of SHS through the project, users pointed to a general lack of capacity to deal with any technical issues arising.

The GED programme was rolled out in communities of the NCMR (departments of Estelí, Madriz and Nueva Segovia). In comparison to Masaya and Managua, the majority of the population reside in rural areas, and employment is mainly concentrated in primary industries (INIDE, 2005c; 2005d; 2005e). While the regions were by no means the poorest of the country, compared to Masaya and Managua, census data reveals that populations in the departments of Madriz and Nueva Segovia in particular, face challenges related to literacy levels, sanitation and access to potable water (INIDE, 2005d; 2005e), while

[82] This offer changed in later phases to also include an inverter (which enables AC devices to be operated).

grid electricity extended to between 65% (Madriz) and nearly 80% (Estelí) of the regions' populations[83]. The main industries of the NCMR included coffee, tobacco, basic grains, livestock, timber and tourism.

The main economic activity of those surveyed was agriculture (80%), mainly the cultivation of coffee and basic grains, as well as some livestock rearing. The majority of those surveyed (63%) reported earning between US $0 and $90 per month, and their economic activities were largely subsistence/cash crop or temporary work[84]. Of those surveyed, just 17.5% were salaried employees (e.g. teachers, plantation workers). In comparison to participants of Project Solar, the majority of GED participants had to finance a large upfront payment for the SHS, which was sourced through a number of ways, including the liquidation of productive assets, savings, earnings, remittances and, in a small number of cases, microcredit. Although far from being a homogenous group (some participants were wealthy landowners and coffee growers, others were living in more financially precarious situations), at the time of SHS implementation, the 152 participants generally had higher levels of purchasing power than those of Project Solar.

At the time of SHS installation, none of the communities were grid electrified; however, within four to five years after the programme was first implemented, grid electricity had reached 18 of these communities (although not all households within those communities due to the dispersed and remote nature of some dwellings). In common with the communities that participated in Project Solar, many respondents surveyed in the NCMR expressed concerns about the lack of access to basic services, including easily accessible drinking water, sanitation facilities, grid supplied electricity, education, healthcare, job security and infrastructure.

[83] See: http://www.mem.gob.ni/index.php?s=3&idp=351&idt=2&id=267

[84] The majority of households found it very challenging to talk about their monthly incomes. This was particularly true for those who specified their economic activities as subsistence-based or seasonal. It is unlikely that households subsisted on zero income (as 37% of respondents reported), but rather did not have a clear picture of their income due to its irregular and/ or precarious nature, or had assets that could be liquidated or exchanged for goods and services. It is also possible that respondents were affected by 'social desirability considerations', where respondents may feel pressure to respond in an 'acceptable' way (De Vaus, 1996:110; see Chapter Four). It is important to reflect on the potential expectations created when researchers enter communities to discuss issues such as energy access – it is possible that responses to questions regarding income, or capacity to pay for energy access interventions, may have been affected.

Figure 22. Participant household in the GED programme

Source: author's own photograph

7.1.3 Case Programme C: Project Santa Clara

This case programme had different origins and a contrasting form of operation to programmes A and B. Seven 2.4 kW solar battery charging stations (SBCS) were installed in 2006 as a sub-project of the PERZA programme (discussed in Chapter Six), located in indigenous communities of the North Atlantic Autonomous Region (RAAN) and executed by the MEM.

In contrast to the individual systems installed in Project Solar and GED, or those promoted through the PERZA solar credit line, the SBCS was a community system where householders cart individual batteries to a central solar station for charging. The SBCS, compared to the 'traditional' SHS, was considered the most viable option for electrification in the context of isolated and impoverished populations in the RAAN. Once charged, the battery is connected to a SHS-like household system (with battery, charge controller, lightbulbs and inverter) to provide services similar to that of an individual SHS (see Figures 23-25 below).

The hardware was donated to communities (and costs borne by the Nicaraguan government) and users were required to commit a regular fee to recharge their individual battery. The original concept was to allow families to charge their batteries only when they had available cash (similar to the retail buying of candles, kerosene or firewood) to contribute to a community sink fund for future maintenance and replacement costs (World Bank, 2003:78). However, the donor organisation later revisited this model due to user non-payment (reasons for non-payment are discussed in detail in section 7.3.4). Under the revised model, users were required to commit regular monthly payments (US $1 per battery recharge, a minimum of four times per month) in order to sustain the SBCS and household kits. When revisiting the model, the World Bank (2008) claimed to have initiated a project to raise farmers' incomes to increase the possibility that householders would be able to pay the monthly recharge fee; a microbusiness services programme was intended to assist households in the transport and marketing of crops and livestock. However, little evidence of this programme was found during research in two of the Project Santa Clara communities. The sink fund was managed by a *comité de luz* (lighting committee) made up of locally-elected volunteers trained in the operation, financial management and maintenance of the stations. It is important to note that not every household of each community participated in the SBCS programme; for instance, in the community of Santa Clara, of a total of 160 households, only 55 participated.

Figure 23. The SBCS

Source: author's own photograph

Figure 24. Batteries are charged centrally at the SBCS

Source: Ley et al. (2006)

Figure 25. Batteries are transported to users and connected to home kits

Source: Ley et al. (2006)

Project Santa Clara was located in the RAAN, which is one of the poorest regions of Latin America, exposed frequently to natural disasters (expert interviewee 8 – social promoter, agricultural cooperative; expert interviewee 24 – NGO worker, global development organisation). The *Plan Nacional de Desarrollo Humano* (GoN, 2009) showed that between 1993 and 2005, while poverty levels fell in the Pacific and Central Regions, in the Atlantic coast region there was an observed increase in poverty levels. Key socio-economic indicators (including infant mortality, illiteracy, housing, sanitation, water access and grid electricity) set this region apart from the others - although the insecurity of the individual households reached by the other projects was striking, particularly in the case of Project Solar described above. According to the World Food Programme (2013), the RAAN is one of the most food insecure departments of the country. For one actor, the paradox of the Atlantic coast region(s) was its lack of socio-economic 'development' despite the presence of abundant natural resources (expert interviewee 23 – President, Atlantic coast development organisation).

The RAAN further contrasts with Pacific and Central regions because it is not covered by the *Sistema Interconectado de Nicaragua* (SIN), but rather is located in the 'Open Area'. This open area lies outside *Disnorte-Dissur's* concession, and is run instead by ENEL, the state-owned electricity company (see Chapter Five). It is made up of several isolated diesel generators, which serve urbanised areas (e.g. Puerto Cabezas, Waspam). Government plans included interconnecting the Atlantic isolated systems with the SIN (expert interviewee 10 – manager, ENEL); however, the extent to which this would significantly expand access to grid-supplied electricity was doubtful. The region remains characterised by very low population density (only six inhabitants per square kilometre), low average electricity consumption, low load factors, low incomes, highly dispersed dwellings and communities located far from the energy distribution network (GoN, 2004).

The RAAN was particularly affected by Hurricane Felix, which hit the Atlantic coast in September 2007. The hurricane affected more than 25,000 families, causing an estimated US $46.7 million in damages to agriculture, destroying homes and forests, and contaminating water supplies (FAO, 2007). The two communities in which the research was undertaken – Santa Clara and El Semau (neighbouring settlements located within the municipality of Puerto Cabezas, approximately 70 km to the northwest of the city of Puerto Cabezas) – were particularly affected by the hurricane. The SBCSs which had been installed in each community were damaged or completely destroyed, and household kits were lost in damaged homes (Focus Group C4 – Santa Clara). While the charging stations and household systems were partially restored by the MEM in 2009, this was done on the condition that users' homes had been rebuilt or were adequate for re-installation. In broader terms, the hurricane was incredibly devastating to livelihoods, completely destroying or disrupting previous means that households had to produce subsistence crops (e.g. rice, beans, cassava, various fruits), or generate incomes (e.g. hunting, harvesting of wood) (see Ocampo, 2010).

Law 445 (GoN, 2003) stipulated communal land titles for the indigenous communities of Nicaragua's Atlantic coast. In Santa Clara and El Semau respondents cultivated parcels of land, often far from their homes, for subsistence purposes (mainly staples such as rice, beans, cassava and fruits). At the time of research, the MEM was planning its ‘exit strategy’ from the communities participating in the SBCS programme (expert interviewee 20 – MEM official). This involves implementing a project to support users in generating incomes, through the production and commercialisation of vegetables. The assumption of the MEM is that increased incomes will ensure continued payment for use of the SBCS beyond Project Santa Clara (expert interviewee 20 – MEM official). In the communities participating in the SBCS programme, there is a large donor and missionary organisation presence and, according to local respondents, this presence had increased in the aftermath of Hurricane Felix. Despite considerable amounts of development assistance enacted in both communities (e.g. construction of wells, latrines, agricultural production projects), residents expressed concerns about the difficulties they faced in accessing basic services, including easily accessible drinking water, electricity, education, healthcare, and transport infrastructure.

This section has reintroduced the three solar energy programmes and has provided detailed information on the regions and communities within which the programmes were operational. This contextual detail provides depth to the subsequent analysis of the three cases. The cases provide a rich and diverse set of local experiences from a variety of points of intersection including: solar energy delivery mechanisms, technology types, varying lengths of user participation in solar programmes, as well as the socio-economic realities of different regions and communities and the households within them. Despite the differences between programmes, the following analysis reveals commonalities in user experience and challenges facing individual households as solar energy technologies are incorporated into their everyday lives. In order to fully examine user experiences of the programmes and their impacts, this chapter first turns to an analysis of the perceptions and dynamics of life prior to the arrival of solar electricity.

7.2 Energy realities before electricity

In order for this chapter to fully engage with the experiences of the projects described in section 7.1, it is necessary to contextualise these within users’ experiences of life ‘before’ solar electricity. The majority of perspectives presented in this section are drawn from interviews with participants of Project Solar; as discussed above (and in Chapter Four), higher levels of access to this programme enabled the collection of a rich dataset from a range of pre-adopters, post-adopters and non-adopters of the technology, compared to the research conducted with participants in programmes B and C who were exclusively post-adopters. The perspectives presented include the current experiences of living in unelectrified households presented by participants prior to the arrival of solar electricity in their community, as well as the recollections of other participants about life before solar electricity (Chapter Four acknowledges some of the methodological challenges implied by recall questions).

Scholarly attention is required in exploring the experiences and aspirations of households in off-grid communities, such that energy interventions can be designed to respond to user needs (see Barnett, 1990; Cook et al., 2005; Practical Action, 2010; 2012; 2013; Shyu, 2013). Current debates on 'energy poverty' do not tell us a great deal about how people living off-grid perceive or use energy, what types of services they require, and the extent to which perceived basic energy needs are, or can be fulfilled (IEA, 2010). In line with the orientation of this thesis to consider off-grid residents as people with different histories, visions and expectations, this section explores the lived experience and realities of those living without electricity or those in 'energy poverty'. The following discussion relates to these perspectives, including fuel use and expenditure, views about the lack of grid supplied electricity in communities, and subsequent motivations for participating in a solar electricity programme.

7.2.1 Perspectives on life without electricity

Interviewees and focus group participants presented a variety of perspectives about what life without electricity was like. Users discussed not knowing what was 'going on' in their country, not having the energy to be 'productive', lacking ironed clothes, entertainment, security, flexibility in their daily routines and free time to perform household tasks. Other users described how they saw that the use of candles, gas lamps or fuel wood for lighting as dangerous, and the poor quality of the lighting produced as an impediment to their daily reproductive and productive activities. The following quotes illustrate the diversity of perspectives (also see Figure 26 below):

> 'You can't be in the dark, can you? So you just have to go to sleep' (Focus Group A1, housewife, Chiquistepe)
>
> 'If I go to buy something in Tipitapa [local town], I have to go with a creased shirt, because there is no electricity to iron our clothes' (Focus Group A2, male *jornalero,* El Rosario)
>
> 'A community without electricity looks so sad' (A31, housewife, non-adopter, La Quebrada)
>
> 'If I had electricity I would be free… I wouldn't have to walk around with a gas lamp in my hand all the time, it [lighting] would help me to cook better and I could move around [in the house] more easily (A28, single mother/*jornalera,* non-adopter, La Quebrada)

Figure 26. 'Preparando la merienda con luz de candíl en la madrugada' (preparing a packed lunch in the early hours of the morning with light from a kerosene lamp)

Source: photograph taken by respondent's son. Notes: Image is of respondent A19 (housewife, pre-adoption, Chiquistepe), she also provided the title for this figure

These quotes highlight the diverse perceptions of what life without electricity access meant to members of communities. These related to the services provided by electrical appliances for consumptive uses (e.g. ironed clothes, cartoons, news bulletins, music) or the direct and indirect services provided by electric lighting (e.g. increased spatial mobility, temporal flexibility, increased security and safety, improved conditions for reproductive tasks (e.g. cooking), the reduction of household tasks (e.g. washing of smoky clothes), more sanitary home environments).

'Life is boring' was the sentiment most commonly expressed prior to the arrival of the solar programme. Life without electricity was described as 'sad', and without *'diversion'* (fun) or *'distracción'* (entertainment) due to households being unable to power devices such as televisions or sound systems. Respondents revealed that members of their families regularly went in search of entertainment outside the home and community during the hours of darkness, which caused them great anxiety. For instance, interviewee A32 (housewife, non-adopter, La Quebrada), described how her family went to the local *hacienda* in the evenings, which was supplied by grid electricity, to watch television and recharge mobile telephones, while she remained at home 'in the dark' to guard the property. Interviewees described the unease they felt about family members 'walking around in the dark' to find entertainment, due to fear of robberies, assaults and animal bites (A3; A7; A14; A16; A21; A28; A30).

Diversity in perspectives was revealed between households, but also within households, particularly when couples were interviewed or entire families were present during the interview. This echoes other scholarly work that has emphasised the intra-household dynamics of energy allocation, particularly with regard to gender (see Clancy et al., 2003; 2004; 2007; Jacobson, 2007; Wong, 2009; see also Chapter Two). For instance, female household members frequently referred to their children and the desire to improve their wellbeing; one respondent explained that she did not want her children to grow up in the dark (A16, housewife/*pulpería*[85] owner, pre-adoption, Chiquistepe), while another common aspiration included being able to provide children with entertainment so that they could be 'closed up' in the home during the hours of darkness, putting their mothers' minds at ease (A28, single mother/*jornalera,* non-adopter, La Quebrada; also A3; A4; A5; A16; A26; A31; A32). Another respondent aspired to electricity so that she could better look after her children in the night if they were ill (A29, housewife/*jornalera,* non-adopter, La Quebrada). Women also emphasised how they felt that access to electricity might assist them with household jobs; lighting was perceived to make tasks easier and safer, while the powering of appliances (particularly irons, liquidisers and rice cookers) were thought to be labour saving. Furthermore, lighting would enable females to get up when it was '*más oscuro'* (darker) and therefore increase flexibility in daily routines. Focus Group A1 (Chiquistepe) was particularly insightful in presenting the potential benefits of access to electricity within a discussion of the roles of men and women in the household. Electricity was perceived to be most beneficial to women because it would enable them to better fulfil their domestic tasks, as one participant described:

> 'the woman is here [at home] day and night, while the man only comes back at night and goes out again in the evening… if something needs to be ironed, it is the woman, if someone needs to get up in the night to see to a child, it is the woman… and so it is the woman who would be most benefitted by electricity… he [respondent's husband] says to me: 'my trousers!' And so I'd switch on the [electric] iron… I wouldn't be suffering so much if I had electricity in my home (she mimics ironing, coughing, leaning over a kerosene lamp)… he says to me: [respondent's husband] 'my dinner!' And I'd switch on the light to cook and wouldn't be worried that some animal or ashes had gotten into his food' (Focus Group A1, housewife, Chiquistepe)

[85] A small shop, usually based in the home of the proprietor

Interestingly, the perspectives presented by males echoed this view, that a lack of electricity in the community was most detrimental to female household members. For example, one couple interviewed prior to their participation in Project Solar stated that their house was always filled with smoke because of the kerosene lamp they used for lighting, which meant that the female frequently had to wash smoky clothes and mosquito nets (A14 – housewife/*chambas* and *jornalero*, pre-adoption, Chiquistepe). While not all females interviewed or surveyed were 'stay at home' housewives (indeed, some combined paid labouring or informal work with domestic duties), it was agreed that electricity would provide most benefit to female members of households to perform their roles.

In general, for both males and females, electricity was predominantly thought of as a means of accessing relaxation and entertainment for the family (e.g. in the form of *telenovelas* – soap operas), particularly from what women described as arduous, physically labour intensive and boring daily experiences. The importance attached to electricity access for entertainment purposes should not come as a surprise; research in other national contexts has shown that the opportunity to operate a television set is considered highly attractive for households considering the purchase of a SHS (see Acker and Kammen, 1996; Gustavsson and Ellegård, 2004; Jacobson, 2007). For many respondents, to have the ability to operate a television set meant that family members had no reason to leave the house at night – resulting in less worry. It also provided relief from an otherwise early, boring night.

This brief exploration of perspectives on life without/before *luz* provides important insights relating to experiences of living without electricity, and the priorities expressed by households and the individuals within them. Some of the perspectives presented here chimed, to an extent, with the perspectives of the key actors discussed in Chapter Six (e.g. benefits to women), but there was also a disconnect, particularly over the 'consumptive' uses of electricity. This was evident in Chapter Six, section 6.2.2, where examples of this disconnect were discussed, for example: expert interviewee 6 (director, renewable energy technology company) who was shocked by off-grid households' decisions to purchase car batteries to run televisions when their lighting needs were being satisfied by comparatively 'energy poor' sources (e.g. candles or gas lamps); expert interviewee 9 (private sector SHS provider) was disappointed by a potential SHS user asking him about the capacity of the system to power an electric iron; and expert interviewee 16 (private sector SHS provider) spoke of his dismay with households that had adapted SHS to power higher wattage devices (sound systems, irons), which ultimately compromised SHS functionality. We return to the implications of this disconnect later in the chapter.

7.2.2 Fuel expenditure and use

Another important aspect of household circumstances prior to access to electricity relates to the pre-existing levels and types of fuel use and expenditure; data was collected on these issues in two of the case programmes - Project Solar (A) and GED (B)[86]. For Project Solar participants, average expenditure on lighting, disposable batteries to operate small appliances (e.g. radios), recharging of car batteries to operate televisions and mobile telephone recharging under 'normal' income circumstances was reported at US $6.80 per family per month (UCA, 2012)[87], while for GED, this was reported at US $7 per family per month[88]. These figures are remarkably similar despite the differences in the socio-economic status of the households participating in each programme (described in sections 7.1.1 and 7.1.2). The issue of expenditure will be returned to in subsequent sections.

Breaking down the expenditure into fuel use, it was evident that households operationalised multi-fuel use strategies that were dependent on income streams and that varied according to the seasonal nature of employment, income shocks (e.g. crop failure or lack of work) and emergencies (e.g. a family member's ill health). For instance, some respondents explained that when household income was scarce, small quantities of fuel (e.g. ¼ litre of kerosene or diesel), individual candles or batteries could be purchased (albeit at a higher per unit cost) and used sparingly to satisfy lighting needs, or to power small appliances like battery powered radios (A14, housewife/*chambas* and *jornalero*, pre-adoption, Chiquistepe). In other cases, families went completely without, or used *leña* (firewood) or *ocote* (pine wood)[89] as a poorer quality lighting substitute (see Figure 27 below), which in the context of all three case programmes, was ordinarily collected without financial cost[90]. Households discussed aspects of 'enduring' times of income scarcity, and the 'sacrifice' that this often demanded on their use of different fuel sources for lighting or for the running of appliances in their homes. While some would sacrifice fuels in order to purchase food (e.g. one household recalled frequently going to bed as soon as it became dark due to their inability to purchase candles, gas and batteries) (A31, housewife, La Quebrada), while others prioritised having fuels for lighting (in the event of a family illness or

[86] The latter was based on recollections rather than current circumstances.
[87] A baseline questionnaire survey was conducted in three Project Solar *caseríos* (La Quebrada, Chiquistepe and El Rosario) prior to the installation of SHS as part of a separate study conducted by the *Universidad Centroamericana* in conjunction with the NGO operating the project. This study (UCA, 2012) gathered data on fuel consumption and quality of life indicators prior to the arrival of the SHS project. The author assisted in data collection.
[88] This sum includes money spent on materials for illumination (dry cell batteries, kerosene, candles), the fees spent on car battery recharging (including transport of the battery) and mobile telephone battery charging.
[89] *Ocote* is a resin rich pine wood that is found in the northern, mountainous regions of Nicaragua. When burned, *ocote* produces more smoke than a typical kerosene lamp and provides lower quality lighting.
[90] While the collection of fuelwood (*leña)* does not incur a financial cost, it is acknowledged that its collection does require time and metabolic energy (usually of adult and child females) (see Mathee and de Wet, 2001; Batliwala and Reddy, 2003; UNDP, 2004; Clancy et al., 2007). Households in cases A and C noted that firewood was an increasingly scarce resource, which implied further time and metabolic energy for the person collecting it.

emergency during the hours of darkness) (A29, housewife and *jornalera,* non-adopter, La Quebrada). Households therefore made use of fuels that were 'flexible' or 'free' during periods of income insecurity (see Chapter Two; Corsair, 2009; Wong, 2009; Rehman et al., 2012).

The fuels used by households also depended on individual preferences. For example, some households had experienced house fires from using candles or kerosene lamps (e.g. A28, single mother/ *jornalera*, non-adopter, La Quebrada) or did not like the smoke produced by kerosene lamps, which they said dirtied and damaged their homes (e.g. A16, housewife/*pulpería* owner, Chiquistepe; C1, *campesino*[91], Santa Clara; C4, female pre-school teacher, Santa Clara); these households preferred to use candles or battery-powered hand torches. In other cases, households opted to use kerosene/diesel lamps for room lighting (due to its perceived superiority for this purpose), while using candles/hand torches for specific 'task' lighting, or for going outdoors during the hours of darkness.

This reveals that important attributes of lighting sources were affordability, cleanliness, safety, flexibility and convenience. However, the actual choices made about lighting sources and the powering of small devices depended on household priorities under scarce income conditions. This supports scholarly work that finds the energy ladder concept to be over-simplistic; homes simultaneously rely on multiple fuels - 'grasping multiple rungs of the ladder' – and switching based on price and availability amongst other factors (Sovacool, 2012b: 274).

Figure 27. Research participant demonstrates how an ocote wick is burnt for household lighting

Source: author's own photograph

[91] *Campesino* has multiple translations, e.g. 'peasant', 'country person', 'agricultural worker', however in the context of this thesis refers to a householder cultivating a small piece of land (rented or owned) for the purposes of producing goods for subsistence living.

7.2.3 Lack of electricity services

Questions about life without electricity frequently turned to discussions about the lack of grid-supplied electricity in communities. For the participants interviewed prior to the arrival of Project Solar in their communities (Chiquistepe, La Quebrada and El Rosario), they expressed frustration and sadness at being 'forgotten' or 'abandoned' by the private electricity distributor and the local and national authorities - despite high voltage grid lines running adjacent to their homes (Figure 28).

Figure 28. Overhead power cables in Chiquistepe - but no connections

Source: author's own photograph. Notes: the community of Chiquistepe was located in close proximity to the national electricity grid, yet none of the dwellings were connected. In the background, an electricity distribution pole, cables and transformer can be seen. Pole mounted solar panels can be seen adjacent to the two homes

While communities had requested electricity (through the local *alcaldia* and directly with the distributor), none had received a positive response. The fact that *Disnorte-Dissur* had been known to flout laws relating to obligations to connect new users was discussed in Chapter Five, this was confirmed by interviews across many of the off-grid communities visited. The notion of 'abandonment' or being 'forgotten' was also articulated by the 'post-adoption' respondents that were interviewed and surveyed. For instance, the participants of the GED programme explained that, while the grid had been extended to communities they never anticipated would receive electricity, often not all households within those communities, or indeed adjacent communities, had been connected. For participants of Project Santa Clara, the electricity grid was seen to be expanding rapidly inland from the city of Puerto Cabezas yet participants expressed their fear of being bypassed by the grid due to their involvement in the solar energy programme (Focus Group C4 – Santa Clara).[92] This fear has also been expressed in other national contexts (e.g. see discussion in Chapter Six; Foley, 1995; Rehman et al., 2012; Sovacool and Drupady, 2012; IEA PVPS, 2013).

Interviewees speculated that the relatively small concentration of households in their communities, their low incomes and 'humble' homes contributed to the lack of interest by authorities. Furthermore, participants suggested that a lack of leadership and organisation within their own communities presented a barrier to gaining an electricity connection. Participants in Project Solar emphasised the difficulty of attracting the authorities' or distributor's attention, in particular in relation to the resources (e.g. finance, time) this often implied (e.g. travel to the distributor's head office in Managua or to the local *alcaldía*). They also stressed the importance of having a community leader to petition the authorities, for example:

> 'In other *comarcas* [districts] they have put it [electricity] in because there are leaders, so the leader is responsible for doing all of the running around, and especially right now if you say you're a Sandinista… and so the leader goes to talk with those [*alcaldías*] in Granada or in Managua… if you notice San Ramon [nearby community], you'll see that it is quite far away from the grid, but just think, they put it [electricity] in there and it's because they have quite an active leader who is involved in the [Sandinista] party' (A26, housewife with SHS installed for two years, La Quebrada)

In addition to the organisation required to request service provision, this quote also highlights the politicised nature of grid electricity access in Nicaragua – the participant viewed that the neighbouring community had been electrified due its leader and their connections with the governing political party. The politicised nature of electricity services was also mentioned by other interviewees, particularly in relation to the presidential elections, for example:

> 'At the moment there is so much propaganda… that they [the political parties] will bring electricity. But they never fulfil the promises… I have seen five governments come and go that have said they will put electricity in [to our community] but they lie' (A1, *campesino* with SHS installed for two years, Guanacaste)

In the community of El Rosario, participants felt that the fact that they were relocated former *contra* fighters meant that they were not a priority for the government (Focus Group A2, El Rosario). Despite the efforts to obtain grid electricity access, for many, grid accessibility was deemed a distant goal.

[92] Santa Clara's location in the 'open area' meant that the responsibility for grid connection lay with the state-run electricity company, ENEL, and not the private distribution company, *Disnorte Dissur*.

Given this, research participants suggested that distributed solar electricity technologies were the best or only possible means for them to obtain electricity services:

> 'In order to extend it [the grid] the company has to invest, they have to get permission… you have to talk to INE [energy sector regulator]… but you know that it is not possible. Only with a panel can you have electricity' (A14, housewife/*chambas* and *jornalero*, pre-adoption, Chiquistepe)

> 'If someone doesn't have the opportunity to have the '*luz convencional'* (conventional electricity), they have to have a panel instead' (A29, housewife/*jornalera,* non-adopter, La Quebrada)

For some interviewees, solar electricity was therefore perceived as the only possible way of gaining access to electricity in locales where neither the private distributor nor authorities had the incentive or the resources to connect households to the national grid. The relative benefits of grid versus solar electricity – prior to the installation of either – will be discussed in more detail in the next section.

7.2.4 Perceptions of grid electricity vs. solar energy

Not all participants thought that connection to the grid was necessary or even a good thing. Indeed, opinion was divided about distributed solar energy technologies and perceptions were frequently framed in opposition to participants' knowledge or experience of grid supplied electricity. For some respondents (pre, post and non-adopters), solar was perceived as far superior due to its reliability in comparison to the conventional electricity service, which, despite some recent service improvements (discussed in Chapter Five), continues to suffer outages and high levels of consumer mistrust. The following quote illustrates this perspective:

> 'There are power cuts and so we decided the panel is better for us because when one is poor, you need something stable and reliable, this is the problem with [grid supplied] electricity, sometimes it works, sometimes it doesn't… And you always have to be on at Unión Fenosa to repair it…there are blackouts, but you still pay full price, as though there weren't [blackouts]' (A15, *jornalero* and housewife, pre-adoption, Chiquistepe)

For this respondent, solar electricity was viewed as more reliable and dependable than grid-supplied electricity. The notion of an unreliable grid echoes Chapter Five's discussion of the issues plaguing the Nicaraguan distribution sector, and the deep consumer mistrust of grid supplied electricity (especially from the private distributor). Sovacool et al. (2011) found that political commitment to grid centralised electricity undermined the implementation of SHS in the case of Papua New Guinea. Conversely, in the case of the GED programme, despite aggressive grid extension activities that had taken place in the region since the programme was first initiated, participants expressed willingness to retain systems. Three-quarters of those respondents maintained their SHS, arguing that it provided an important 'back up' during interruptions in electricity supply. Some respondents disclosed that there were outages of two to three hours per day as much as three times per week. During the rainy season, these outages could last up to eight days due to damage caused to the electrical system (e.g. surveys B54, B64, B66 and B67).

A fear of grid electricity was also articulated by interviewees, who expressed concern about what they saw as poorly maintained and ageing infrastructure:

> 'I say that grid electricity is really dangerous, you hear of stories where posts have fallen and burned houses and killed people… the cables fall and you are burned… but with the panel I think it is much safer' (Focus Group A1, female *jornalera,* pre-adoption, Chiquistepe)

In addition to the perceived safety of solar energy technology, other respondents also emphasised its relative flexibility and informality. For example, one respondent, recalling a previous experience of grid supplied electricity, explained how the process of gaining an electricity connection was highly formal because it required land titles and a lawyer:

> 'I had it [a grid connection] in my house… in order to get it [a connection] my mother had to speak to a lawyer to confirm that she had given me a plot of land for my house so that they could put in a [grid] connection… in the case of a panel, I just buy it and I don't have to ask permission from anybody, I just put it on my house and they can't say anything' (A14, housewife/*chambas* and *jornalero,* pre-adoption, Chiquistepe)

This perceived flexibility and informality was also extended to the financing of solar energy technologies. In the case of Project Solar, respondents described their gratitude for the NGO's tolerant attitude towards monthly SHS loan repayments, for example allowing participants to delay repayments during periods of income scarcity or emergencies. Similarly during periods of income scarcity participants of Project Santa Clara elected to not recharge their batteries (despite not being officially permitted to do so by the rules established by the implementing organisation). Solar electricity in these cases was therefore perceived as 'flexible' compared to the strict monthly payment regimes required by the electricity distributor. While this flexibility was perceived as a positive aspect of solar energy, this flexibility had consequences both on the long-term financial health of the project as well as the life spans of individual systems; this is discussed further in section 7.3.4.

In the case of Project Solar, respondents explained that owning the means to generate their own power granted them independence from a lifetime of monthly payments to the electricity distributor, and represented a great achievement. Respondents A2, A3, A5, A21 talked of the pride they felt from owning a SHS. This sense of pride has been echoed in other examples worldwide (see Green et al., 2001, for example, on the Kenyan case). These sentiments were illustrated by the following interviewee:

> 'with conventional electricity one has to be paying all the time, forever, meanwhile with a panel, no. Once you have paid it off it is yours, you don't have to be paying for electricity every month… with [grid supplied] electricity if you don't pay, they cut you off and you are left in the dark, whereas with a panel nobody is going to take it from you if it is already paid for' (A21, *jornalero* and housewife, SHS installed for 3 months, Chiquistepe)

It is important to note that 'ownership' may be limited to how long the SHS is in place however; as Chapter Six revealed, there are a number of obstacles to the longer-term sustainability of solar energy interventions, which will be examined from the perspective of the users in section 7.3.

For some, solar energy technologies were beautiful, safe, clean and appropriate for 'poor people' because they were deemed 'accessible' and sufficient to fulfill needs:

> 'the panel is for poor people, it is able to fulfil the necessities we have' (Focus Group A2, housewife, El Rosario)

For others, however, there was a perception that solar electricity was insufficient to fulfil energy needs. For example, one respondent declared her intention to wait for grid electricity, rather than to participate in a forthcoming solar programme, due to the perceived incompatibility of solar electricity with her aspiration to power large appliances:

> 'She thinks it is better to wait for grid electricity to arrive as she'd like to power appliances, for example a refrigerator so that she can set up a shop. She says she can't see how a panel could help her with this. She has heard that from other people in La Quebrada [nearby community] that the panel isn't enough to even watch a whole DVD at night. She's heard that people get half way through a film before the charge on the battery goes. She firmly thinks that it is not enough to cover even her basic needs, never mind her desire to earn a wage' (extract from field notes taken during interview with A32, housewife, non-adopter, La Quebrada)

This echoes the divided opinion expressed in Chapter Six, where solar energy was thought to be (in)sufficient to meet local energy needs. At the local level, the divergence in views about the potential compatibility of solar electricity with the aspirations of households was manifested most clearly in focus group A2 (El Rosario – a community poised to participate in Project Solar). A heated debate arose during this group interview which saw respondents disagree over the hypothetical question: 'what would life with electricity look like?' Some respondents rejected the idea that the solar energy technologies would be sufficient to fulfil their aspirations to power large devices (e.g. refrigerators), whereas other focus group members argued that lighting, rather than appliances, should be prioritised by users:

> 'we shouldn't be thinking in the refrigerators that we're going to have… the big things we'll have once we have electricity… no… We want to have electricity so that we have lighting, that is what is most needed. Sometimes someone is really poorly in the night, it is midnight, or someone is giving birth. They're scrambling to find a light, a torch or a gas lamp, but then comes a breeze and it is put out… Someone needs to make a remedy for the person bursting with pain… and so with an [electric] light someone can do that [easily]…. the [quantity of] electricity [of a SHS] might be less, but we shouldn't be thinking like this… It is important that we'll be able to see where we're going, where we're going to sleep, we won't sleep on a scorpion or a snake' (Focus Group 2, female pastor, El Rosario)

These divergent views show that respondents were often unsure about the potential benefits of solar versus grid electricity. For programmes that aimed to provide electricity to communities where grid access was not considered viable in the short term, this divergence could be problematic. Programmes in Nicaragua typically promote one product (SHS) which has a panel sized between 50Wp and 85Wp; it is therefore limited in capacity and (financially) difficult to scale-up at an individual household level, which may not be compatible with the visions and expectations of potential users. This also points to the lack of user participation in the design of programmes. As discussed in Chapter Six, there was only limited consultation about what was important to users, the energy inspirations and needs of these communities; rather assumptions were made by implementers about what users ought to aspire to and need.

With all of this in mind - the adoption of SHS is not inevitable. If users perceived grid electricity as superior, thought that the arrival of grid-supplied electricity was imminent, or were constrained financially, then the adoption of SHS was not an obvious or straightforward decision. Out of ten respondents interviewed in communities targeted by Project Solar, half went on to participate in the programme. The costs of participating in Project Solar (i.e. the initial deposit and the ongoing monthly loan repayments) and the possibility of grid connectivity reaching households were disincentives to participate. These findings echo those in other contexts; Komatsu et al. (2011b) found that household income, kerosene consumption, ownership of rechargeable batteries and number of mobile phones were key determinants of the SHS adoption in rural Bangladesh (see also Green et al. (2001) for similar experiences in Kenya). This reflects the complex motivational structures and ultimate expectations of users adopting solar energy technologies (e.g. Sonnberger, 2013). For those that chose to participate, respondents' basic expectation was that they would be able to access electricity to achieve electric lighting and AC power to run domestic appliances. Inherent in this expectation are the assumptions that the technology functions; is reliable; is a comparatively more convenient or higher quality means of accessing energy services than they had previously enjoyed; is not cost prohibitive; and is compatible with the attitudes, values, beliefs and needs of potential users (e.g. Rogers, 1995; Troncoso et al., 2007).

It is also important to remember that decision making processes at the household level are not isolated from the impacts of the political economy of solar electricity access, discussed in Chapter Six. Users ultimately 'buy into' programmes that are available to them from a range of actors operational in their geographic areas, which as Chapter Six indicated, are motivated by a multiplicity of factors. The household is the point of intervention in which the priorities, motivations and expectations of multiple stakeholders (implementers, donors, users, community leaders, etc.) converge. It is therefore necessary to understand household motivations to participate in a solar programme as embedded within the socio-cultural and political context elaborated in Chapters Five and Six; in an era of politicised electricity access, households may potentially wait for a grid connection, or a highly subsidised or 'free' SHS.

This section has illustrated respondent perspectives on 'life before' solar energy interventions, their opinions about the lack of conventional grid electricity provision in communities and, related to this, their initial perceptions of solar energy, and ultimate decision to participate in a programme. It has highlighted the diversity of perspectives on life without electricity; fuel usage and expenditure prior to participation in solar programmes; the 'forgotten' communities bypassed by the electricity grid; and respondent views on solar energy, in particular the perceived strengths and weaknesses of grid vs. solar electricity, and the compatibility of the latter with user visions and aspirations for electricity. The following section reports on user experiences post-participation in solar energy programmes.

7.3 User experiences of solar electricity

Having examined the perspectives and realities of households living without electricity, this section of the chapter moves to examine user experiences of solar energy interventions. As first noted by Nieuwenhout et al. (2001), research is required to understand the perspectives and experiences of solar energy technology users over time. Ex-post data can provide valuable insights into what occurs beyond initial access to solar energy technologies, including the impacts wrought as technologies are integrated into the daily routines and livelihoods of users, as well as the challenges this implies. From the perspective of those implementing such interventions, these kinds of data are useful for monitoring and evaluation purposes, but also for determining whether technologies fulfil the practical energy needs and priorities of users (e.g. Cherni, 2008). However, Chapter Six revealed that in Nicaragua, 'success' of the off-grid solar energy market was framed around the strengthening of market infrastructure, rather than from the perspective of the users ultimately using technologies. In the case of the *Proyecto de Electrificación Rural para Zonas Aisladas* (PERZA), experts pointed to its macro successes, but also revealed a general unawareness of the longer-term implications of solar energy interventions, particularly at the user level. This information gap is potentially harmful. Without follow up research on user experiences, it is possible that negative implications of interventions are not uncovered (e.g. Wong, 2009), and that technology 'graveyards' remain as rumours amongst key actors too embarrassed to follow up on interventions (see the discussions in Chapter Six, section 6.3.1) rather than serving as important lessons for the future design of solar energy programmes (Schäfer et al. 2011). Indeed, if no measures are taken to revisit and evaluate projects, how can we ascertain the sustainment of benefits or newly arising needs several years after project completion (see D'Agostino et al., 2011)? If ambitious goals, such as those advocated by the UN SE4All initiative are to be achieved and *sustained*, then the monitoring of user experiences is vital.

The following results are drawn from the experiences of participants across the three solar programmes. Those interviewed/surveyed had been using systems for a period of between three months and five years. To commence the 'post-adoption' analysis, this section begins by detailing a brief 'snapshot' of each programme at the time when interview/surveys were conducted in 2011; each summary reveals information about the health of programmes, in organisational, financial, technical and social realms.

7.3.1 Programme snapshots

7.3.1.1 Project Solar

Of the 27 interviews conducted, 90% SHSs remained installed in people's homes. In the cases where SHS had been returned to the NGO, two households had been connected to grid electricity, and one household had been unable to maintain the SHS loan repayment. Of the SHSs still present, 67% were functional, 11% were reported to have 'partial use' (which was due to battery deterioration and in one case also due to a lack of light bulbs) and 22% were not in use (largely due to technical issues, most commonly related to battery failure). For half of those users without full use of their SHS, financial difficulties in acquiring a new battery were cited as the main barrier to system functionality. While all households still owed money on the loan taken to finance the SHS, 26% of households had actually stopped servicing their monthly loan repayments; all cases of non-payment were for SHS of partial or no functionality. Loan defaults were due to unwillingness or inability to pay: four users were unwilling to continue repaying the loan while their system was out of service despite the agreement with the NGO stipulating user responsibility for system maintenance and battery replacement; while three households experienced financial difficulties in servicing the monthly loan repayments. On defaulting, households risked having their SHS removed by the NGO. The entrepreneur collecting payments on behalf of the NGO estimated that across the entire project, approximately half of all households were not repaying their solar loan due to unwillingness or inability to pay (expert interview 2 - Technician and repayment collection, NGO operating a small-scale solar programme).

The participants of Project Solar demonstrated mixed levels of satisfaction. While the majority said that their expectations had been met, other respondents expressed their discontent. Amongst the latter, many reflected cases where components (particularly batteries) were perceived to have failed prematurely, and where users were unable to finance replacement parts. In these cases, users were no longer repaying their loans. Some users were disappointed at not being able to run high-wattage appliances such as electric irons, fans and liquidisers. Interviews revealed that not all users had been aware of the power limitations of a SHS prior to their participation in the programme. For those households that were new to SHS ownership, finance was not identified as a difficulty. While these users were able to service the monthly loan instalment, they were not necessarily able to save additional funds for future replacement parts and none had experienced component failure. Those users with several years of experience with SHS discussed the challenges associated with financing replacement components. While initial expectations were fulfilled, users demonstrated increasing energy aspirations; some users, for example, had taken out finance for a second panel to increase system capacity.

7.3.1.2 GED

In the case of the GED programme, despite the increased penetration of the electricity grid in the post-installation period, 91% of SHS remained in the original users' homes. As discussed earlier, respondents reported that the SHS provided an important back-up for interruptions in service from the national electricity grid. Of those systems still present in users' homes, 76% were still in use and functioning technically; 11% of systems were reported to have 'partial use'; in most cases, this was due to battery deterioration, which meant that the SHS was not performing at its maximum capacity. The remainder were not in use largely due to technical issues, most commonly related to battery failure. For those users without full use of their SHS, financial difficulties in acquiring new components, principally the battery, were cited as the main barrier to system functionality. A technical diagnostic conducted on the SHS projected that if, by the end of 2012, users who had not already replaced batteries had not done so, then almost two thirds of the SHSs installed would be out of service (see Wheelock-Horvilleur and Gent, 2011).

The participants of the GED programme revealed high levels of satisfaction and claimed that their expectations of the systems were fulfilled. All users reported a positive experience with the SHS, and almost all of those surveyed said that they would recommend a SHS to another family. While initial expectations of the SHS were met, the survey revealed that four to five years after installation, users' energy aspirations and demands had increased, such that discontent with the limited capacity of systems was expressed with the 50-85Wp systems in place. Some users expressed desires to harness solar energy for productive uses (e.g. water pumping). Users also described concern about the future financing of replacement parts, and also the unevenness of SHS distribution (i.e. the 'haves and have nots') in their communities.

7.3.1.3 Project Santa Clara

In two communities which implemented the SBCS, the treasurers of each *comité de luz* reported that not one household made the four monthly payments considered necessary by the project implementers to financially secure the project for future battery replacements (Focus Group C3, El Semau; Focus Group C4, Santa Clara). Users discussed strategies they employed to reduce the cost burden of using the SBCS during periods of income scarcity, for example, through only charging the battery once a month, and then rationing its use to provide a limited service (e.g. one light bulb for one to two hours per night) (Focus Group C4, single mother, *chambas,* Santa Clara). This strategy however was recognised by users to jeopardise the long term financial sustainability of the project, as hypothetically when the useful life of the current battery stock was reached, insufficient funds would have been saved in the community sink fund to finance new batteries.

The participants of Project Santa Clara expressed relatively low levels of satisfaction. Expectations in many cases were not fulfilled, since users claimed that project implementers had originally promised individual SHSs, but had then installed the SBCS. Users perceived the SBCS as 'second best' to individual SHS due to certain particularities; for instance it requiring users to carry their battery, which weighs more than 30 kilograms, to and from the charging station. It also required the unpaid members of the *comité de luz* to manage its use, which was seen to occasionally cause tensions within the communities.

In summary, the case 'snapshots' reveal a number of challenges that face both users and programmes. A particularly interesting aspect is the spectrum of experience across the programmes. Some respondents were relatively new users of solar energy who were making use of working components and potentially still in receipt of institutional support. By contrast, respondents at the other end of the lifecycle had experienced challenges, particularly related to the deterioration of initial components that were costly to replace. Somewhere in this spectrum a 'critical moment' is reached, when users are required to replace costly components. Indeed, the summaries reveal that some households had full use of their systems, others were using kits that were deteriorated, while some had abandoned systems altogether, meaning that solar electricity was being supplemented or substituted with the comparatively 'energy poor' fuel sources discussed in section 7.2.2. While scholars have compared users' lives 'before' and 'after' solar electricity (e.g. Acker and Kammen, 1996; Mondal and Klein, 2011), this demonstrates that considering life 'beyond' the SHS is also vitally important. Other inter-related aspects to consider are the perceived impacts of participation, levels of user satisfaction, as well as issues of affordability. These key themes are analysed during the remainder of this chapter.

7.3.2 The non-monetary lifestyle benefits of solar

Before considering the challenges associated with each of the programmes, this section discusses the beneficial impacts of access to solar electricity, as described by research respondents. Research from countries as far afield as Bangladesh, Sri Lanka and Kenya discuss the multiple benefits of access to solar electricity, which include improvements in overall living standards, particularly household health, education and security (see Acker and Kammen, 1996; Nieuwenhout et al., 2001; Gustavsson and Ellegård, 2004; Wijayatunga and Attalage, 2005; Obeng et al., 2008; Mala et al., 2009; Komatsu et al., 2011a; Mondal and Klein, 2011). This research also identified similar benefits, in particular users identified what are commonly described in the literature as 'non-monetary lifestyle benefits' (Komatsu et al., 2011a) or 'soft' benefits (Wamukonya, 2007). However, in addition to the benefits commonly cited in the literature, this research also highlighted less tangible impacts, including psychological benefits, which this section discusses in more detail.

The 'pre solar' expectations of electric lighting and appliance use expressed by respondents (discussed in section 7.2.1) were largely delivered in terms of improved levels of entertainment, household security and assistance with reproductive tasks (although, as sections 7.3.3 and 7.3.4 later discuss, household expectations did not necessarily remain static, and in some cases, problems of affordability and technical functionality undermined the use of the technology).

Observations made during and immediately after the installation of SHSs in three *caseríos* of Project Solar, revealed that solar energy technologies quickly became incorporated into the daily routines of users. An immediate impact was changed energy consumption habits. In the case of the GED programme, kerosene and candle consumption were almost entirely eliminated, with household expenditure on fuel sources being reduced from US \$7 to US \$1.03 per family per month (the cost implications of solar are discussed in more detail in section 7.3.4). Changed consumption habits had important implications for household air quality. For instance, in the GED programme, the near elimination of kerosene was reported to have had significant positive impacts on the home environment, with 95% of respondents observing that indoor air quality had improved. This finding is echoed in a study on indoor air pollution and photovoltaic lighting in Ghana (Obeng et al. 2008). However, observations revealed that nearly all households continued to rely on open fires or unimproved cook stoves for cooking, posing a continued health risk to household members; echoing findings by Clancy et al. (2003) and Mathur and Mathur (2005), electric lighting simply illuminated a smoky and unhealthy kitchen. The benefits of clean electric lighting were therefore not so obvious because of respondents' continued reliance on traditional cooking fuels.

The arrival of solar electricity implied new daily routines and activities for the participants of each of the three solar programmes. In the GED programme for instance, a survey of daily routines revealed that respondents' day length had increased by an average of two hours. While Wong (2009) found that increased day length added to householders' workloads (particularly women's), this research found that for the majority of respondents the extension of day length was perceived positively; providing greater flexibility by enabling users to shift tasks to the early morning or evening (see also Clancy et al., 2004). For example, one respondent explained how with electric lighting she was able to wash clothes during hours of darkness:

> 'When I got up in the early hours of the morning, I couldn't really wash [clothes] because how could I wash in the dark? For example, right now, I know at 4 in the morning, if there is water, I can wash my basket of white clothes... While before when I didn't have energy, I had to take advantage of the time when there was solar light (laughing) I mean day light… I found it very difficult to wash my white clothes before when it was dark' (A11 – housewife and *pulpería* owner, with SHS for 2 years)

For this particular respondent, electric lighting enabled her to reorganise housework. Rather than increasing the number of tasks she undertook, it gave her flexibility to perform reproductive tasks at any time of the day. Electric lighting was seen to make some household tasks 'easier'. For instance, the vast majority of GED participants stated that lighting made household tasks either a 'little' or 'much' easier. However, it is important to note that such tasks were not 'easier' in terms of physical labour - washing still required individuals (usually women) to spend hours hunched over a washboard scrubbing clothes - the limited electricity outputs of the SHSs or SBCS could not be harnessed directly to power labour saving appliances (such as a washing machine). Rather, electric lighting meant users were better able to see the clothes that they were cleaning.

Many respondents referred to the quality of life impacts of increased day length. For instance, A11 spoke of the 'extra' time she had each day that she was able to dedicate to relaxation, helping her children with homework and socialising. This response was echoed amongst respondents across the three programmes, as one respondent described:

> 'We're happy, sometimes in the evening, my son visits and we're just talking and talking… and so we make the dinner later in the evening… this isn't difficult for us [to do] anymore because we have the light to sit chatting…we used to go to bed as it was becoming dark, because with a kerosene lamp, the wind would always blow it out, so we would have to go to bed… but now with this system, even though there is wind, it [the system] does not go out, and so we can stay up quite late... now we never want to go to sleep' (A19 - housewife, with SHS for 3 months, Chiquistepe)

In addition to the facilitation of reproductive tasks and quality of life improvements, in a small number of cases, electric lighting facilitated productive tasks. For example, A9 spoke of how electric lighting made milking easier:

> 'With the luz, you see a lot better to work, when I was milking my cows with a kerosene lantern, it was really difficult, because it would just blow out in the wind… so I'd have to stop what I was doing to go back and relight it, for it to only blow out again… and so it took a long time to finish the work… now with the luz, we don't have this delay' (A9 – male smallholder with cattle, with SHS for 2 years)

This respondent had modified his solar home system to provide lighting to the corral outside his home; electric lighting made the milking process significantly easier. A9 also claimed to earn more from this activity because the milk no longer tasted of kerosene. One other respondent interviewed from Project Solar shared a similar experience (A18), however these responses were rather atypical; in very few cases observed across the three programmes did solar electricity facilitate productive activities to the extent that a significant impact was felt on incomes. In the case of the GED programme for example, a fifth of respondents stated that solar lighting had made their economic activities 'more productive and easier'. In the case of small businesses, including *pulperías,* those surveyed stated that lighting enabled them to stay open later, which made their businesses more attractive to others. In direct monetary and economic terms, a fifth of respondents from the GED programme reported using the SHS to sell mobile telephone battery recharges; however, it is unlikely that this made a significant contribution to household income, since only symbolic payments of approximately US $0.13-0.42 were made per recharge. These finding resonate with Laufer and Schäfer (2011), who found in the Sri Lankan case that while the use of SHS led to increased quality of life, household incomes were not improved (see also Mala et al., 2009; Mondal and Klein, 2011).

In addition to the benefits cited above - those that are commonly cited in the literature on solar energy - this research also highlighted benefits that were less tangible or measurable; these included psychological and wellbeing impacts, growing autonomy and increased aspirations. The psychological impacts of solar electricity included increased happiness and wellbeing. Many of these impacts were related to the use of TV or radio, and the ability to recharge mobile telephones. One respondent explained:

> 'To be alone and in the dark, one can become sad… to be honest from where we come from [name of distant home town], we have a piece of land, where we could have a connection to the electricity grid, but here we can't… when we first moved here, she [my wife] wanted to leave because she was so sad, and it was dangerous, it is dangerous to be in the dark with snakes and dangerous animals… well now this thinking has changed, now she is a little more relaxed because she has some entertainment and doesn't have to get up [in the early hours of the morning] with a hand torch… now she only switches on the [electric] light… we are more animated and lively… we decided to start raising animals, before we never kept animals because we thought that we might leave [the community] at any moment because of how sad we were… but now with the [SHS] system, this panel… it changed our mind' (A14 – housewife/*chambas* and *jornalero* with SHS for 3 months, Chiquistepe)

This perspective was frequently mentioned by respondents across the three programmes; as section 7.2.1 illustrated, boredom and sadness were common across the pre-adopters. As well as easing feelings of depression, respondents also highlighted their heightened autonomy as a result of participation in the programmes. One respondent described this:

> 'There is no need to go around bothering people anymore to charge my cell phone or watch the soaps' (A15 - *jornalero* and housewife, with SHS for three months, Chiquistepe)

Having solar electricity in respondents' homes meant the end of reliance on grid-supplied neighbours, family members, or in the case of Project Solar, local haciendas. One respondent exclaimed that with SHS, she was able to choose which TV channel she wanted to watch. This perspective links back to the discussion in section 7.2.1 in which participants expressed their desire to 'close up' their family during the evening – with solar electricity in the home, nobody need venture outside at night for entertainment.

The relationship between the arrival of electricity and user feelings of progress has been examined in other contexts; in the Senegalese context Magrath (2010) found that with the arrival of electricity, respondents exuded new pride in their village, and had a sense of confidence and optimism about the future. Similarly, in the Indian context, Parikh et al. (2012) found that once the demand for energy provision was met, households shifted toward higher order social aspirations. The sense of solar electricity providing individual, household and community-level 'progress' was encapsulated in the following quote:

> 'This 'luz', I'm going to give you an example, it's like when a child begins to crawl, from here, it [the child] starts to stand up, and then begins to take little steps, and then it's walking, this is what is happening to us. Now we are starting with a panel and we can see that it is good… perhaps [in the future] we'll get another [panel] to run a television, and perhaps we can look at other things and begin to solve our other problems' (A19 - housewife, with SHS for 3 months, Chiquistepe)

In summary, a multiplicity of benefits that can be characterised as 'soft', or 'non-monetary lifestyle' impacts were identified by users. In particular, the consumptive uses of energy (e.g. lighting, TV, radio, charging of mobile telephones) had the potential to increase the quality of life of people in rural areas (see also Martinot et al., 2002). However, as the summaries presented in section 7.3.1 reveal, benefits can only be enjoyed for as long as systems continue to function. As the next section discusses, the limited life of key components represented a key limitation of solar energy in these cases.

7.3.3 User dissatisfaction

As previously discussed, the 'success' of solar energy in the Nicaraguan context was frequently framed in terms of the market infrastructure created, rather than from the perspective of users - a key element of which is user satisfaction. While perhaps under-appreciated by key actors in the Nicaraguan context, scholars have argued that user satisfaction is one of the determinants of long-term sustainability of solar energy programmes (Schillebeeckx et al., 2012; Komatsu et al., 2013; Shyu, 2013). As discussed above, respondents expressed satisfaction with the 'soft' benefits experienced through the use of solar electricity; benefits which may encourage others to participate in a solar programme. Dissatisfaction, on the other hand, may discourage users from continuously paying their electricity bills (as evident in Project Solar) or dissuade further households from participating in solar programmes. As the summaries presented in section 7.3.1 revealed, various levels of user satisfaction were expressed across the three case programmes. Dissatisfaction stemmed from factors relating to unfulfilled expectations and/ or perceived needs, which can be categorised into i) technical aspects, ii) implementing organisations' communication and delivery strategies and iii) the increasing energy aspirations of users. These themes are considered in turn.

7.3.3.1 Technical aspects

Dissatisfaction with the technical functionality of the solar energy technology was an issue common across all programmes, especially related to reduced levels of functionality during winter months. Respondents from Programme A in particular expressed concern that kits did not function to the standard or for the duration they had anticipated (e.g. A7; A10; A14; A16). This led some users to question the quality of components, particularly batteries, and installations. The perception that the technologies were 'second rate' or faulty made respondents more risk averse, which meant that users chose not to replace components leaving non-functional or partially functioning systems (see also D'Agostino et al., 2011). One respondent explained:

> 'look, the project is really nice because you go from having no electricity to having electricity, but now… the duration [of components] is really very short and we as very poor people cannot be buying a new battery every year… the battery didn't even last for a year… and so we decided to hand back the panel and so we're in the dark again' (A12 - housewife, handed SHS back to NGO, Guanacaste)

This respondent returned her SHS to the NGO because she was unable to service the loan repayments as well as replace expensive components which had required replacing earlier than she had expected - section 7.3.4 discusses issues of affordability in more detail. Other Project Solar users had stopped servicing loan repayments due to the reduced or non-functionality of the SHS, thus risking its removal by the NGO. This is a finding repeated in other contexts (see Green, 2004). It is possible that the components installed by the NGO were of a low quality, although as Chapter Six described, a legacy of PERZA is improved quality standards of solar components (see Ley et al. 2004). However, an alternative explanation is that users were not adequately trained in how to use and maintain SHS. Indeed, as van der Plas and Hankins (1998) state, poor user training may lead to the deep-discharging of batteries, which ultimately reduces their lifecycle (see also Gustavsson, 2007). In the case of Project Solar, user dissatisfaction with the life of components potentially jeopardised the long term health of the programme, since the revolving fund for future developments depended upon user repayments.

The soft benefits delivered by solar electricity were only experienced for as long as systems function technically. As Mondal and Klein (2011) found in their research in Bangladesh, users become accustomed to the better quality of light and could not perceive returning back to traditional consumption habits. However, as the case summaries above reveal, some of the respondents had no use or partial use of their systems as a result of system failure. Respondents reflected on the negative social and psychological impacts of this i.e. the transition from having access to electricity to facing life without it. Similar findings were highlighted by Wong (2012), who linked disconnection rates from SHS services in Bangladesh to the development of a new layer of social divide, widening disparities (see also Wong, 2009) and visibilising the 'haves' and 'have nots' of a community.

7.3.3.2 Implementing organisations' communication and delivery strategies

As the previous section highlighted, user satisfaction is intimately tied to user understanding and expectations. Users expected that components would function for longer than they actually did and dissatisfaction ultimately resulted in *no pago* or respondents managing with partially or non-functioning systems. As Nieuwenhout et al. (2001) state, users who understand the constraints and limitations of a solar home system are generally more satisfied than those who are promised 'heaven on earth' (p. 469). The awareness raising activities and communication strategies of those promoting solar energy technologies are therefore vitally important to ensure that users are well-informed, thus increasing the chance of user satisfaction.

In Programme A, some respondents claimed they were told by the implementing organisation that the SHS could power high-wattage devices, such as fans, refrigerators or irons, providing a near equivalent to grid-supplied electricity; the relatively limited output of installed SHS therefore caused disappointment. Similarly in Programme C, users claimed to have been misinformed about the specifics of the project. For example, respondents in Focus Group C1 described how project implementers had promised to provide community members with individual SHSs rather than the communal SBCS that was ultimately installed. The *operador* (operator) of the SBCS in Santa Clara explained:

> 'We were told we could have individual systems… but instead we got this [SBCS]... If we had individual systems the single women wouldn't have to carry their batteries to the centre [SBCS] also we wouldn't have to collect payments from everyone… the work [of the *comité de luz*] is

> voluntary and hard, every time the Ministry come here they ask me a thousand questions, sometimes I work late into the night writing reports… if we had individual systems it would be better' (Focus Group C1, male SBCS operator on the *comité de luz*/*campesino*, Santa Clara)

Other focus group members agreed with this statement. When entering into Project Santa Clara, users had high expectations of the individual SHSs promised, and were extremely disappointed in the community system installed, which also implied different forms of use and management.

Discontent was also expressed despite users being aware of the limitations and constraints of the solar technologies they adopted. As Acker and Kammen (1996) state, this dissatisfaction may derive from increased expectations, rather than disillusionment with the services delivered. Indeed, while nearly all of the participants surveyed in the GED programme expressed satisfaction with the technology and overall programme, they also expressed their desire for greater amounts of energy. The theme of increased energy aspirations forms the focus of the following section.

7.3.3.3 Increased energy aspirations

As discussed in 7.3.2, respondents discussed their changing outlooks due to the sense of 'progress' that had been instilled through the arrival of solar power. Experience with electricity also led to a desire for greater quantities of power. This echoes the perspective of some actors in Chapter Six – for instance expert interviewee 19 identified small scale solar power as the first 'teaspoon' of electricity - as well as research by Sovacool and Drupady (2012) who found that, over time, users of solar energy aspired to higher rates of energy consumption. Sovacool and Drupady (2012) cite a research respondent who observed: 'Once people get a SHS, for example, they want more services, it doesn't stop with lights, they want a television, or if they have a television, they want a colour one…. In this way SHS is like a drug, it gets a household addicted to modern energy services, to convenience and comfort, but cannot always provide the energy needed to back that addiction' (p. 80) (see also Gustavsson, 2007; Hajat et al., 2009).

This study also found that participation in a solar programme led to increased energy aspirations. Indeed, a common view expressed by participants across each of the three solar programmes was discontent with the limited outputs of solar electricity. Respondents expressed their desire to increase consumptive uses (e.g. greater hours of television or lighting), to power labour saving devices (e.g. irons, rice cookers), to power refrigerators and workshop-style equipment (which were perceived to enable engagement with income generating activities), or pump water, in order to address perceived problems in their communities. With regard to the latter, a quarter of those surveyed in Programme B identified the lack of potable water in their community as a key issue, which highlights concerns raised by some actors in Chapter Six that electricity may be provided to communities with more pressing needs.

In the case of Project Solar, several respondents had increased system capacity by taking out microfinance on a second solar panel (interviewees A3, A6, A22, A26). One user described how the initial system had caused conflict within her home: her children used the system to watch television during the day, thus depleting the stored battery power, which did not leave sufficient power for lighting in the evening. This motivated the household to acquire a second panel (increasing capacity to 100Wp); as she described:

> 'My children liked to watch DVDs, but it [the SHS] didn't give enough energy for this, and sometimes when I came home [from work] there wouldn't be enough power for lighting in the night time… and so my son said 'Mum, let's get another [panel], so that we have enough power' and so that's when we got another' (A3, housewife with SHS for 2 years, La Quebrada)

This experience echoes Jacobson (2007) who notes that intra-household dynamics shape the use and allocation of solar electricity; the relatively small outputs from a SHS might be prioritised for certain uses over others – in this case, television over light. While this household was able to acquire a second panel to boost system capacity – and resolve the conflict - not all households had the financial resources to do so. This raises questions about *whose* needs within the household can be satisfied with limited amounts of power.

Returning to the issue of gender roles and responsibilities, female participants emphasised new aspirations to power devices to assist with reproductive household tasks e.g. labour saving devices such as rice cookers, electric irons and refrigerators, or devices to improve the household environment (e.g. fans) (A6, A3, A18, A19, A24):

> 'Before we had nothing, so to have this [SHS] we feel relaxed, happy, the children now enjoy themselves because they can watch a film they like, or the cartoons they love so much, but if it [SHS] was a bit stronger [more powerful] well, we'd like a fan for the heat, and an iron, and I wouldn't have to iron with a charcoal iron which really irritates my eyes' (A26, housewife with SHS for 2 years, La Quebrada)

This type of perspective has led some scholars to question the gender consequences of solar energy interventions. The gender interests of introducing renewable energy technologies are not always clear cut. For instance, Clancy et al. (2004) argue that the limited outputs of SHS may serve household recreational activities, but not necessarily help to reduce the burden of household reproductive tasks (for instance through powering labour saving devices) (see also Cowan, 1983). This again raises the question of *who* benefits from the introduction of technologies so limited in capacity.

Households also discussed the non-productive or consumptive nature of solar electricity. While it provided important 'soft' benefits (as discussed in 7.3.1), in very few cases did it directly support household livelihood production to help pay back the initial loan taken to purchase the SHS or finance replacement components (e.g. Jacobson, 2007, Wong, 2012). As one respondent emphasised:

> 'The panel only took money from me, it didn't give me anything' (A27, housewife/*chamba, r*ecently returned SHS to NGO)

Respondents therefore discussed their aspirations to power devices that could enable income generating activities - meaning that the technology would help to 'pay for itself' (see also Figure 29):

> 'Look, if we could get hold of a panel [system] that could power a freezer…it would be great…it would help us to generate a bit of financial help for the house which would be good. It would make quite a lot of money because here people are always looking for a *fresco* (cool drink), ice pops*,* some cold water, an ice cream…But for now, I know that the system isn't enough to power a freezer, but think how good it would be… if you could do this you'd make more money and pay off the loan sooner' (A14, housewife/*chambas* and *jornalero* with SHS for 3 months, Chiquistepe)

> 'With a more complete [electricity] service you could have a liquidiser, a fridge, lighting and a TV… these things are important.. but also things to serve the community, if we had a full [electricity] service, we could start a workshop or a joinery to serve the community, but in this case [with the SBCS] we can't' (C3, community leader*/campesino,* Santa Clara)

These perspectives reveal that respondents felt it was important to examine the potential for productive uses of solar electricity at both the household and community level. The individualised nature of SHS (and the individual household kits connected to the SBCS) was not conducive to the generation of incomes; the possibility for direct economic impact therefore depends upon cooperation within communities and community-scale solar energy. This links to current moves to develop community-scale solar technologies that provide energy for both productive and consumptive purposes (see Khan (2012) for a discussion of the solar PV nano-grid concept and Quoilin and Orosz (2011) for a discussion of community-level solar thermal power systems).

Figure 29. Participants from Project Solar stand next to their unplugged refrigerator: 'Of course, I'd like to switch to a system that powers a refrigerator, so that I don't have to buy ice every other day'

Source: author's own photograph. Notes: a participant household from Project Solar stands next to an unplugged refrigerator which is used to store food and drinks. The participant purchases ice every other day (from a town 30km away), which is then used to preserve and cool items in the refrigerator. The items cooled in the refrigerator are for subsistence and income generating purposes (she has a small *pulpería* that sells fizzy drinks to workers in the fields). She aspires to power the refrigerator with solar electricity, but says that she'd need to add 'at least 10 panels' in order for it to be powerful enough, which would be cost prohibitive from her perspective (A16, housewife/*pulpería* owner, with SHS installed for 3 months, Chiquistepe)

These findings are reflected in other research, for instance, Shyu (2013) examined the experiences of users with mini-grid solar PV power stations in China, and found high user expectations post-installation. This included aspirations to operate high power electrical appliances and productive machines. Similarly, the IEA PVPS (2013) reports that users' increasing energy aspirations often mean that a grid connection is a favoured choice over access to small-scale solar energy technologies (see also Wamukonya and Davis, 2001). A mismatch between the capacity of systems and the aspirations of users to earn an income is evident. Users demonstrated changing energy expectations with time. Solar is perceived to provide a restricted service (where users desire to power refrigerators, irons, fans, larger

TVs). This is problematic and raises the question of how the technologies and programmes be reoriented in line with increasing aspirations; as discussed in Chapters Two and Six, it is expensive to scale up the capacity of solar home technologies (e.g. Pielke Jr, 2012).

7.3.4 Affordability

In a comprehensive review of the literature examining the barriers to energy access interventions in the Global South, Watson et al. (2012) find that scholarly interest predominantly focuses on economic and financial barriers as the most pervasive and important. The high costs of energy access interventions, combined with a lack of user capital, high levels of poverty and 'day to day' financial cultures, reduce the affordability of solar energy technologies (see also Sovacool et al., 2011; Sovacool, 2012b; Wong, 2012). Even if the high upfront costs of energy hardware can be overcome, Watson et al. (2012) identify the ongoing operation and maintenance costs as a significant challenge for end users. Indeed, in this research, some respondents found it difficult to continue paying for systems after the initial installation (in terms of loan or fee payments), or once balance of system (BOS) components required replacement. While solar panels may be guaranteed for up to 25 years, BOS components have to be replaced at much shorter intervals, which incur significant capital costs to the end user (Corsair, 2009).

The different delivery mechanisms of programmes meant that the use of solar electricity implied different costs to participants; Table 17 displays estimated replacement costs averaged on a monthly basis[93]. User fees in project C/ Santa Clara were designed to have the cost of battery replacement components 'built in'; however, the calculation shows that the US $4 monthly fee paid to the community sink fund fell short of estimated replacement costs[94]. In project A and B, no formal savings mechanisms existed for users to prepare for eventual component replacement.

Table 19. Financial implications of solar energy technologies across three programmes (US $)

	Solar programme		
	A Project Solar	B GED	C Project Santa Clara

[93] These figures are based on component costs and the average useful life of components. Costs and estimated lifecycle data were provided by one of Nicaragua's leading solar home system providers (May 2013). The costs for replacement batteries were based on an estimated lifecycle of two years. However, as noted in section 7.3.3, some respondents observed that batteries failed prior to this, which would therefore result in higher monthly recurrent costs than stated in Table 17.
[94] Also many users claimed not to not make the US $4 per month fee, which is discussed in more detail below.

Upfront costs paid by users	20	400	0
Estimated system capital cost at time of installation	675	800	n.d
Savings on candles/kerosene/battery charging (per month)	6.8	7	n.d
Ongoing repayments (case A) or service fees (case C) paid by users (per month)	11	0	4
Battery, lamp, inverter and charge controller replacement costs (per month)	9.57	9.57	8.42[95]
Net savings (per month)	-13.77	-2.57	-

As shown in Table 17, in cases A and B, the recurrent fees required to keep the systems operating were larger than the avoided expenditure on non-electric lighting/ running of appliances. Without data on the previous fuel consumption and expenditure habits of Project Santa Clara participants, it is impossible to determine whether the SBCS implied higher costs to users. However, accounts from interviewees suggested that they too faced higher expenditure with solar electricity due to previous dependence on 'free' *ocote* wicks for lighting.

As the programme summaries (section 7.3.1) illustrated, some users were able to adjust to the financial demands of sustaining solar energy technologies, while for others, the increased costs of energy provision posed significant problems. Many users therefore questioned whether a connection to the electricity grid might be more favourable in financial terms. It is difficult (and not within the scope of this thesis) to estimate the cost of a connection to the electricity grid, however it is evident from Chapter Five that an important determining factor is household distance from the distribution network. Notwithstanding the potential costs and benefits of grid electricity discussed in sections 7.2.4 and 7.3.3, it is likely that the subsidised tariffs available for low-consumption households would prove to be less expensive in financial terms than solar electricity.

The following sections discuss issues relating to the affordability of solar electricity, as expressed by respondents in more detail. Themes include the incompatibility of vulnerable or seasonal incomes to the upkeep of solar electricity; user capacity and willingness to pay; and the unaffordability of solar when other rudimentary household (and community) needs were not met.

7.3.4.1 Vulnerable and seasonal incomes: the inflexibility of solar

Accessing and maintaining solar energy technology presented a barrier for households whose incomes were insufficient or incompatible with payment regimes. The 'cost burden' implied in accessing solar

[95] Excludes costs for a replacement inverter – most households observed in Project Santa Clara did not have an inverter.

energy technology was manifested most clearly in the case of Project Santa Clara, where users experienced difficulties in making monthly financial commitments to the project. One respondent explained how a lack of formal employment and markets for selling agricultural produce, meant that cash was scarce amongst the users of the SBCS:

> 'The greatest problem is money… people don't work in any type of institution and so there are few monthly incomes… People sow, but there is no market for our produce, therefore people have no money. This is the most serious problem we have. If we had the money, people would pay to recharge their battery, they would buy their light bulbs, buy the things they need, so there wouldn't be a problem' (C3, male, community leader/*campesino,* Santa Clara)

Paying the cost of monthly battery recharges to Project Santa Clara was seen as impossibly difficult, particularly in the wake of Hurricane Felix, which destroyed housing, livelihoods, the SBCS and lighting kits in the two communities surveyed:

> 'After Hurricane Felix people have found it very difficult to recover everything they lost… while some are recovering many remain with the same problem… the monthly payment is eighty córdobas (US $4) which doesn't seem like a lot, but it is difficult for some people… they don't have the [agricultural] products like before to sell and so they find it very difficult' (C2, male, headteacher of community primary school, Santa Clara)

Participants from Focus Group C4 described how the hurricane had destroyed large forested areas surrounding their community, which for some provided valuable income-generating resources, including wood and food. A former president of the *comité de luz* described how prior to the hurricane he had been able to produce dragon fruit to sell in the city; however, Post-Felix he had been unable to recover this production. In addition to the difficulties associated with recovery from Felix, respondents discussed what they described as a 'changing local climate', which increasingly affected their ability to produce basic staples even for subsistence purposes:

> 'Right now the climate is changing… in the dry season it rains and during the wet season the sun comes out... this is the change, so this year lots of people lost their beans, including me, I lost a part.. Why? Because when it came to preparing and drying the beans for storage, it rained and rained and rained... so, the beans germinated and they were no good for selling or for eating. They were lost. The same thing happened with the rice… So, we, the *campesinos* of beans and rice, we were stuck, at times we had nothing to eat' (Focus Group C4, Santa Clara, male, *campesino*)

Respondents discussed the additional financial burden placed on households by access to solar electricity, in particular, the difficulty faced by female-headed households:

> 'She says that she wants to keep her lighting [kit]… for when she has sick children and for the children that want to study at night… therefore she'd like to maintain it [solar lighting kit]… but she finds it very difficult to pay the four monthly recharges. She is a single mother, and she doesn't have support from anybody, not a monthly or fortnightly income and this is a problem for her because she doesn't want to lose this electricity under any circumstances' (Focus Group C4, Santa Clara, single mother, responded through translator - Miskito to Spanish)

Similar financial difficulties were expressed by participants of Project Solar. One respondent explained that the combination of low income and the seasonal nature of agricultural work affected his capacity to pay regular monthly loan instalments:

> 'We have a problem and I want to be quite frank…we are poor people, we don't have a fixed job, that is to say that our work is seasonal… I work in agriculture and when winter is over we're here without a job… we have problems with paying [for the SHS loan] because we earn so little, because for poor people two hundred and forty pesos (US $11) [a month] is a lot… while it [the SHS] is useful and everything the economy is what breaks us… perhaps for someone with [a means for] survival and security, this financing is not going to bother them, but for me, it does, it harms me' (A1, *campesino* with SHS installed for two years, Guanacaste)

This quote demonstrates the cost burden felt by many users when income streams (which may be low or seasonal – or in the case of Project Santa Clara, vulnerable) are incompatible with making fixed financial contributions. This echoed the viewpoint of several users who were struggling to pay for the financing of their SHS in Project Solar, and therefore risked its removal by the NGO. In addition to servicing monthly loan repayments, participants of Project Solar were also required to pay for replacement components, which also presented challenges for users.

On embarking on research into the GED programme, it was not anticipated that those participating would demonstrate the financial difficulties articulated by those from the other two solar programmes. The GED programme had approached households specifically because of their ability to finance a subsidised SHS – upfront - at a cost of around US $400 in 2006-7. In order to finance the SHS, the majority of respondents had the immediate capacity to make this payment (two fifths of those surveyed liquidated assets (i.e. sold crops or animals) and a further two fifths used savings), while just one fifth drew on micro-finance and remittances. At the time of this research however, respondents had experienced difficulties in replacing components, particularly batteries which cost approximately one third of the original outlay. This compromised system functionality and ultimately led to those users supplementing or substituting solar electricity with ‘traditional’ fuels. These users explained that their financial circumstances had deteriorated somewhat since the programme began. A representative from one of Nicaragua’s largest micro-finance institutions confirmed this; he observed that the global financial crisis had impacted negatively on the incomes of agricultural producers in various regions of the country, including the NCMR (expert interviewee 14). This was compounded by heavy rains during 2010 which had severely disrupted agricultural production. As discussed at the beginning of this section, for many households the arrival of solar electricity implied increased (rather than reduced) financial costs, which in the context of strained financial circumstances is problematic.

7.3.4.2 User capacity and willingness to pay

In facing circumstances of income scarcity, households with solar electricity employed strategies to reduce the cost burden of its use. For example, in the case of Project Santa Clara, households opted to charge their solar battery just once a month, which provided a minimum service (e.g. operation of one light bulb for 1-2 hours a night). This practice however jeopardised the long term financial sustainability of users’ solar kits, as when the useful life of the battery has been reached, users will not have raised sufficient funds for battery replacement. One respondent that participated in Project Santa Clara explained this strategy through a translator:

> **Translator**: she says that she only has one light bulb and that she can charge the battery and it will last for up to three months…
>
> **DG**: so she recharges her battery once every three months?
>
> **Translator**: yes. She says that her mother is ill and so she keeps the light on almost all night, but even still the battery doesn’t run down for three months…
>
> **DG**: and so for her, does this seem quite favourable?
>
> **Translator**: she says that she doesn’t find the cost [of battery recharging once every three months] difficult, but she is telling me that she is supposed to recharge the battery four times a month…. But she says that she does not recharge the battery this often, because her light bulb keeps working, the battery keeps it illuminated. She says that she doesn’t have the money to recharge the battery that often. She is worried that she has hardly saved any money for the [replacement] battery [in the community sink fund]… she worries for the day that the battery

> breaks down (Focus Group C4, Santa Clara, housewife, responding through translator - Miskito to Spanish).

While the programme implementer stipulated weekly battery recharges, users' rationed system use due to issues of income scarcity, this finding was echoed in Green (2004). This raises key questions related to the appropriateness of financial arrangements between users and programmes. For example, were feasibility studies carried out during project planning and implementation to assess user capacity to pay? And if so, how was user capacity to pay calculated? Participants of Project Santa Clara in particular were critical of the implementing institution's delivery of the SBCS project. The way in which user capacity to pay was calculated was criticised by one respondent:

> 'They used this mathematics… they looked at the useful life of the battery, OK two or three years. And so, users have to save 2000 or 3000 cordobas over two years, so this worked out at 20 cordobas [US $1] per recharge [four times per month]… in other words they calculated everything according to the battery life…but this is the problem. We can't pay this…. We won't save this money [in the sink fund] perhaps we'll have 1000 cordobas when the battery stops working and we'll have to look for the money otherwise we'll be left without light in our homes… this is the problem' (Focus Group C4, Santa Clara, male, *campesino*)

Another respondent suggested that during the planning and implementation of Project Santa Clara, user capacity to pay' had been overestimated:

> 'They came to monitor the community… how many batteries do we use in our torch? How much is a pair of batteries? How much do we spend on diesel? But perhaps not everyone always bought these batteries for their torches, nor did everyone always have diesel for their lamp… and so perhaps this figure [capacity to pay] came out higher than it actually was because some lit *ocote* to do their activities, you know a scrap of *ocote…* and so they [project implementers] came here multiplying this figure… multiplying batteries, the candles, the cost of diesel…and they said 'you can pay such and such a price monthly'.. from here they had us… and so this is how they calculated the price [of battery recharges] (Focus Group C4, Santa Clara, *campesino*/ treasurer of *comité de luz*)

The average or typical fuel consumption reported to the programme implementers may have represented what households used under stable or 'normal' conditions. This would overstate overall household expenditure over the medium to longer term (and underestimate the importance of non-monetised fuel such as ocote), and therefore overestimate households' 'capacity to pay' for solar electricity.[96] Indeed, drawing on the analysis of fuel use/expenditure highlighted in section 7.2.2, users demonstrated flexible patterns of fuel consumption and expenditure according to the incomes available to them. While 'traditional' sources of lighting may be more expensive per unit compared to solar electricity, they may also be more 'affordable' because they can be purchased in small quantities or, in the case of leña or ocote, collected without financial cost (see Corsair, 2009). By contrast, the fairly regular capital intensive investments required of users in each of the three programmes were inflexible (e.g. Mala et al., 2009).

Another theme that emerged related to willingness to pay; this was particularly an issue for the respondents from Project Solar and Project Santa Clara. As discussed in sections 7.3.1 and 7.3.3, dissatisfaction with the short lifecycles of components meant that some participants in Project Solar had stopped servicing loan payments. The implementing organisation's tolerant attitude (as discussed in Chapter Six) however meant that it was unlikely that SHSs would be removed from homes. In contrast, the issue of unwillingness to pay in the case of Project Santa Clara derived from a sentiment of *no pago*. It is important to understand this in the context of the substantial development agency presence in the Project Santa Clara communities (described in section 7.1.3), and the associated culture of *no pago* discussed in Chapter Six. Users admitted that prior to hurricane Felix, while they had relatively higher and more stable incomes to pay monthly fees, they did not always pay. This had led to the MEM stipulating stricter rules, which unfortunately coincided with the post-Felix period which witnessed worsened financial situations. The new rules required the *comité de luz* to enforce four monthly payments from users, with non-compliance potentially resulting in the removal of the household kit; despite continued non-payment (albeit for different reasons than before) the *comité de luz* stated that not one system had been removed. This caused intra-community tensions however, and rules were difficult to enforce because participants perceived the SBCS (and household kits) to be communal property (see also Wong, 2012, for a similar case).

7.3.4.3 Are there more rudimentary household needs than solar electricity?

Financially sustaining solar energy technologies is especially difficult when other rudimentary non energy-related 'needs' are not met, particularly those related to food, water, health and education. One respondent for example, returned the SHS once the battery had failed because she was concerned about funding her son's education:

[96] As the case of the GED programme illustrates however, even if households are carefully selected based on 'capacity to pay' measures, there is no guarantee that the financial circumstances of households remain static.

> 'When the battery no longer works, when it [the system] won't even light up the people have to hand over their panel because there is no money [for the new battery]... in my case it was that my son was in the last year of school.. I decided to hand back the panel because it was more important to pay for school' (A12 – housewife, handed SHS back to NGO, Guanacaste)

Another participant explained:

> 'When she earns a bit of money... she looks at the necessities of the home... if they need soap, if they need salt, if they need rice, oil, sugar.. also school things... exercise books, a pencil, whatever is needed... But this does not leave anything to pay for the battery [recharge]...and so if she pays for the battery, the children will be without food... although she doesn't want to be without her lighting... What can she do? The needs of the home obligate her to spend her income on food' (FG4, housewife, through a translator – Miskito to Spanish)

Users described the difficulties they faced in addressing other household needs which were in some cases viewed to be more pressing than (solar) electricity. In the case of the two interviewees above, the energy services provided by solar energy technologies were more easily sacrificed than other household needs, in these cases, education and food. This raises the question, why solar energy programmes were initiated in areas where populations had difficulties in securing incomes and adequate nutrition. Are there more basic needs that need to be addressed prior to, or alongside the 'energy problem' faced by households? This resonates with the arguments advanced by Taylor (2005), whose research on rural electrification in Guatemala found that while residents recognised the benefits of electricity, they were in no position to pay for electricity services or appliances. Instead, Taylor (2005) found that households prioritised other forms of 'development', for instance, access to water, schooling or adequate roads (see also Chapter Three). Also echoed is the perspective of several actors in Chapter Six, who called for more 'integrated' approaches to the implementation of solar energy initiatives, such that multiple 'development' concerns may be tackled simultaneously.

7.4 Conclusion

This chapter has analysed the perspectives of households adopting, using and sustaining solar energy technologies across three programmes and the challenges they faced in doing so. Experiences prior to the arrival of solar energy revealed a multiplicity of fuel use strategies, expectations and aspirations of what life with electricity might look like – these often differed within and between households, particularly related to gender roles and responsibilities. The decision to adopt a solar energy technology was not straightforward – but rather bound up in the political-economic and socio-cultural context of electricity that was described in Chapters Five and Six. In an era of politicised electricity access, households believing that a grid connection was imminent may wait to be connected, or wait for a highly subsidised or 'free' SHS.

If the decision to adopt the technology was taken, solar was quickly incorporated into the daily routines of users. Households discussed significant 'non-monetary lifestyle benefits' – considerable improvements in quality of life aspects, such as increased flexibility, day length, improved air quality and the facilitation of reproductive activities (see Komatsu et al., 2011a). A series of less tangible impacts were articulated, which could also be categorised as 'non-monetary lifestyle benefits', but are not as frequently cited in the literature; these included psychological and wellbeing impacts, increased household autonomy and aspirations. In terms of monetary impacts, the chapter's findings resonated with other studies that find household incomes are not directly improved as a result of solar electricity use (see Mala et al., 2009; Laufer and Schäfer, 2011; Mondal and Klein, 2011). In fact, the use of decentralised solar energy technologies implied a cost burden to users, as discussed below.

Gender emerged as an important theme in this chapter. The gender implications of introducing solar energy technologies are not, however, clear cut; for instance, while users stated that some household tasks were 'easier', in reality the technologies provided light to a smoky kitchen, or light to better see the clothes that householders (mostly women) were toiling to clean. Small scale solar energy technologies did not assist women to reduce the drudgery of their day to day lives. This gives rise to questions about the *types* of energy being delivered through the current explosion in access initiatives discussed in Chapter Two. While solar electricity casts lighting on reproductive activities, a host of other activities it cannot address, for instance, energy for cooking, ironing or making a living, are also revealed. This urges us to revisit the question of who benefits from access to solar electricity. While in Chapter Six this question referred to the potentially skewed distribution of benefits towards international and national level actors, rather than the off-grid households intended to use the technologies, this chapter highlights the urgent need to examine the intra-household dynamics of solar electricity. This echoes Jacobson's (2007) call to examine the social implications of solar by delving both 'inside' and 'beyond' the household (p. 147).

Such implications at the household level – positive or otherwise - are not guaranteed however because of how solar energy ultimately 'works' in the homes of users, whether in technical, financial or aspirational terms. The literature on the social shaping of technologies is helpful in this regard, conceptualising 'working' technology as more than mere technical functionality. 'Working' technology is socially constructed, it is built in accordance with user realities and aspirations, is appropriate to local contexts, and able to gain the support of local participants to ensure its long term maintenance (see Akrich, 1992; de Laet and Mol, 2000; Dusek, 2006). For some respondents, solar electricity did not 'work'. Indeed, dissatisfaction was expressed at the poor technical performance of components, as well as limited capacity to power large appliances, such as refrigerators or workshop-style equipment (which were perceived to help engagement with income generating tasks). Other respondents were concerned about what they considered to be other more pressing 'development needs' facing their households and communities, including access to water or to secure incomes. In some cases, the concern for more rudimentary household needs intersected with the 'energy problem' faced by these users (i.e. lacking the power to pump water from a deep well or lacking the power to be 'productive'). Small scale solar energy technologies were therefore not necessarily the most appropriate for this context because they are difficult (financially) to scale up in capacity to satisfy the various needs and wants expressed by respondents, for instance to make the technology go 'beyond the light bulb' (see Clancy, 2001; 2003; Clancy and Dutta, 2005). Indeed, initial experience with electricity evidently amplified the aspirations of households. In this instance, grid-supplied electricity may ostensibly present the most 'appropriate' solution. However, issues relating to the distributional equity of centralised grid-supplied electricity have emerged as major themes throughout the previous chapters. While recent political commitment to grid expansion and electrification is evident, Chapters Five and Six raised concerns about the politicised and haphazard progression of electricity grids. Furthermore, as evidenced in this chapter and in Chapter Five, unreliability of the grid and the deep mistrust held by many households, remain key issues. For example, participants of the GED programme maintained SHSs despite gaining a connection to the national grid because of frequent disruptions in service.

Another aspect that complicated whether technologies 'worked' at the household level was the issue of affordability. While programmes provided *access* to solar electricity, at the time of research, there was a lack of *continued* support once the useful life of expensive components (particularly batteries) had been reached. Relatively high ongoing costs and significant capital investments costs every two to three years (in the case of GED and Project Santa Clara) resulted in a high cost burden articulated by many respondents. In addition to this, the chapter revealed that continued user capacity to pay cannot be assumed – indeed, in two of the three case programmes, participants experienced significant income 'shocks' (e.g. hurricane Felix, the global financial crisis), which affected their standard of living and ultimately their capacity to continue paying for solar energy technologies. Notwithstanding the issues highlighted about grid-supplied electricity (related to distribution, transparency and reliability), it may provide more affordable electricity services.

Chapter Seven contributes to the thesis and broader literature in two key ways. Firstly, this chapter adds the final layer of analysis to this study's broader global to local or 'nested scales' framework, presenting analysis on the local level implications of solar energy technologies. It embeds the perspective of households adopting, using, maintaining and sustaining (or abandoning) solar energy technologies within the broader governance and political-economic frameworks discussed in Chapters Five and Six. Secondly, this chapter has contributed a further case study to the highly policy relevant literature on the experiences of off-grid electrification programmes that currently calls for greater research on user perspectives.

Chapter Eight. Conclusions

8.1 Introduction

The global energy trilemma has brought attention to the importance of energy access, in particular to the 1.3 billion people worldwide without access to electricity. Vital for addressing poverty, improving people's quality of lives and meeting the MDGs, solar energy technologies have been espoused as a solution to household energy needs. This thesis has contributed to this critical research area through an investigation of energy governance issues in Nicaragua. It has paid particular attention to the practices and experiences of off-grid solar energy technologies, and placed emphasis on the role of the user within this. The lived realities, voices and aspirations of energy users are largely absent in scholarly accounts of energy poverty, as such this thesis has considered the implications of solar energy technologies from the perspective of those ultimately adopting, using, maintaining (and, at times, abandoning) them. This approach fits with this study's commitment to illuminate the realities of families living with and without access to basic electricity services in Nicaragua – therefore examining the dynamics of solar energy both 'inside' and 'beyond' the household (Jacobson, 2007).

This final chapter synthesises the key findings of the thesis and highlights its major empirical and conceptual contributions. Specifically, it demonstrates how this study expands current understandings of the practices and experiences of solar energy technologies in off-grid areas of the Global South. The remainder of this chapter is divided into five sections which address each of the research question areas, as well as outline an agenda for further research. Section 8.2 outlines the major contributions of this thesis to understandings about energy governance. Section 8.3 highlights how this research enhances scholarly work on the dynamics of off-grid solar energy market segments in developing countries. Section 8.4 discusses the thesis' contribution to understandings of user experiences and perspectives of solar energy in the Global South. Section 8.5 highlights how this study adds to literature on the challenges faced by off-grid solar energy interventions in the Global South. Finally, section 8.6 offers potential areas for future research.

8.2 Governing energy in Nicaragua

This study's first research question interrogated the ways in which Nicaragua's power sector has been shaped by global and domestic pressures. Through tracing the historical and contemporary dynamics of electricity generation, distribution and consumption, this study concludes that Nicaragua's electricity sector has been influenced profoundly by the interplay of global energy paradigms, regional geopolitics and domestic political shifts. These findings make a unique contribution to an emerging literature on global energy governance. In particular, rather than focus on the so-called 'rule makers', this study has investigated Nicaragua, a 'rule taker', which despite being hailed as a key site for renewable energy investment (IDB 2012; 2013), has received scant scholarly attention.

Conceptual frameworks that help to disentangle the ways in which energy is governed are essential to enable policy makers, businesses and civil society to navigate effectively in changing energy environments. The application of Andreas Goldthau's (2012) energy paradigm framework to the Nicaraguan context represents one of this thesis' empirical and conceptual contributions. Evidence presented in Chapter Five illustrates that the development of the electricity sector broadly reflects Goldthau's paradigm concept. In other words, common to other parts of the globe, the governance of Nicaragua's power sector has shifted from statist to neoliberal to interventionist regimes – as theorised by Goldthau. This study concludes that shifting energy governance prescriptions have been translated to the Nicaraguan context, most recently during a period of significant domestic conflict and upheaval. This interaction of global and local pressures contributed to the sector being characterised by low distributional equity, deep consumer mistrust and dominated by fossil fuel-based electricity generation. This culminated in a severe energy crisis in 2006-7, one induced by multiple pressures, including poor governance, historical under-investment and a 'non-payment' culture. The energy crisis contributed to the near-collapse of the Nicaraguan economy. The evidence presented in Chapter Five reveals that the crisis represented a 'tipping point' for the electricity sector in two key ways. Firstly, an interventionist government with credible plans to rapidly resolve the crisis was re-elected. With regional cooperation, the newly-elected FSLN government quickly overcame the crisis, and further adopted the core mandate of enacting sector transformation - reversing the country's fossil fuel-reliant electricity generation matrix, while also championing universal electricity access. Secondly, evidence points to increasing interest from international donor agencies to address Nicaragua's 'energy problem', with the crisis catalysing the flow of grants and concessional finance to support this ambitious overhaul.

The pervasive government discourse of sector 'transformation' and a raft of recently approved energy programmes (for instance, programmes to tackle low electricity coverage) present an image of a sector that is progressive and inclusive. However, the evidence provided in this study also shows that issues connected to equity, power and vested interests remain unresolved. For instance, decisions made about electricity grid expansion are as political as they are technical. Again, this thesis provides evidence that, similar to other geographical contexts, electricity access has become a key tool for electoral campaigning (see Rehman et al., 2012). As such, the extent to which sector transformation can result in a more equitable energy landscape is questioned. The politicisation of electricity access and recent developments in the sector (for instance, the recent awarding of potentially oil and gas rich areas of the Caribbean Sea to Nicaragua) cast doubt on Nicaragua's potential to enact a truly renewable, equitable 'revolution'; these issues are raised as areas for further research in section 8.6.

8.3 Nicaragua's solar actors: motivations and misalignment with end users

This study's second research question focused on the key stakeholders involved in the promotion and deployment of off-grid solar energy technologies in Nicaragua. Through engaging with their positions, motivations and expectations, the research concludes that a highly complicated infrastructure – incorporating IFIs, private sector providers of solar technology, NGOs, micro finance institutions and government actors - has emerged to distribute off-grid solar energy technologies at scale. Actors operate under different mandates with varying motivations for engaging with off-grid populations and solar energy in particular. Evidence from this study asserts that the perspectives of actors do not always align with the perspectives of those using the technologies.

This research presents an important empirical contribution to a growing area of scholarship on the delivery of solar energy in off-grid areas of the Global South. International agencies are presently designing programmes to incubate solar markets in other developing world contexts; critical interrogation of off-grid solar market development in Nicaragua presents an important contribution to this debate. For instance, the solar market development programme, led by IDCOL in Bangladesh, is renowned globally as a 'success' due to the scale and pace at which it has delivered solar energy products to the rural poor. However, fewer questions are posed about what the proliferation of this technology means for the end users. This study challenges hitherto uncritical studies of solar energy programmes – which typically fail to view interventions as the product of interactions between the complex agendas of IFIs, national government actors, development agencies and the communities/households within which technologies are used.

Evidence presented in Chapter Six establishes that international donor agencies, non-governmental organisations, businesses and government actors shape the politics and availability of off-grid energy choices according to their mandates – whether climate change-related or poverty focused (Newell et al., 2014). Off-grid solar energy technologies satisfy the 'needs' of those various stakeholders, with the technologies performing as flexible 'agents of multiple objectives' (Hunsberger, 2010: 959).

This thesis provides evidence that the attitudes of solar actors reflect the broader international community's fixation with facilitating access to small scale solar lighting technologies[97]. Lighting is presumed to be a 'basic need'. However, this study finds that the energy needs of off-grid populations are not as unproblematic or straightforward such that they can be fulfilled with lighting alone. Furthermore, this study presents evidence that 'different priorities and problems are relevant to different communities' (Escobar, 1995:45-46) - and indeed, amongst the constituents of those communities. Engagement with the narratives of people living off the grid concludes that within households, perceptions about the uses of electricity vary significantly. For instance, along gender lines, with women viewing electricity as a means to facilitate (often arduous) household tasks, such as ironing, cooking, washing or care duties (Cowan, 1983; Clancy et al., 2004). Householders more broadly desire to consume electricity for entertainment purposes, i.e. television. While lighting is clearly an important end use, so too is electricity for (re)productive or connective purposes.

This contrasts to the tendency in debates on energy poverty to assume that all people living in off-grid areas conceptualise electricity (and the services it facilitates) in the same way. Global initiatives such as 'sustainable energy for all' frequently refer to the 1.3 billion people living without access to electricity – the 'all' – which implies homogeneity and oversimplifies the incredibly heterogeneous panorama of energy 'needs' and 'wants' across different geographies, genders, cultures or classes (Kumar, 2013b; see also Bellanca and Garside, 2013). By illuminating the narratives of those individuals and households living in off-grid areas, this thesis challenges narrow techno-economic conceptualisations of energy need or 'energy poverty' that assume all people living without access to 'modern energy services' face the same level of marginality (see Cloke, 2010; Chapter Two). Through challenging the pre-conceptions about energy users in off-grid areas, this study demonstrates that small scale solar energy technologies (delivered via various mechanisms and in varying configurations in the Nicaraguan context) do not necessarily address the multiplicity of energy wants, needs and aspirations of males and females living off the grid.

This misalignment between promoters of solar energy and end users is echoed in other 'development' interventions; Mercer's (2006b) research on community telecentres in Tanzania for instance revealed that while donors assumed that the newly-installed internet would be put to 'productive purposes', in

[97] For instance, TERI's programme to 'light a billion lives' or the World Bank/IFC's 'Lighting Africa' programme, which accredits and promotes basic 'entry-level' solar-powered lighting devices.

practice it was used for leisure purposes and/or communicating with family members. In other words, its usage did not differ from global patterns of internet use. This mismatch highlights the 'we know what the poor need' attitude inherent in these activities as well as Madeleine Akrich's theorisation of 'imagined' versus 'real' users (Akrich, 1992). These findings bring into sharp relief the power gradients involved in 'development' interventions, in particular, what development constitutes by whom and for whom.

This research concludes that even within the off-grid solar energy market segment, there are multiple interests and complex, interconnected agendas, which determine the technologies, products and services available at the local level. This study urges the donors, development agencies, NGOs, etc. seeking to tackle the 'energy access' challenge to do so in a way that considers the multiple needs, wants and priorities of users – this may mean adopting a variety of approaches and technologies.

8.4 End user perspectives: the implications of solar energy technologies

This study's third research question interrogated user experiences and perceptions of solar energy technologies. Through examining the perspectives, voices and aspirations of off-grid energy users, this thesis addresses an important gap in the literature, concluding that the implications of solar energy technologies are far from guaranteed. Further evidence suggests that not all households (or members of households) capture the benefits (or burdens) associated with solar energy technologies. This represents another of this study's key empirical contributions – adding new dimensions to a growing literature on the outcomes and experiences of solar energy in off-grid areas of the Global South.

Evidence presented in this thesis concludes that small scale solar energy technologies provide important 'soft benefits' or 'non-monetary lifestyle benefits' (Wamukonya, 2007; Komatsu et al., 2011a) which include increased levels of comfort, security, flexibility and psychological wellbeing, as a result of access to electric lighting or television. For users of the technologies, these represent important and transformative benefits. However this study's engagement with the narratives of users at different stages of technology ownership/participation in solar programmes reveals that these implications are not guaranteed or fixed through time, or indeed captured by all household members.

For example, this study presents evidence that the benefits of solar energy technologies are only valid for as long as the technology continues to 'work' in financial, technical and social terms (these are elaborated further in section 8.5 below). One critical factor in this is households' *continued* ability to pay for solar energy. As evidence in Chapter Seven concludes, regardless of the delivery model used, the technologies investigated in this study imply greater financial commitments that are also relatively inflexible, compared to previous energy consumption patterns (e.g. Corsair, 2009). When 'critical moments' in the technology's lifecycle are reached therefore, not all households are able to make the (relatively large) investments (e.g. for a replacement battery) necessary to keep the system operational. A potential outcome of this is complete or partial technology failure, where solar electricity becomes substituted by/ or supplemented with comparatively 'energy poor' fuel sources. Evidence presented in Chapter Seven illustrates that it is in these circumstances that solar energy technologies are perceived as burdensome. Under strained financial circumstances - in which other rudimentary household needs may be unmet - dissatisfaction with the technology's 'consumptive' nature is expressed. An important empirical contribution therefore is that the benefits of solar energy technologies are not necessarily sustained in the long term. While scholars have compared users' lives 'before' and 'with' solar electricity (e.g. Acker and Kammen, 1996; Mondal and Klein, 2011), evidence presented in this thesis urges scholars to also consider life 'beyond' solar electricity, given that livelihoods and household financial situations – particularly in vulnerable parts of the Global South – are far from stable. Indeed, evidence presented in Chapter Seven illustrates the extreme vulnerabilities of even relatively 'well off' households.

This study also provides evidence to suggest that the outcomes of solar energy technologies are not necessarily distributed equally within or between households. For example, evidence presented in this thesis draws attention to the intra-household dynamics involved in the use and allocation of limited amounts of power. Competing priorities within a household, for example, the choice between powering a television and DVD player or illuminating spaces in the home, present tensions, and raise interesting questions about who within a household has the power to allocate power (see Jacobson, 2007). This study questions the extent to which the limited outputs of solar energy technologies can adequately address differentiated energy aspirations within households; competing priorities mean that not all household members benefit equally. Further evidence highlights that not all households can capture the benefits (or otherwise) of solar energy. In all programmes examined, the deployment of solar was not universal in target communities – rather, access to the technology was connected to a household's relative financial position, given that in most cases, an upfront financial commitment was required to secure participation in the programme. Evidence presented in Chapter Seven supports empirical work in other geographical contexts that finds solar energy can serve to widen the gap between the 'haves' and 'have nots' (e.g. Wong, 2009; 2012).

8.5 The challenges facing solar energy interventions in Nicaragua

The final research question interrogated the obstacles faced by solar energy interventions in Nicaragua. The study provides evidence of numerous barriers, some of which link to the specific circumstances of end users, and others that connect to the domestic political economic context within which programmes operate. The obstacles are complex, interconnected, pervasive, and not entirely unique to Nicaragua – but rather echo findings from across the globe - providing further evidence of the relative neglect of user realities in the design and delivery of solar energy interventions.

A common challenge, as discussed in section 8.4, is user capacity to pay – whether this is servicing loan repayments, paying monthly usage tariffs, or investing in replacement components. This study presents evidence that, unlike biomass, candles, kerosene or batteries (which can be bought irregularly, and in small quantities) solar electricity implies relatively high and rigid financial commitments. This presents a challenge to users; reverting to relatively 'energy poor' yet flexible fuel sources may be preferable under strained financial circumstances (Corsair, 2009). If financial resources are not committed to basic and major maintenance, even small technical issues may become a cause of system failure. Echoing the discussion in section 8.4, this finding raises important questions about the suitability of solar energy in households with vulnerable, unstable incomes, and where the maintenance of such a technology has become burdensome.

User dissatisfaction is a further challenge highlighted in this research. Evidence presented points to a range of factors impacting on levels of user satisfaction, which may ultimately deter users from maintaining systems (and making the investments this requires). Firstly are the communication strategies of organisations that implement solar energy technologies. Evidence suggests that if the limitations of the technologies are effectively communicated, users are generally more satisfied than those who are promised 'heaven on earth' (Nieuwenhout et al., 2001:469). Evidence discussed in Chapter Seven reveals that users provided with false information (e.g. those promised a certain system that did not materialise, or provided with inaccurate information about system capacity/output) manifest higher levels of dissatisfaction with the technology, which may lead to unwillingness to pay for systems, and ultimately, abandonment.

However, there is also evidence to suggest that users - while initially aware of the limitations of SHS and satisfied with its outputs - over time, desire to power larger wattage appliances. A key empirical contribution of this study is that initial access to solar electricity amplifies user energy aspirations. Solar energy technologies cannot always provide sufficient power to satisfy growing energy aspirations, which may ultimately lead to user dissatisfaction (see Gustavsson, 2007; Hajat et al., 2009; Sovacool and Drupady, 2012). This key finding, alongside the findings discussed above regarding differentiated energy needs within households (section 8.3), suggest that the technologies and approaches taken to tackle low levels of electricity access should be flexible in order to reflect changing household/ community needs, wants and priorities.

User satisfaction is also connected to the technical functionality of the solar energy technology, which in turn links to adequate after sales care and the training of users and technicians alike. Again, this thesis provides evidence that, similar to other geographical contexts, there are gaps in the provision of technical support and training (see Sovacool et al., 2011 and Tillmans and Schweizer-Ries, 2011). This has damaging outcomes for the continued functionality of systems; evidence indicates that lack of training and technical support leads to systems that are non-functional or partially functioning. This may trigger unwillingness to pay. This, alongside other findings, points to a worrying trend of programmes that focus primarily on the provision of hardware or financing mechanisms rather than on the skills, knowledge or social and economic conditions required to sustain technologies in the long term (Byrne et al., 2011; Sesan et al., 2012).

The second grouping of challenges connect to the domestic political economic context. As discussed in section 8.2, this study provides evidence that grid electricity access has become increasingly politicised, which raises questions about the equitable nature of Nicaragua's energy 'revolution'. This situation also presents challenges to solar energy interventions at multiple levels.

For example, this thesis provides evidence that the promise of grid-supplied electricity may deter consumers from adopting a renewable alternative, specifically undermining the desirability of technologies such as SHS. This finding supports empirical work from other geographical contexts (e.g. Sovacool and Drupady, 2012). However, in contrast, this study also presents evidence that off-grid energy users are mistrustful of grid-supplied electricity because of the sector's history, as well as the perceived expense, insecurity or unreliability of the service. As such, solar energy technologies also represent an important alternative to grid supply, or provide a back-up option where grid connections exist. The relationship between centralised grid-supplied electricity and distributed electricity solutions is therefore not clear cut. For households with growing energy aspirations, a connection to the grid may be the only way to ultimately satisfy increasing demand, given the relatively high costs involved in scaling up the capacity of solar home systems. However, negative perceptions of the grid mean that solar energy technologies present a 'safe' or 'reliable' means to access electricity. A detailed examination of the tensions and complementarities between more recent (politicised) expansion of the grid and the development of programmes promoting distributed solar energy technologies represents one of this study's key empirical contributions.

The specificities of the domestic political economic context pose challenges for those actors and institutions working to implement solar energy technologies. Firstly, this study presents evidence that the lack of transparent electrification plans means that programmes are potentially launched in areas already earmarked for grid extension. As discussed above, this could lead to programmes being rejected by users, or programmes which do not have the anticipated levels of uptake. This key finding urges for greater policy coherence and communication, such that implementing organisations are better able to target interventions and resources.

Connected to the call for greater policy coherence, is a second challenge, which is the relative scarcity of data on solar energy initiatives underway in Nicaragua. Not all implementing organisations operate via the Ministry of Energy and Mines, and there is not one body with oversight, or ability to coordinate the activities of multiple donors. Evidence presented in this thesis highlights a highly fragmented, uncoordinated and politicised sector. For example, some communities were simultaneously targeted by grid extension activities and distributed solar energy technologies; in other cases, neighbouring communities were targeted with different solar energy 'packages' – some of which required users to make significant financial commitments, while others did not. This lack of coordination has the potential to undermine interventions and highlights the need for greater coordination, coherence and data on the activities of organisations operating in the off-grid solar energy space.

A final, connected challenge is the socio-cultural, political aspect of non-payment or *no pago*. Evidence presented in this thesis highlights that the non-payment culture does not exclusively apply to electricity services, but to wider services (e.g. micro loans). *No pago* is a means of protest, but evidence also suggests that it became linked to the most recent presidential election campaign. Evidence points to the unease felt by implementing organisations (and partner insitutions, for instance, the micro finance institutions that in some cases provide finance packages to end users), given the risks that users default on solar loans, or fail to make pay monthy service payments. This specificity of the Nicaraguan political economic context poses a further challenge to those implementing programmes.

8.6 Future research agenda

This study presents evidence of significant, recent shifts in Nicaragua's energy pathway[98], with commentators suggesting that Nicaragua has the potential to become a 'learning laboratory' for other countries enacting low carbon transitions. As discussed above however, there is some further research to be done around the extent to which the so-called energy 'revolution' presents a more equitable energy landscape. Key questions arise, such as can this seemingly progressive shift be sustained? Could it be vulnerable to political shifts, when (or if) Ortega stands down as president? Future research could usefully re-examine energy governance issues in Nicaragua, specifically, what is the progress of the 'energy revolution' underway, and how is it shaped by developments such as the recent acquisition of potentially oil rich areas of the Caribbean Sea (in which the Nicaraguan Government expresses intentions to explore for oil and gas) (see BBC, 2013b; 2013c)? Another key governance issue for future research concerns the transparency of transactions in Nicaragua's energy sector; all empirical chapters point to poor governance, particularly in the privatisation of the electricity distributor or the kick-starting of the solar energy sector, resulting in suboptimal outcomes for energy users and broader society.

As discussed above in section 8.2, one of the conceptual and empirical contributions of this research is its application of Goldthau's energy paradigm thesis to the 'rule taking' Nicaraguan context. The study concludes that the development of Nicaragua's electricity sector broadly reflects Goldthau's paradigm framework. Evidence presented in this thesis however highlights some limitations of the framework, and points to the need for conceptual reworking to improve its applicability to energy systems within 'rule taking' contexts. For instance, an important finding of this thesis is that the capacity of Nicaragua to negotiate its energy pathway is conditioned by its relative power in the global political economy; furthermore, and intimately connected to this, is its relationship with international financial institutions (see Baker et al., 2013). While Goldthau recognises that energy paradigms are linked to 'rule-setting power', the key transmitters and enforcers of 'rules' are not elaborated within the framework. This study concludes that major IFIs – the IDB and World Bank – are key vectors of energy policy prescriptions in Nicaragua and the wider Central American region (Nakhooda, 2011; see Chapters Three

[98] Transformations are not only underway in Nicaragua's energy sector, but also in relation to the wider economy. The economy has grown significantly over the past five years; economic growth is expected to reach 5% between 2012 and 2013 (CEPAL figures, cited in El Nuevo Diario, 03.10.12). In addition to this, Nicaragua's Congress recently awarded a concession to build an inter-oceanic canal, representing the largest infrastructure project in the country's history (see BBC 2013a).

and Five). The channelling (or withholding) of grants and concessional finance for targeted energy development assistance programmes serve to privilege some technologies, policies and market segments over others (Smits and Bush, 2011; Sovacool and Drupady, 2012), impacting profoundly on the energy pathway adopted.

Other spheres of influence also require further attention in the energy paradigm framework, for instance, this study highlighted the key role of South-South cooperation in shaping Nicaragua's energy pathways. Evidence in Chapter Five draws attention to the vital role of regional actors; for instance, Brazil has emerged as an important financier of renewable energy projects, while Cuban generating plant and Venezuelan petrodollars revived the collapsed electricity sector in 2006/07 – with cheap Venezuelan oil continuing to subsidise electricity tariffs. This echoes findings from other studies concluding that energy assistance is an increasingly important feature of South-South cooperation (Johnson and Power, 2012; Baker et al., 2013). Further work is therefore required on the influence of 'rising powers' in energy governance.

Another future research area is to address the dearth of literature on the wider dynamics of energy transformation in Central America (see Gent and Tomei, forthcoming; Chapter Three). Further research is warranted specifically in light of the soon to be inaugurated SIEPAC project, and specifically the concerns raised over the uneven distribution of costs and benefits of regional electricity integration (Taylor, 2005). A further study could more explicitly tease out the 'winners' and 'losers' of such a mega project, and helpfully contribute to Dolezal et al.'s (2013) questions about Central America's capacity to fulfil its 'sustainable energy potential' (p. 12) and how this can be achieved in an equitable manner.

When the field research for this study was taking place (2010-2011), products such as the solar pico system (SPS) were still emerging; in Nicaragua, SPS dissemination was observed only at demonstration level. Since the completion of this study however, there have been incredible shifts in the global off-grid solar PV market (REN21, 2012; IEA PVPS, 2013) – with the costs of PV technology decreasing dramatically and the efficiencies of appliances improving markedly (e.g. LED lighting). This has led to huge growth in the variety of solar energy products (and innovative delivery models) available on the market, and recent years have witnessed increasing international support for programmes that promote solar lanterns. For instance, solar pico systems feature prominently amongst high-level commitments made under the SE4All initiative[99]. Compared to the 'traditional' SHS, SPS can be purchased relatively cheaply (entry prices for SPS can be as low as US $5, IEA PVPS, 2013) and typically

[99] For example see:
http://sustainabledevelopment.un.org/index.php?page=view&type=1006&menu=1348&nr=561 (also IEA, 2012b)

offer 'entry level' or 'basic' electricity services (e.g. sufficient solar electricity for one lantern and/or to charge one mobile telephone). SPS are, however, relatively scalable and users can add larger panels, further batteries and appliances, eventually reaching the service level of a SHS[100]. The reduction in technology costs means that there have been further, significant developments in the piloting of larger scale solar photovoltaic configurations which are connected to 'mini-grids' and can provide larger quantities of electricity to clustered, off-grid households (see Quoilin and Orosz, 2011; Khan, 2012; IED, 2013). These developments demand future research into the 'scalability' of solar and its potential configurations (technological configurations, as well as social configurations, e.g. in ownership and governance terms) for off-grid households. Specifically, it would be instructive to tease out the benefits of a particular system configuration in a specific context, with regard to relative cost and levels of user satisfaction.

While exploring gender was not a specific objective of this thesis, it emerged as an important theme, and the findings highlighted above suggest that greater empirical work is required. Aside from Grogan and Sadanand's (2013) recent paper that discusses the impact of rural electrification on time use and employment of men and women, relatively little is known about the gendered dynamics and implications of electricity allocation and use in Nicaragua and indeed, beyond[101]. There is increasing traction around the issue of gender and energy poverty – which is reflected in the mainstreaming of gender into the energy policies/interventions of international bodies (see for instance, the recent gender strategy of the Latin American Energy Organisation[102]). While there is a growing body of research on gender and energy poverty (see in particular the work of Joy Clancy), there is the need for greater empirical work to explicitly tease out the impacts of access to different technologies or quantities of electricity on women and girls. Future studies could explore how differently configured energy technologies address the specific needs of women. Other research could examine broader political economy questions related to the impacts of reform processes or energy paradigm shifts on women.

In summary, this thesis has provided a unique exploration of energy governance issues in Nicaragua, with specific reference to the practices and experiences of off-grid solar energy technologies. In doing so, this research has made valuable empirical and conceptual contributions to emergent 'energy geographies' (see Bridge et al., 2013) and broader social science studies of energy and development

[100] See for example the Indigo pay-as-you-go model: http://www.azuri-technologies.com/indigo/
[101] In recognition of this gap, the UK Department of International Development has recently launched a research programme on gender and energy, see: http://www.utwente.nl/en/newsevents/2014/5/336458/energia-and-dfid-join-forces-to-further-knowledge-on-impacts-of-energy-access-for-women-and-girls-led-by-dr-joy-clancy-cstm
[102] See: http://www.olade.org/sites/default/files/CIDA/Gender%20Estrategy%20Report%20Formato.pdf

(see Sovacool, 2014). The momentum behind the energy poverty agenda is unprecedented. This moment should be seized to end the inequalities of our global energy system. In facilitating access to energy, context-specific, long-term commitments are required which, rather than focus on providing X kWh of electricity, should first understand what off-grid populations hope to achieve from energy, and how it can make their lives easier, better and more productive. Energy access programmes should be suited to the people they allege to serve; the needs, wants and perspectives of users should therefore be incorporated into the design of initiatives, while not underestimating (or viewing them in isolation from) the political economies of energy in domestic, regional and international spheres.

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Appendix

1. Table of key stakeholder interviewees

Interview	Position	Organisation	Location
1	Founder and campaigner	Consumer defence organisation	Masaya
32	Campaigner and energy specialist	Consumer defence organisation	Managua
6	Director	Renewable energy technology company	Estelí
16	Director	Solar energy company	León
27	Founder director	Renewable energy technology company	Managua
9	Marketing director	Renewable energy technology company	Managua
26	General manager	Renewable energy technology company	Managua
33	Finance official	Disnorte-Dissur (private electricity distributor)	Managua
28	Distribution engineer	Disnorte-Dissur (private electricity distributor)	Masaya
10	Manager	ENEL (state-owned electricity company)	Puerto Cabezas, RAAN
11	Official	Instituto Nicaragüense de Energía (INE) Nicaraguan Energy Institute	Masaya
21	Renewable Energy Expert	Ministerio de Energía y Minas (Ministry of Energy and Mines)	Managua
19	Officials	PERZA (Proyecto de Electrificación Rural para Zonas Aisladas) (Rural electrification for isolated zones project) Ministerio de Energía y Minas	Managua
20	Official	PERZA, Ministerio de Energía y Minas	Managua
35	Social Promoter	PERZA, Ministerio de Energía y Minas	Managua
22	Official	FODIEN (Fondo para el Desarrollo de la Industria Electrica) (Electric Industry Development Fund), Ministerio de Energía y Minas	Managua

13	Coordinator of large donor funded solar programme	Ministerio de Energía y Minas	Managua
12	Coordinator of large donor funded solar programme	Consejo Hondureño de Ciencia, Tecnología e Innovación (Honduran Council for Science, Technology and Innovation)	Tegucigalpa, Honduras
25	Coordinator of large donor funded solar programme	Proyecto de Infraestructura Rural (Rural Infrastructure Project) and Fondo Hondureño de Inversión Social (Honduran Social Investment Fund)	Tegucigalpa, Honduras
30	Central American coordinator of global donor funded electrification programme, case programme B	European development agency	Managua
29	Official	Inter-American Development Bank (IDB)	Managua
18	Energy specialist	Sistema de Integración Centroamericana (Central American Integration System)	Skype interview
14	Loan product manager	Large micro-finance institution	Managua
31	Former official	Pre-1990 state owned electricity company	Masaya
3	Director	NGO operating a small-scale solar programme	Masaya
2	Technician and repayment collection	NGO operating a small-scale solar programme	Masaya
4	Representative and project fundraiser	NGO operating a small-scale solar programme	Masaya
36	Coordinator	NGO operating a small-scale solar programme	Masaya
7	Co-founder / Convenor	NGO operating a small-scale renewable energy programme in off-grid communities / National renewable energy interest network	Managua

15	Founder and academic	Network of organisations promoting solar energy in rural Nicaragua	Managua
8	Social Promoter	Agricultural production cooperative, which supports an off-grid solar energy programme	Francia Sirpi, RAAN
5	Director	Atlantic coast development organisation, which supports an off-grid solar energy programme	Puerto Cabezas, RAAN
23	President	Atlantic coast development organisation, which supports an off-grid solar energy programme	Puerto Cabezas, RAAN
24	NGO worker	A global development NGO, which supports an off-grid solar energy programme	Puerto Cabezas, RAAN
17	Director	Atlantic Coast Development organisation, which supports an off-grid solar energy programme	Puerto Cabezas, RAAN
34	President	Agricultural production cooperative, which supports an off-grid solar energy programme	Estelí

2. Table of solar energy programme participants interviewed

Interview	Individual	Occupation[103]	Village	Location (Department)	Programme
A1	Alejandro	*Campesino*	Guanacaste	Masaya	A
A2	Alfonso and Luisa	Smallholders – fruit	Guanacaste	Masaya	A
A9	Uriel	Smallholder – cattle	Guanacaste	Masaya	A
A12	Amada Concepción, Maria and Catalina	House wives	Guanacaste	Masaya	A
A13	Gloria	House wife	Guanacaste	Masaya	A
A18	Oscar	Smallholder – cattle	Guanacaste	Masaya	A
A20	Ricardo and Angela	Pastors	Guanacaste	Masaya	A
A7	Felix	*Campesino*	Sabaneta	Masaya	A
A10	Kevyn	Smallholder – cattle	Sabaneta	Masaya	A
A24	Lorenzo	*Campesino*	Sabaneta	Masaya	A
A23	Geovany	*Jornalero*	Sabaneta	Masaya	A
A8	Francisco	Smallholder – fruit	El Amatillo	Masaya	A
A11	Erica	House wife and *pulpería* owner	La Concha	Masaya	A
A25	Eleonore	House wife and *jornalera*	La Concha	Masaya	A

[103] *Campesino/a:* this term has multiple translations, e.g. 'peasant', 'country person', 'agricultural worker', however in the context of this thesis refers to a householder cultivating a small piece of land (rented or owned) for the purposes of producing goods for subsistence living.
Jornalero/a: paid day labourer (usually seasonal and informal work).
Chambas: informal paid work undertaken by females (e.g. clothes washing).
Pulpería: a small, local shop, usually based in the home of the proprietor.
Smallholder: a householder cultivating a larger piece of land than the *campesino/a* for the purpose of selling their produce (e.g. milk, fruit).

A4	Belarmina	House wife and *jornalera*	Chiquistepe	Managua	A
A14	José and Maria	*Jornalero* and house wife/ informal *chambas*	Chiquistepe	Managua	A
A15	Juan and Esmerelda	*Jornalero* and house wife	Chiquistepe	Managua	A
A16	Maria Antonia	House wife and *pulpería* owner	Chiquistepe	Managua	A
A17	Miguel	*Jornalero*	Chiquistepe	Managua	A
A19	Prudencia	House wife	Chiquistepe	Managua	A
A21	Candido and Rosa	*Jornalero* and house wife	Chiquistepe	Managua	A
A27	Francesca and Angela	House wives and informal *chamba*	La Boquita	Managua	A
A26	Sulema	House wife	La Quebrada	Managua	A
A5	Bernarda	House wife	La Quebrada	Managua	A
A6	Yessica	House wife and *pulpería* owner	La Quebrada	Managua	A
A3	Yunely	House wife	La Quebrada	Managua	A
A28	Johanna	Single mother and *jornalera*	La Quebrada	Managua	A
A29	Anabel	Housewife and *jornalera*	La Quebrada	Managua	A
A30	Yamisel	Housewife	La Quebrada	Managua	A
A31	Ana	Housewife	La Quebrada	Managua	A
A32	Juana	Housewife	La Quebrada	Managua	A

C1	Kervin and family	*Campesinos*	Santa Clara	RAAN	C
C2	Denis	Headteacher of community school	Santa Clara	RAAN	C
C3	Apolinar	Community *juez*	Santa Clara	RAAN	C
C4	Andrea	Pre-school teacher	Santa Clara	RAAN	C
C5	Fernanda	*Campesina*	Santa Clara	RAAN	C
C6	Adalicia	*Campesina* / informal *chambas*	Santa Clara	RAAN	C
C7	Santos	*Campesino*	Santa Clara	RAAN	C

3. Questionnaire survey

Facultad de Ciencia, Tecnología y Ambiente

Encuesta Nº y identificación del encuestador/a: __________ Fecha: _________ Hora:

UCA
Universidad
Centroamericana

Buenos [días/tardes]. Mi nombre es [...] soy estudiante de la Universidad Centroamericana (UCA) en Managua. Estamos realizando un estudio sobre las experiencias de las familias que adquirieron un panel con el programa de En-Dev / GIZ / Cooperación Alemana en Nicaragua en **2006 y 2007 **COMPROBAR**** a través de la cooperativa ____.

Nos interesa las experiencias vividas con su equipo, para qué se usa el panel, cómo la vida de su familia ha cambiado y ver si han experimentado algunos problemas técnicos. Por lo tanto, me gustaría hablar con el jefe/la jefa de la familia y realizar una entrevista breve.

Por favor diga francamente lo que piensa sin preocuparse, su nombre no va a aparecer en ningún tipo de reporte y sus detalles estarán en anonimato. Sus respuestas serán muy importantes para los fines de esta investigación y le agradecemos su colaboración, esperamos que con este estudio podamos mejorar fases futuras de proyectos. Sin embargo, si hay algunas preguntas que prefiere no contestar, no hay problema, saltaremos a la siguiente pregunta.

I Demografía

1. Comunidad: ____
2. Municipio: ____
3. Ubicación GPS: ____
4. Nombre del jefe/la jefa de la familia: ____
5. Nombre del participante: ____
6. Sexo: 1. H 2. M

7. ¿Cuántas personas **mayores de 18 años de edad viven permanentes en esta casa?**
Hombres ________ Mujeres _______

8. ¿Cuántos niños viven en esta casa? ___________________________
Menores de 12 años ___________ Entre 13 – 18 años ___________

II Datos económicos

9. Cuantos miembros económicamente activos	**10**. Actividad Económica a la que se dedica	**11**. Ingresos netos **MENSUAL** (total del hogar)	**12.** Ingresos por salarios **MENSUAL** (total del hogar)	**13**. Gastos fijos **MENSUAL** (total del hogar)

III Datos generales sobre el panel

14. ¿En que año compró su panel?

1. 2006
2. 2007

15. ¿Quién fue el proveedor?

1. Altertec
2. ECAMI

16. ¿A través de cual fundación o federación compró su equipo?

1. Unión de Cooperativas Agropecuarios - UCA Miraflor
2. Federación para el Desarrollo Integral de Campesinos y Campesinas – FEDICAMP: Nombre Cooperativa
3. Fundación entre Mujeres – FEM

17. ¿Cuales fueron sus motivos principales para comprar el panel? **NO LEER RESPUESTAS**

1. Tener luz eléctrica
2. Tener el uso de electrodomésticos (ej. Tele, recarga de celular)
3. Reducir el humo de los candiles/candelas en el hogar
4. Reducir el gasto en energía
5. Mejorar oportunidades para actividades productivas
6. Mejorar condiciones de trabajo
7. Porque otros lo tenía
8. Otro *(explica)*____

18. ¿Usted considera que sus expectativas se han cumplido?

1. Si
2. No

19. ¿Existen otros beneficios que tal vez no había previsto?

1. Tener luz eléctrica
2. Tener el uso de electrodomésticos (ej. Tele, recarga de celular)
3. Reducir el humo de los candiles/candelas en el hogar
4. Reducir el gasto en energía
9. Otro *(explica)*____
5. Mejorar oportunidades para actividades productivas
6. Mejorar condiciones de trabajo
7. Porque otros lo tenía
8. Ninguno

20. ¿Cuánto pagaron por el panel? ***SUMAR PAGOS PARCIALES O ANTICIPOS***

____

21. ¿Cómo la familia reunió los fondos para la compra del panel?

1. Con ingresos normales de trabajo
2. Con crédito de una micro financiera
3. Préstamos de otra persona
4. Con fondos ahorrados
8. Otro *(explica)* ____
5. Con remesas
6. A través de la venta de bienes/animales
7. Intercambio (ej. cosecha de café por el panel)

22. ¿Hay luz eléctrica de la compañía de distribución DISNORTE en esta comunidad?

1. Si *(pasa a pregunta 26)*
2. No *(pasa a la siguiente)*

23. ¿Espera tener luz eléctrica de la compañía de distribución DISNORTE en el futuro?

1. Si
2. No

24. ¿Ha habido algún tipo de gestión comunitaria / de la cooperativa / fundación para solicitar la luz eléctrica?

1. Si
2. No

25. ¿Qué tipo de
22 **gestión?**____
____

26. ¿Cuando llegó la red nacional en esta comunidad?
____

27. Aparte del panel instalado con el apoyo de la cooperativa o fundación (y el programa EnDev / GIZ / cooperación alemana), ¿tiene otra forma de acceso a la electricidad?

1. Otro(s) panel(es)
2. Planta eléctrica
3. Otro equipo de generación utilizando energía renovable (ej. Mini-eólica)
4. Ninguno

28. Como habíamos comentado, el panel fue cofinanciado por EnDev / GIZ / cooperación alemana, ¿conoce usted de otras organizaciones que haya financiado otros paneles, plantas eléctricas o otros equipos de generación en la zona?

1. Unión Europea
2. Cooperación Austríaca
3. Cooperación Española
4. Ni uno
5. ___________________
6. ___________________

IV. Presencia física del panel. ¿Está funcionando todavía el panel? Motivos para el abandono/uso continuo.

El panel era suyo y podía hacer con él lo que quisiera, pero tenemos curiosidad lo que hizo con el panel.....

29. ¿Tiene todavía el panel instalado bajo del programa En-Dev / GIZ / cooperación alemana Nicaragua?

1. Si está el panel en la vivienda *(pasa a la pregunta 33)*
2. No está el panel en la vivienda *(pasa a la siguiente)*

30. ¿Por qué no cuenta físicamente con el panel?

1. Lo vendimos a otra familia
2. Lo vendimos a un comerciante
3. Devolvimos al proveedor
4. Lo prestamos a otra familia
5. Lo robaron
6. Lo botamos
7. Otro *(explica)*

____

31. ¿Por cuánto? ____________________________

32. ¿Qué lo motivo para abandonar el panel? Si es posible, explique a continuación:

1. No cubrió nuestras necesidades eléctricas	Porque…
2. No nos gustó a utilizarlo	Porque…
3. No funcionó	¿Cuáles fueron las dificultades (técnicas o económicas) para componerlo?
	¿Qué hicieron para solucionar el problema?
4. La luz eléctrica llegó en la comunidad	¿Por qué dejaron de utilizar el panel junto con la luz eléctrica?

5. Tuvimos dificultades con el crédito que obtuvimos para comprar el panel	¿Cuáles?
6. Otra familia lo necesitaba más que nosotros	¿A quiénes? Nombre, dirección
7. Otro	(explica)

29

33. ¿Están utilizando el panel solar en su hogar actualmente?

1. Si *(pasa a la pregunta 36)* 2. No *(pasa a la siguiente)*

34. ¿Por qué no están utilizando el panel actualmente? Si es posible, explique a continuación:

1. No cubre nuestras necesidades eléctricas	Porque…
2. No nos gusta utilizarlo	Porque…
3. No funciona	¿Cuáles fueron las dificultades técnicas para componerlo?
	¿Qué hicieron para solucionar el problema?
4. La luz eléctrica ha llegado a la comunidad	¿Por qué han decidido no utilizar el panel teniendo la conexión de la luz eléctrica?
5. Tenemos dificultades en el reemplazo y mantenimiento de las partes	¿Cuáles dificultades?
6. Otro	(explica)

35. ¿Le gustaría que volviera a funcionar el sistema fotovoltaico?

1. Si 2. No 3. No sé

33

V. Capacitación

36. ¿Recibieron algún tipo de taller o capacitación sobre el uso y mantenimiento de su equipo?

1. Si 2. No

37. ¿Quién lo hizo?____

38. Cuando compró el panel ¿sabía cuánto tiempo duraría cada componente (vida útil)?

1. Si 2. No

VI. Problemas técnicos: reemplazo de componentes y sostenibilidad financiera

39. ¿En el caso de problemas técnicos, quien le ha ayudado a resolverlos, o ¿quién podría ayudarle?
Indique su disponibilidad con una 'X'

¿Quién?	**Disponible**	**No disponible**	**Explica**
1. La cooperativa o la fundación			
2. El proveedor del equipo (Altertec/ECAMI)			
3. Un técnico local			
4. Otro usuario			
5. Nadie			
6. Otro			

Salto numeración

40. ¿Han tenido que reemplazar algunos componentes desde que instalaron el equipo en 2006-2007?

1. Si *(pasa a la siguiente)*
2. No *(pasa a la pregunta 45)*

41.¿Cuales componentes han tenido que reemplazar?
¿Cuales recursos económicos utilizaron para pagar el reemplazo?
¿En qué año los reemplazaron? *** ponga el año(s) en la casilla adecuada***

Recursos	Batería	Inversor	Controlador	Cableado	Bujías	Panel
1. Ingresos normales						
2. Crédito de una micro financiera	ej. 2008					
3. Préstamos de otra persona						
4. Fondos ahorrados						
5. Remesas						
6. Con la venta de bienes / animales						
7.Otro Ej. donación						

42. ¿Cómo consiguieron los componentes? ***Ponga un 'X' en la casilla adecuada***

	Batería	Inversor	Controlador	Cableado	Bujías	Panel
1. A través de la cooperativa						
2. Directamente del proveedor original						
3. A través de otro proveedor	Nombre	Nombre	Nombre	Nombre	Nombre	Nombre
4. Mercado						
5.Otro						

43. Identifique el tipo de problema han tenido en el reemplazo de los componentes:

1. Dificultades económicas en la compra de equipos
2. Lejanía de los proveedores
3. Falta de conocimiento de los componentes
4. No hubo problema
5. Otro *(explica)*

____

44. ¿En caso del reemplazo de la batería qué hicieron la batería vieja? O ¿en el reemplazo futuro qué harían con la batería vieja?

1. La tenemos todavía
2. La botamos
3. La devolvemos al proveedor para reciclaje
4. Otro *(explica)* ____

VII. Gastos en energía: Comparación entre antes de la instalación, durante el uso (y después?)

40

Ahora vamos a hablar sobre el uso de energía en su casa, y reflexionar un poco sobre la situación antes que tuviera el panel y el tiempo que ha estado en uso su panel.

45. ¿Antes de la llegada del panel, ¿cuánto gastaban **POR MES para iluminarse, divertirse, operar aparatos?**

46. Una vez que adquirió el equipo, ¿cuánto gastaban *POR MES para iluminarse, divertirse, operar aparatos?**

47. En el caso que el panel ya no lo utilice, ¿cómo ilumina su casa y operar aparatos? ¿Y cuanto gasta mensualmente?

Materiales	Antes de la llegada del panel ¿cuánto gastaban en energía para iluminarse, divertirse, comunicarse? Córdoba/por mes	Una vez que adquirió el equipo, estos ¿cuánto gastaban? Córdoba/por mes	En el caso que el panel ya no lo utilice ¿cuánto gasta? Córdoba/por mes
1. Candelas			
2. Pilas Linterna y radio			
3. Batería de carro para TV DVD/video			
4. Combustible para candil			
5. Leña para iluminación			
6. Combustible para planta eléctrica, Iluminación, Aparatos domésticos			
7. Recargas de baterías para linterna o celular			
8. Pago servicio eléctrica (de la luz eléctrica)			
9.			
10.			

48. ¿Considera que el panel ha contribuido a reducir su gasto de iluminación?

1. Si   2. No

49. ¿Cuál es la carga instalada en la casa? ***SOLO SI ESTÁN UTILIZANDO EL PANEL***

Tipo de carga	Potencia (watts) - CALCULAR CON LA TABLA	Horas de uso
1 Bujías 12 V		
2 Bujías 120 V		
3 Radio		
4 TV (blanco y negro) o color		
5 DVD/video		
6 Recarga de celular		
7 Recarga de baterías para foco o radio		

50. ¿Se siente satisfecho con la cantidad de electricidad disponible? ***SOLO SI ESTÁN UTILIZANDO EL PANEL***

1. Si **2.** No

51. ¿Es suficiente para cubrir sus necesidades? ***SOLO SI ESTÁN UTILIZANDO EL PANEL***

1. Si **2.** No

52. ¿Si tuviera más electricidad, cuales serian sus prioridades para su uso? ***SOLO SI ESTÁN UTILIZANDO EL PANEL***

1. Mas uso de la iluminación
2. Mas uso de la TV
3. Nuevo o más uso en comunicación: celular o internet
4. Mas uso de los aparatos electrodomésticos (algunos no pueden ser usados con paneles fotovoltaicos)
5. Utilización de equipos para la generación de ingresos (Recarga de baterías de celulares, recarga de baterías para iluminación, computadora, internet, plancha, refrigeradora, congeladora, taladro, soldadura, molino,….)
6. Otro *(explica)*

____

53. ¿Están pensando en invertir en otra manera de conseguir más energía?

1. Planta eléctrica
2. Otro panel solar
3. Otra tecnología utilizando energía renovable (ej Micro hidro, micro eólico)
4. Ninguna

VIII. Cambios en: Rutina diaria, familia, comunidad – como resultado del panel en uso

Ahora vamos a hablar sobre los cambios que han/habían experimentado en la casa como **resultado del uso del panel.**

54. ¿Cómo ha cambiado la calidad del aire dentro de su casa? ***EXPLICAR que la calidad del aire refiere a la falta de humo***

1. Ha mejorado bastante 2. Ha mejorado un poco 3. No hay cambio

55. ¿Han aprovechado el panel para mejorar el ingreso familiar? ***AHORRO DE DINERO NO CUENTA-solamente si el usuario está generando ingresos con la electricidad, ej. la venta de recargas de las baterías de celular***

1. Si 2. No

56. ¿En qué manera ha mejorado el ingreso familiar?

1. Tener iluminación hace nuestras actividades más fáciles y más productivas
2. Tener iluminación lo hace más atractivo para nuestros clientes
3. Utilizamos la electricidad para prestar un servicio remunerado de recarga del celular o baterías
4. Ahora utilizamos el celular para comprar y vender y hacer mejores negocios
5. Ahora tenemos un ciber para comunicación por internet que se alquila por hora
6. No hay beneficios
7. Otro *(explica)* ____

57. ¿Le parece que se han sido extendido las horas de estudio de los niños como resultado del uso del panel?

1. Si, por mucho
2. Si, un poco
3. No cambia
4. No sé

58. ¿Le parece que los niños dejan a sus tareas para ver la televisión?

1. Sí, eso pasa muchas veces
2. Si, a veces
3. Eso apenas pasa
4. Eso nunca pasa
5. No sé

59. Respecto a lo que pasa en el mundo y en el país, diría que por la tele siente:

1. Mucho más conectado e informado
2. Un poco más conectado
3. Igual que antes

60. Respecto a la comunicación por celular con familiares amigos o para el trabajo, ahora lo utiliza:

1. Mucho más que antes de tener el panel solar
2. Un poco más que antes
3. Igual que antes

61. ¿Cuáles son las actividades que se pueden hacer en la noche, ahora que tiene el panel, que no podían hacer antes?

1. Descansar y divertirse
2. Quehaceres (ej. Cocinar, cocer, limpiar)
3. Platicar y divertirse con la familiar
4. Platicar y divertirse con los vecinos
5. Actividades para mi negocio/actividades que generan ingresos
6. Actividades religiosas
7. Actividades políticas
8. ____

62. ¿Sienten que sus tareas del hogar son más fáciles con el panel solar?

1. Si, por mucho
2. Si, un poco
3. Igual que antes
4. No es cierto

63. Extensión de la jornada diaria

	Antes que compraron el panel	Después
Hora de levantarse		

Hora de acostarse		

64. ¿Siente que con el panel, pasan más horas trabajando?
1. Sí, mucho mas
2. Si, un poco mas
3. Igual que antes
4. No es cierto

65. ¿Cuál ha sido el beneficio más grande que ha traído el panel?
1. Una mejora en la salud de la familia
2. Mejores oportunidades educativas para los niños (ej. Más horas de estudio)
3. Más información/conocimiento (TV, radio)
4. Mejor seguridad
5. Más oportunidad para diversión/distracción
6. Más oportunidades para mejorar ingresos
7. Reducción en gastos de diesel/querosene
8. No hay beneficios
9. Otro *(explica)*____
10. No es cierto

***Casi terminamos la encuesta, muchas gracias por su paciencia con nosotros. Sus respuestas son excelentes.

66a. Sabemos que la energía es una necesidad bastante importante, pero también que existe otras necesidades para su familia. ¿Cuáles son los cuatro problemas más importantes de su familia y su comunidad?

1. _______________________________
2. _______________________________
3. _______________________________
4. _______________________________

66b. ¿Tener acceso a la electricidad es más importante que los problemas que ha mencionado?

1. Si
2. No

IX. Satisfacción general

67. En general, la experiencia con los paneles solares ha sido:

1. Positivo 2. Regular 3. Negativo

68. ¿Recomendaría un panel a otra familia?

1. Si
2. No

69. ¿Por qué?
____

70. ¿Qué fue bueno sobre su experiencia con FEDICAMP: Nombre Cooperativa _________________; UCA Miraflor; FEM, y ¿por qué?

____
____
____

71. ¿Qué podría mejorar por su experiencia en la relación con FEDICAMP: Nombre Cooperativa _________________ UCA Miraflor; FEM, y ¿por qué?

____
____
____

72. ¿Qué recomendación daría usted como beneficiario del proyecto, a la organización de GIZ para mejorar el proyecto en el futuro?

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