A Rapid Rural Appraisal of Energy Access in Cambodia

Doctoral thesis for

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June 2016

Abstract

This thesis develops a set of methods for assessing rural energy access. The proposed strategy is intended to facilitate decision-making in conditions of poverty by judiciously combining both quantitative and qualitative styles of assessment. As such, this research evaluates the respective strengths of the two approaches, finding ground for their synthesis and mutual benefit. These methodological findings are demonstrated via an appraisal of energy access in several villages in Cambodia.

Underlying the following study of methods is the theory of energy access. The theory posits that if poor people can access energy then they will have the capabilities to satisfy their basic needs, contribute to an economy and otherwise promote the development that will let them escape poverty. This project has conclusions about what aspects of energy access are most significant, but more substantially, these conclusions are upon meaningful ways in which to measure that access. Particularly, the main thrust of the argument is that contemporary, predominantly quantitative, measures miss out on some of the vital issues within energy access that make it such a helpful theme when considering poverty.

Data for this PhD was gathered in Cambodia over a period of five months. The actual research methods were mainly interviews in a style akin to a Rapid Rural Appraisal. This generated a protocol for effective and efficient – but brief – rural studies into energy access. Consequently, the thesis' contribution is the appraisal tool and frameworks which support it.

To Pom, for all your wisdom
and to Bean, for all your love.

Acknowledgements

First thanks go to my academic supervisors, Steve Connelly and Alan Dunbar, for years of patient support and many hours' inspiring conversation; also, to my fellow PhD students and other friends around Sheffield for their equally enduring role in providing sustenance and camaraderie. Without you I'd have finished long ago. Further, I am grateful to the EPSRC, the University and especially to any academics or staff who had a hand in the E-Futures Doctoral Training Course; it has been a most interesting journey you've allowed me to take.

This project started with Practical Action and so to them I extend warmest regards for inspiration, for providing a wealth of knowledge and their continuing mission to make the world a better place. Moreover, my fieldwork would never have left Sheffield without the kind support of SNV and in particular Jason Steele, so thanks to them for the invitation to Cambodia and unerring support to make sure I was alive and could get to work; equally to NBP and MJP for agreeing to help a stranger in a strange land. I hope this research proves useful to you.

Foremost, I must extend great thanks to my Khmer translators: Pok Bunat, Sok Heyn, Moth Sopheap and Kim Priseth. You were my closest friends in Cambodia and I'm not sure you realise how much help it was to have that amiable guidance along the way.

Of course, to the kind people of Cambodia who took the time to participate in my research and allowed me to stay in their homes, to you I am indebted – I have been thinking of you for the past eighteen months, I won't forget your openness, honesty and good humour.

Finally, thanks to everyone I met along the way for their contribution, however small; to my friends and family, for that too big to measure; and lastly to the White Rabbit Guesthouse (street 294, Phnom Penh) for comfy beds, charming company and reasonably priced tea.

Post-viva addition: Thanks also to my examiners Michael Clifford and John Henneberry – it was a fantastic, exhausting, discussion.

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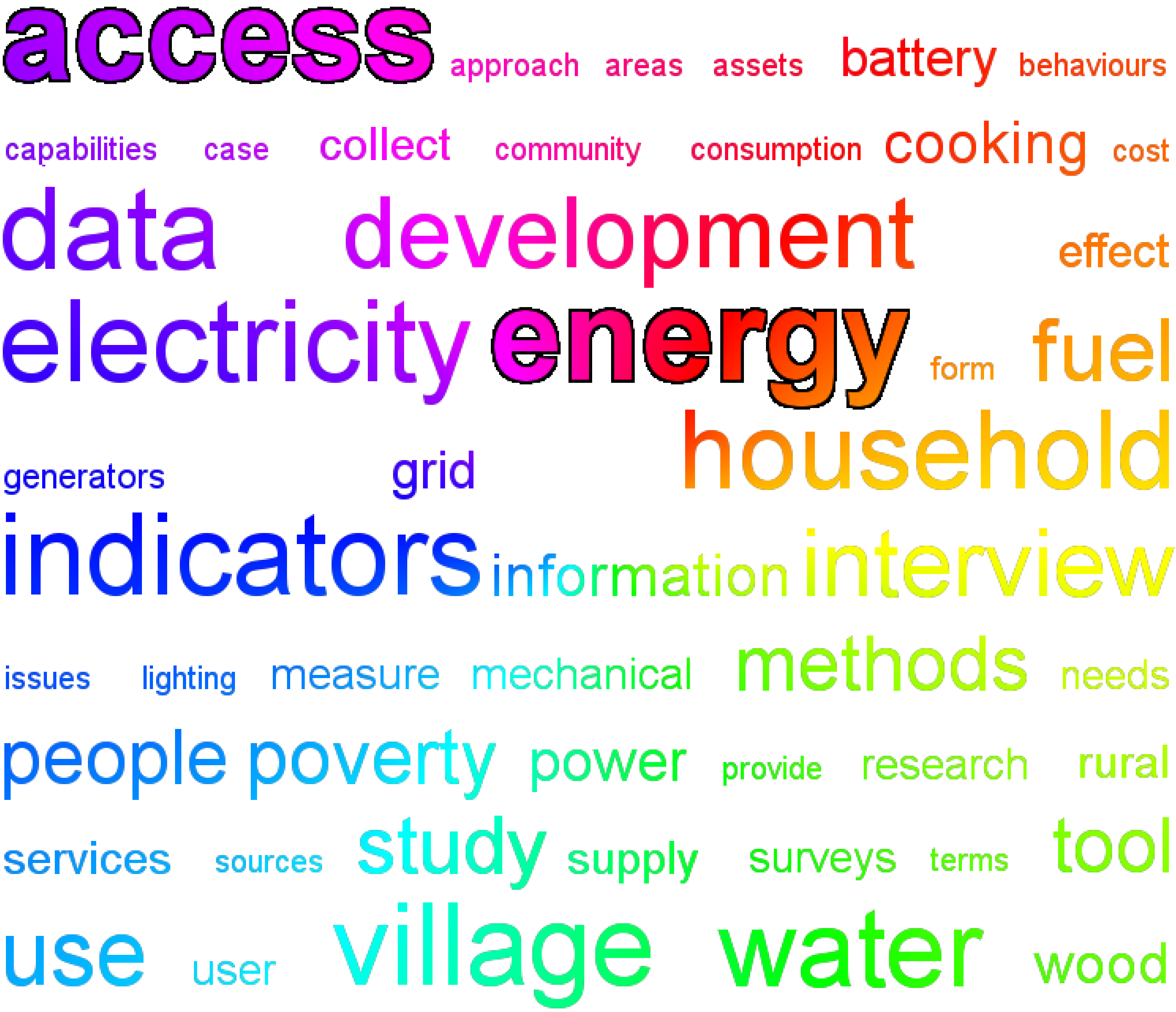
Glossary

API	Access Priority Index
BLEN	Biogas, Liquid petroleum gas, Electricity, Natural gas
CAGR	Compound Annual Growth Rate
CDP	Committee for Development Policy
CO2	Carbon dioxide
CPF	Community Protected Forest
DfID	Department for International Development (UK)
EAP	East Asia and Pacific
EDI	Energy Development Index
ESI	Energy Supply Index
GDP	Gross Domestic Product
GNI	Gross National Income
GTF	Global Tracking Framework
HDI	Human Development Index
ICT	Information and Communication Technologies
IEA	International Energy Agency
ILO	International Labour Organisation
IPCC	Inter-governmental Panel on Climate Change
kWh	kilowatt hour
LDC	Least Developed Country
MDG	Millennium Development Goal
MEPI	Multidimensional Energy Poverty Index
MJP	Maddox Jolie-Pitt foundation
MPI	Multidimensional Poverty Index
NBP	National Biogas Programme
NGO	Non-Government Organisation
NOAA	National Oceanic and Atmospheric Administration
PJ	Petajoule, 10^{15} joules
PPEO	Poor People’s Energy Outlook
PPP	Purchasing Power Parity
QAT	Qualitative Assessment Tool
RRA	Rapid Rural Appraisal
SDG	Sustainable Development Goals
SEA	South East Asia
SI	System of International units
SNV	Netherlands Development Organisation
SSA	Sub-Saharan Africa
TEA	Total Energy Access
TFEC	Total Final Energy Consumption
UDHR	Universal Declaration of Human Rights
UN	United Nations
WDI	World Development Indicators
WHO	World Health Organisation



1 Introduction

Poverty is a most serious problem for the world; it suppresses people and maligns progress. Finding ways to improve the alleviation of poverty is the underlying concern of this project. This is the development of a strategy, one built on the progression of historic responses from the global community: from colonialism, though neoliberalism to human rights and needs-based approaches. Recent strategy is underpinned by targets for combating the most severe and debilitating problems of poverty. The United Nation's Sustainable Development Goals have marked a shift in development thinking by including a multitude of vital issues, one of which, the focus of this project, is *energy access* (UN General Assembly 2015). Particularly, my purpose is to design a set of methods which can be used to appraise energy access.

Energy access is an increasingly popular concept, it builds on existing theories such as Amartya Sen's (1999) notion of development as freedom: our capabilities form the limitations of our choices in how to live the kind of life we want – these can be redefined in terms of the energy we access, as that is how we effect change in the world. The study of energy access is both about the energy itself as a resource to be used but also the user who would harness that energy, the effect they feel and the wider consequence. Notably, energy access is of contemporary significance because of its part in any debate on sustainable development to which it is intrinsically linked due to the tight relation of environmental issues to energy consumption. Thus energy, and access to it, makes a useful lens in planning, so the planner's perception of energy access is crucial to their decision making and the consequences of those decision – that is to say, poverty can better be tackled with an understanding of energy access. However, a person's energy access is not entirely simple; their behaviours, welfare and ecological footprint make it a complex phenomenon. Accordingly, studying ways to assess that energy access is the function of this PhD; the thesis argues the case for *including the qualitative approach in such assessments*.

The most commonly accepted convention for assessing energy access is to take the quantitative approach, measuring it in terms of the number of people with or without a modern supply of energy. This perspective is useful for outlining the extent of the problem, for instance 1.2 billion people live without an electrical connection to their homes and 2.7 billion rely on traditional biomass to cook their food (IEA 2015). The direness of the problem is that many of those people have little light at night and suffer from the smoke emitted by their stoves and fires. This lack of access to modern energies is both a cause and symptom of situations of poverty. However, though these oft-cited figures are illuminative, the lifestyles of those billions of people are an uncertainty. It is the need to add meaning to those figures which drives this project – doing so will hopefully facilitate efforts to mitigate poverty with energy access themed development initiatives. This aim is pioneered by Practical Action who have produced a series of publications, the Poor People's Energy Outlook; these study energy access from the perspective of the poor. Over the years, this series has raised awareness of issues relating to energy access and energy poverty; significantly, it has made the call for greater data availability on these matters so that the problems are more visible and the planning of their resolution is more tangible.

In line with this objective of aligning a progressive narrative to the perspectives of the poor is Robert Chambers' (1983) study of intervention in rural areas and the consequent movement of participatory development; his work is highly influential on this project's methodology. It is at the smaller scale, to do with village appraisals and not global tracking frameworks, that the contribution of this thesis is made – in finding what future development would be most appropriate or what past development was most valued, according to those rural people most affected. As such, this project studies the process of data gathering from rural environments – improving that process is this project's intended outcome.

The novelty in the proposed methods of appraising rural energy access can be expressed in relation to the literature. There is an abundance of documentation on the measurement of poverty and increasingly so on measuring energy access, though as mentioned, much of this is from a quantitative approach. These contemporary methods serve larger institutions, such as the World Bank and the UN, in identifying which countries are in the least favourable position to access modern energies and which countries have overcome the trappings of energy poverty; this is an important task when differentiating the many poorer countries of the world and appreciating the extent of their deprivations or the successes of their policies. Unfortunately, all large-scale tools for measuring energy access are, by necessity, simplifications of that access. Consequently, the concept of energy access can be misunderstood and oversimplified in the discourse because of the very basic indicators which are used to represent it and foster discussion. So, in undertaking research on data gathering, this project seeks to demonstrate that energy access is a complex concept and that in operations at the small scale, its study deserves congruently sophisticated tools of assessment. *The culmination of this thesis is the creation and demonstration of two tools for* *use in rural studies*. Separately, they embody the quantitative and qualitative approaches, and used in conjunction they synthesise the advantages of the opposing methods; that is, the versatility of indicators based on surveys and the in-depth understanding that comes from interpretative interviews.

1.1 Context

This project emerged from a smaller piece of research done in conjunction with Practical Action that evaluated their indicators of energy access. It is upon their work of measuring, appraising and representing poor people's energy perspectives that this PhD was founded and it is that field to which this research makes its knowledge contribution. This field covers the methods of communicating the state of energy access and the reality of life where that access is problematic. The point is to provide information so that the various actors involved in development can make more well-informed decisions. These actors range from regional civil authorities, to charitably NGOs, to international finance institutions. Though as stated, it is the smaller scale which is the focus of this project so the most relevant bodies are the local arms of those actors.

Motivation for the research is not just that the problems of poverty are dire, but that attempts to resolve them are difficult to undertake and often fail. The best strategy for effective and successful aid is contested (Sachs 2005), though what is clear is the need for information in decision making, and indicators are the key to this as their function is to give the users awareness of conditions and their change (Heink & Kowarik 2010). It is gaining information from indicators which this project seeks to facilitate.

This project draws upon the literature of aid, development and indicators that is produced by high level institutions like the United Nations and their affiliates such as their Development Program (UNDP) and the World Bank; also, from intergovernmental or international non-government organisations, for example, the International Energy Agency and the Netherlands Development Organisation (SNV). They are actively involved in tackling poverty and it is for them that these tools of communication are constructed. Equally, there is much academic interest in the fields of energy access and sustainability. Part of the novelty of this project is the extent to which it combines the various topics relating to energy access: from its indicators (Nussbaumer et al. 2013), to its anthropologies (Winther 2008) and critical reviews of policy in the past (Bhattacharyya 2012) – thus shaping an inter-disciplinary study.

The empirical evidence gathered for this project is from case studies. These are of village communities in Cambodia. As such, the substantive findings on energy access from this project are most relevant in that country and by association, to its peers that are also of low income per capita or have high reliance on crude forms of energy. Notwithstanding this, the primary contribution of the project is in terms of developing methods of assessing energy access, including the design of tools that is based on fieldwork experience. The findings relate to theoretical approaches to study in the field and so are generalisable to other areas throughout the Global South. The location of the case studies was chosen because Cambodia is perceived to have high levels of energy poverty (by current indicators); and SNV's generous invitation and support in carrying out research there. The main beneficiaries of this project are those actors such as SNV who are interested in methods of collecting data from rural environments in a cheap, succinct and yet informative program.

1.2 Research in brief

Overall, this project is a piece of research on the process of data gathering; the output is two tools that are made for assessing energy access in rural locations. Design and trial of these tools took place in Cambodia. Six regions were selected for case study. This selection was intended to cover a variety of conditions such that a wide range of energy behaviours could be observed. This was to increase the robustness and generalisability of the tools constructed.

Fieldwork was divided into two phases, scoping and appraisal. The first phase was to trial various methods of data gathering, to identify the most efficient and effective techniques, then to apply the best of these in the second phase of fieldwork, finally honing them into two tools, one quantitative and the other qualitative.

The methods employed were predominantly interviews and surveys. Other techniques of observation and participation were also used to optimise the data gathering, in that they had an influence on the interview structure.

Study of interviews led to iterative recreation of analytical frameworks, these identifying the subjects to focus upon in assessments of rural energy access. These frameworks were then used to inform the design of the assessment tools, which were then demonstrated in the final case study, Samlout.

1.3 Thesis structure

The three chapters that follow this introduction review the literature and explain why tools for communicating the state of energy access should be researched. The first (Chapter 2) is on the wider problem at hand: poverty, development and aid strategy. Chapter 3 focuses on the concept of energy access, exploring what it means, how it is fundamental to the satisfaction of basic needs and sustainable growth. Then, Chapter 4 looks at indicators and the contemporary ways in which energy access is measured; ultimately concluding that the literature is saturated with quantitative methods and there is little appreciation of the social side of energy access in these assessments.

At the end of the literature review an initial map of the energy landscape is provided. This is the basis for the data gathering process and is continually refined throughout the thesis.

Chapter 5 describes the research methodology. It covers the aims and procedure of the research, and presents the research questions. A full account is given of my philosophical perspective as a researcher, the design of the methods and the strategy behind their evolution.

After a study of methods, Chapters 6 and 7 respectively express the findings from fieldwork when applying the quantitative and qualitative approaches. These chapters explore ways in which to evaluate and represent that data. Ostensibly, they describe energy access in Cambodia, though the ulterior function is to set up discussion in the next chapter. With reference to that prior discussion, Chapter 8 covers the design of the two tools, the first is the Access Priority Index and the second is the Qualitative Assessment Tool. Their mechanisms are described in detail, then the tools are demonstrated fully in Chapter 9, which also includes suitable recommendations in response to the message the tools convey.

Finally, Chapter 10 concludes the research and discusses its limitations and implications.

1.4 Applications

The relevance of this thesis is that other research agents or development actors can mimic the strategies which are argued to be effective. In particular, these strategies relate to methods for assessing rural energy access – in general, they mix quantitative and qualitative methods in a rapid data gathering project. Findings are applicable both in a methodological sense but also more substantively: in terms of what energy access means for capabilities and poverty. Recommendations are to use mixed methods research both to mitigate time or resource constraints and also for the mutual support of those diverse methods.

Findings of the project constitute a critique of existing methods of indicating energy access; in doing so, they open new lines of enquiry as to how this process of data gathering should be handled. However, whilst a detailed but narrow study allows a fairly high degree of understanding to be obtained about a few cases, this understanding cannot simply be transferred to other people and communities. Indeed, one finding of the project is the significance of context and its pivotal role in interpreting data – consequently, taking my other findings about energy access out of context is to be avoided. Quite simply, the energy access behaviours I observed may be unique to Cambodia so the methods designed to assess that access may not be directly applicable elsewhere. However, the tactics adopted in the construction of those tools are more universal as they relate to the data and its meaning, which is not exclusive to Cambodia.

The tools, and the way of constructing them, that are proposed in this research are customised for rural Cambodia. However, throughout the thesis the concept of energy access is discussed thoroughly, so in addition to the basic knowledge on how rural people access energy, and what tools can be used in gathering/representing data on that, there is a final layer of knowledge that relates to the meaning of energy access itself. Like poverty, it has been defined in many ways to match various perspectives or ideologies. The initial definition of energy access in this project is given in the literature review based on notable sources in the discourse; throughout this document, that initial definition is elaborated and more complexity is worked into the concept. Energy access is more than a helpful way to look at capabilities and poverty; it is a way to interpret people's behaviours in relation to their environment. 'Energy' gives it a physical basis and 'access' frames it in a social reality. Thus, the more sophisticated appreciation of energy access that emerges from this thesis can be taken to entirely new domains: urban areas, developed countries, office spaces, even individual people or assets.

Finally, this project has implications for other studies in that it relates to the qualitative and quantitative divide in data. In particular, this project argues that the divide is more entrenched than it need be. Certainly, the qualitative and quantitative approaches give rise to very different methods and the data that emerges from these is crucially different, yet, as will be shown, those forms of data are not fundamentally incompatible – with solid groundwork they can be made to work for one another.

2 Poverty and Development

> From a social researcher's point of view, poverty is a complex phenomenon influenced by a large number of factors and which can be studied from many different perspectives. The study and interpretation of poverty isn't a simple task, as there are as many ways of measuring poverty as there are ways of defining it – (Instituto Nacional de Estadistica 2009)

2.0 Introduction

The purpose of this chapter is to introduce the concepts of poverty and development. These are the overall motivating forces behind the research, study of them sets out the policy environment into which this project fits. The thrust of the argument in this chapter is that there are many ways of interpreting poverty and these different conceptions have a consequent effect on strategy employed to alleviate that poverty. In the next chapter, the concept of energy access will be used as a lens on poverty, though first, the foundations will be laid for an exploration into issues of poverty and an account of society's response to it.

To begin, this chapter explores what it means to be in poverty, starting with a stance that poverty is an objectively measureable condition, then shifting to consider it as a multi-dimensional and unquantifiable problem. Related and significant issues are introduced: basic needs and the trapping nature of deprivation. It will be shown that there is complexity in poverty, that the tools used to assess it give attention to different aspects and so serve different purposes. In effect, these purposes are to communicate, either in a straightforward or more comprehensive manner – a trade-off which reverberates through the research.

Discussion then turns to development. Partly, this is to lay out the terminology used throughout the thesis: theories of development, styles of intervention and the actors involved. A historical narrative of development is given; from this account, the particular approaches that were embodied in the fieldwork of this project are studied in more depth. This sets up the remainder of the literature review with ideas of sustainable development and indicators of it, but also the methodology, which draws heavily on the participatory approach to rural development studies.

2.1 Poverty

2.1.1 Definitions and theories

Three different perspectives on poverty will be introduced as a basis for this study. The first is based upon income: a commonly accepted definition and de facto measure (for example in the Sustainable Development Goals, see 2.2.3). The second is a theory of poverty that switches focus from income to capital, explaining how there are various forms of capital and being poor in these can amount to and perpetuate poverty. The final perspective is one that unites the understanding of poverty and the means to alleviate it into the single concept of expanding freedoms – though the former two are important, they merely lay out groundwork, it is the 'capabilities' perspective which is key to the thesis.

The income poverty threshold: this definition is based upon income, although that can be substituted for consumption or the benefit/gain of consumption, that is, utility. The underlying idea is that an expenditure function – based upon commodity prices, a household's characteristics and consumption preferences – can be evaluated at the point where utility is great enough to escape a predetermined threshold of poverty (Ravallion 1998).

For example, a household with a per capita income of a dollar per day could be said to be in poverty, but if a non-earner from this household gets a job or leaves the household then the per capita daily income of the household might rise above a dollar – there would be more money to go around and they could then be said to be out of poverty.

The threshold-method can be used as a definition for who is or is not in a state of poverty, but the threshold itself must be drawn according to a pre-determined set of basic needs – the 'dollar a day' is based upon the $370 per year threshold that was a common national poverty line in the '80s (World Bank 1990). Lately, this figure has been inflated to $1.90 per day to reflect modern prices and the recent weakening of the dollar (Ferreira et al. 2015). Some analyses use many figures simultaneously, drawing several lines can give the distribution of the poor and very poor (Chen & Ravallion 2010).

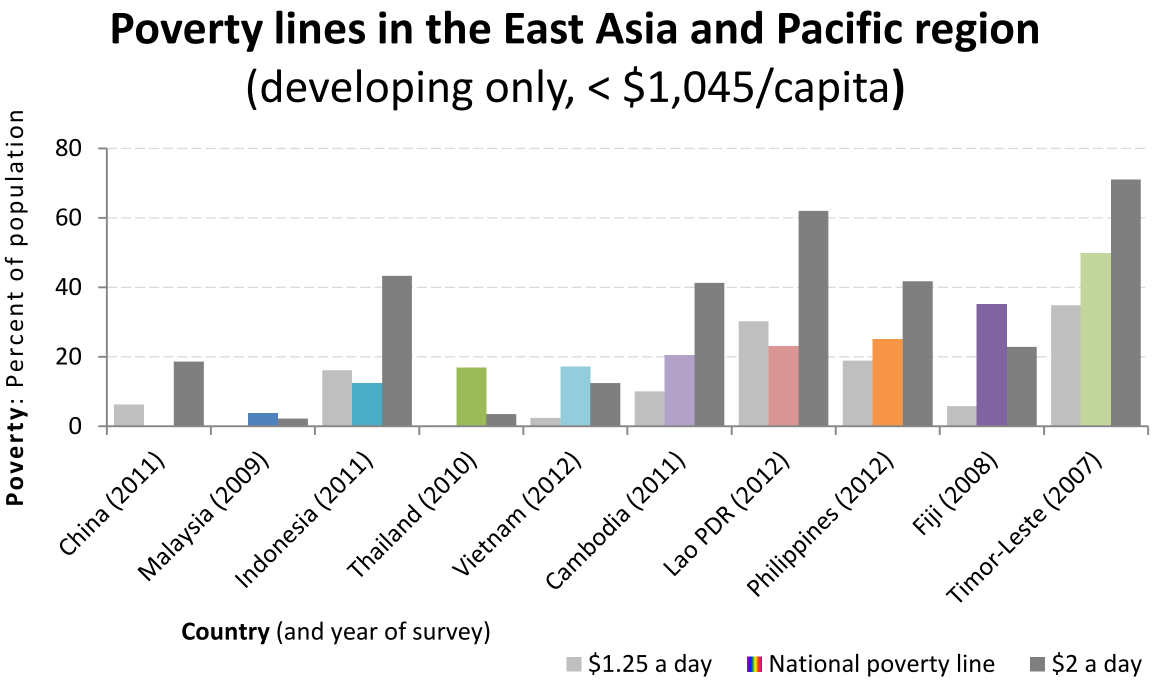


Figure 2.1: Poverty lines in the East Asia and Pacific region.

Subject to data availability, poverty lines are drawn for developing countries in the East Asia and Pacific region. They are ordered by the percent of population under the national poverty line, set by each country individually; note that China does not provide this data. It can be seen that the different thresholds relate to a different distribution of poverty and that national poverty lines may be above or below the international lines of $1.25 and $2 per day.

Note: these countries in the East Asia and Pacific (EAP) region are used throughout this chapter to analyse various methods of measuring poverty; this is also done to reference Cambodia which is the location of this thesis' fieldwork. There are 14 other countries in the EAP region which are left out of the analysis due to data unavailability – this in itself signifies how data affects the visibility of problems. Unless otherwise stated, data comes from the World Bank's World Development Indicators (WDI).

Viewing poverty through these lines has a benefit, in the sense that money is almost a universal medium through which one can obtain food, housing and all the essentials of survival. This universality allows the threshold-understanding of poverty to be used as an instrument to design economic policy and compare heterogeneous family compositions (Ravallion 1998). This is an easily quantifiable way to look at poverty, but it does have drawbacks in that it is blind to non-financial aspects which characterise much of society, especially areas of informality (Williams et al. 2009).

Whilst this definition is making assumptions about utility maximisation (that $1.90 is enough to buy a basket of goods that would constitute non-poverty), the following stance tries to identify the other, less quantifiable, factors that determine a person's well-being.

Six forms of capital: Jeffrey Sachs (2005) considers poverty as being multidimensional, he writes that those who are extremely poor lack six forms of capital, as listed in Table 2.1. According to Sachs, the six forms should be tackled simultaneously and this is why much aid intervention fails. For instance, a project teaching farmers how to increase their cash-crop yields will not help if there are no roads to the market or if they become bedridden with malaria. These famers need more than just one of their problems solving.

Capital	Main components
Human	Health and nutrition
Business	Machinery and facilities
Infrastructure	Transport, utilities and telecoms
Natural	Healthy soil and biodiversity
Public Institutional	Commercial law, judicial systems and policing
Knowledge	Technological know-how

Table 2.1: Six forms of capital and their main components (Sachs 2005, p.244-245)

This table shows the multidimensionality of poverty – few of these varied capitals can be denoted in dollar terms. It is an advance upon the income threshold given above which is (intentionally) a narrow perspective. With this it can be seen that being poor in money is not the only concern as there are other issues which can compensate or exacerbate monetary poverty. Returning to the example above, even if the farmers had a lot of income from their agriculture, their poor health and weak transport infrastructure could make their lives very difficult – conversely, their business may be poor but their lifestyle good otherwise.

It is more difficult to assess this type of poverty; none of these six forms is measurable as easily as income-poverty. The benefit is that one considers a person not as a separate, isolated entity but as part of a system with at least these six interrelating factors that determine their welfare. Through this perspective, poverty is not just a lack of consumption but a combination of many issues. Here, a step is taken in understanding why poverty is there and what makes it so complex.

Sachs also mentions that the six forms are not a comprehensive list; poverty is too convoluted to be described exhaustively, especially as there is such disconnection between those *in* poverty and those *studying* poverty. So whilst Sachs' perspective of poverty has the advantage in that it recognises its multifaceted nature, it has the disadvantage that it cannot measure poverty in any complete sense – there is no limit to the number of facets of poverty even if forms of capital can be found to represent them.

Though this perspective is broader than the one before and appreciates its multidimensional nature, it is not yet a sufficient basis for the main argument of this literature review. The following 'capabilities' approach serves better.

Capabilities and freedoms: The third definition of poverty given here is by Amartya Sen in Development as Freedom (1999). Instead of understanding poverty through the finances or capitals that one lacks, Sen views it in terms of the deprivation of capabilities, for example: not lack of food, rather, being incapable of attaining nourishment. Since the needs of a person are satisfied through their capabilities, this theory says that if they lack these capabilities then they are in poverty.

Through Sen's theory, finances are still integral to welfare but only as a *means* to acquiring something else. He reasons that focusing only on the means of development doesn't account for variations in what the individual actually needs, this being a function of their identity, environment and social system. Instead of focusing on *means*, thinking about the *ends* for which development aims makes for a better strategy. The ends being "*substantive freedoms he or she enjoys to lead the kind of life he or she has reason to value*" (Sen 1999, p.87); so, the very basic freedom to live without hunger is a developmental end. The elegance in Sen's argument is that to expand these freedoms is not just the aim but also the most apt method of development – by enabling people's capabilities to feed themselves.

From this theory of poverty as capabilities-deprivation, Sen (1999) makes the corollary that freedoms include financial transactions and employment, that these are basic liberties. So, some of the strength of the poverty headcount can work for the capabilities-definition, namely, the ubiquity and significance of money. To enter the market is a freedom and to trade labour for income and then income for food are capabilities – if a person is without these capabilities then they could be considered to be in poverty. Moreover, it can be argued that Sachs' perspective is also compatible, as the restriction of a freedom can be traced back to a lack of some form of capital. Quite quickly it can be seen that this approach can begin to encompass the complexity of poverty.

Here, the focus is not upon a measureable value (such as income) but shifted towards people, what they can do and how they feel:

> The success of a society is to be evaluated, in this view, primarily by the substantive freedoms that the members of that society enjoy – (Sen 1999, p.18)

Poverty is seen in relation to the person themselves as the subject of interest; crucially, this elevates the significance of their subjective opinion on what kind of freedoms they should have. This is a much more 'personal poverty' than the conceptions covered above.

The capabilities approach does not simplify the measurement of poverty but rather interprets it as something which should be 'evaluated'. As opposed to the threshold-definition which gives a figure to represent a population, capabilities allow understanding of a person's poverty and the solution to it. Essentially, the theory says that people are in the best position to understand their own needs and as these are idiosyncratic, any approach to assess poverty must account for their perspective.

It is this theory of poverty that I subscribe to in this thesis, though others are referred to throughout. Later, I argue that because it is so tightly linked to capabilities, the concept of energy access is useful in trying to understand poverty and also in planning development initiatives which would alleviate that poverty. Though first, discussion is given to the basic needs that are addressed through essential capabilities so that the argument for energy access can be grounded more firmly.

2.1.2 Basic needs

In a formal sense, the basic needs of people can be seen through our given rights. The Universal Declaration of Human Rights (UDHR) came about after the Second World War; the foremost message is that we are entitled to these rights equally and without exception. Several key concepts emerge which serve in discussing basic needs. These come from articles 21 to 27 of the UDHR: democracy, 'free development of personality', employment, leisure, 'food, clothing, housing and medical care', education, and 'share in scientific advancement' (UN General Assembly 1948). Immediately, it can be seen that these rights extend beyond mere survivability; they state that everyone should be given the chance to do more than just exist, that they should be able to interact, gainfully, with culture and society.

The UDHR makes a starting point for the narrative of development in section 2.2.2. Though these rights are useful in understanding needs, they relate to a consensus of what society should provide rather than the most essential basics that a person needs. However, such fundamentals are hard to assign objectively. Consider Maslow's hierarchy which seeks to classify and order needs into groups: he argued that foremost come the physiological needs, then the social, with the final level of self-actualisation only possible after the others are achieved (Maslow 1943). A critique is that needs are not necessarily sequential and that this ordering is based on a bias from an individualistic society (Hofstede 1984) as collectivist cultures would not place self-actualising atop the hierarchy (Cianci & Gambrel 2003). Ethnocentric biases can lead to false assumptions about needs and how a person should satisfy them; for example, religious practises and diet vary greatly between cultures. To resolve this bias, Max-Neef (2007) writes that the fundamental human needs are the same in all cultures but that the variation is in the particular ways in which these needs are met (fitting in with Sen). This implies that there can be a normative element to defining what basic needs are, but not to describing how these needs should be satisfied, that is, the associated capabilities.

Drawing from the above authors and a classification adapted from Tay & Diener's (2011) study of universal needs, the set below is this thesis's definition of basic needs. Where they may not be not intrinsic to survival they are part of subjective well-being and mental health:

- Physical – nutrition, warmth, water, sanitation, shelter, security, clean air, health and safety
- Social – interaction, respect, love
- Progressive – education, self-direction, work

Not being able to satisfy these needs is indicative of poverty. These needs will be referred to throughout the thesis. The chapter on energy access in particular argues that, though behaviours to satisfy needs differ, they can be unified by their relation to energy. This transcends cultures so it makes an effective lens through which to perceive capabilities and poverty.

The following moves on from what defines poverty, to issues that create hardship within it, and difficulty escaping it. In part, this frames the role of aid or development intervention.

2.1.3 The trapping nature of poverty and deprivation

The poor can be characterised by their tendency to remain poor. By Sachs and Sen's theory it is a stable condition – within poverty it is difficult to acquire the assets or enable the capabilities that would allow one to escape from poverty. Robert Chambers (1983) goes into more detail about what prevents this acquisition or enablement. He writes about a set of five 'clusters of disadvantage' that beset people in poverty, which all interact to trap unfortunate people in *deprivation*. Some of these disadvantages are quite obvious for example physical weakness (health), but the subtler ones that Chambers writes about are 'isolation' and 'powerlessness' – being far from centres of economic or social activity and losing in negotiations or competition against those who are dominant or in control. Each cluster causes difficulty but it is their interaction that makes them more oppressive.

> Isolation is linked with powerlessness through the inability of those who are powerless to attract government aid, schools, good staff, or other resources – (Chambers 1983, p.113)

These forces combine to form a *poverty trap* as one deprivation cannot be overcome due to the others. A consequence of this argument is that the poverty trap can only be escaped through outside influence.

Banerjee & Duflo (2011) outline two theoretical perspectives on whether or not poverty traps exist. In the stance that they do not, the individual can achieve economic growth by their own means, given time; external influence is unnecessary and can lead to dependency on aid funding by distorting the wider economy in which the recipient exists. In the other case, they argue, aid is necessary for people who are very poor because without it, they cannot achieve growth over time and their state of poverty will steadily exacerbate. It is not just that the people are poor but that their situation will not allow for them to accrue greater income or otherwise develop. Thus, the outside influence is necessary to help people past insurmountable barriers until they are in a state where they can grow on their own.

Banerjee & Dufflo's contention is that there exists a tipping point below which people are simply too poor to grow. At this point there is *subsistence*: on average earning just enough in one day to provide for that day. Through the lens of energy this is: an equilibrium state in which an individual has little and few resources other than their own time and energy, and they expend the full extent of these on survival "*with no prospect of human development*" (UNDP 2005b, p.3). So, no form of capital can be accrued and no new capabilities can be gained. With no surplus capital (or savings) poor people are vulnerable to shocks such as a price increase or temporary loss of income. This makes them adverse to risk, again, reducing their opportunity for growth and development (Chambers 1983).

The implication here is that poverty is not just a hardship to endure but a kind of fatigue which will not simply fade with time. This is discussed further in section 2.2. Next, attention is given to measures of poverty – these are vital. Without a measure of poverty it is difficult to identify problem areas, monitor them or evaluate the effects of aid intervention. Measures are crucial in understanding the nature of the problem and planning around it.

2.1.4 Methods of measuring poverty

This subsection deals with the issue of measuring poverty and is concerned with methods. It begins with the familiar income-threshold and then builds on that with other methods that use wealth in their analysis. These demonstrate different aspects of poverty and also different techniques in measurement. The final methods considered drop the purely monetary focus and instead look to other measureable quantities related to poverty; these stem from different conceptions of development as outlined in the next section.

Recall the threshold-definition given at the beginning of the chapter; counting on either side of a particular income line yields a ‘poverty headcount’. Until recently the $1.25 per day line was used to define people as in poverty – taking their ratio to the total population gives a straightforward indication of the poverty in the respective group. This method has been developed into the ‘poverty gap index’, looking at how far each member of the population is from that poverty threshold, and taking the average (mean) of these distances. These simple measures have been used in high levels of policy such as target 1.A of the Millennium Development Goals (MDG wiki 2012), more on these goals is given later.

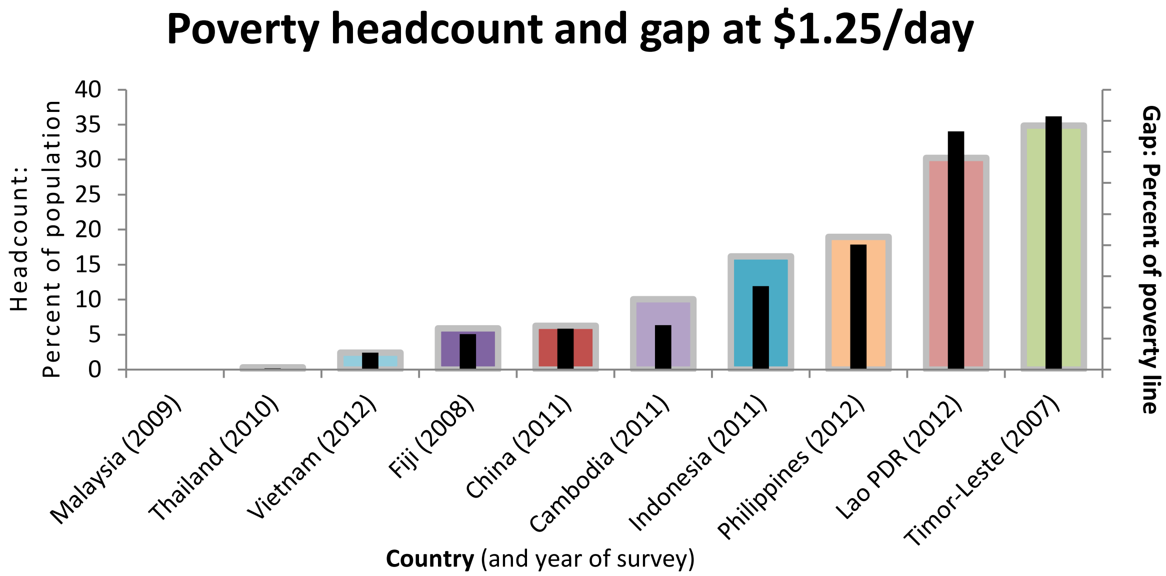


Figure 2.2: Poverty headcount and gap at $1.25/day

Using the poverty line of $1.25 per day, the headcount (coloured) and gap (black) measures are taken; note that the gap is taken as a percentage of the headcount, showing that of those poor people, how acute their poverty is. The distribution is similar, but is in some ways more representative of the poverty in each country. With a headcount of 10.5%, Cambodia is in the middle of the group, although its relatively lower poverty gap implies that many are not too far from the threshold.

To develop the methods above even further, the 'poverty severity index' adds greater weight in the calculation to those who are poorer. For every person in the population their distance from the poverty threshold is squared before it is averaged. Thus, the index is more sensitive to unequal distributions of wealth (Haughton & Khandker 2009). The severity index is better at capturing more aspects of poverty in its calculation than the headcount, but in doing so it is harder to explain and use in publications. In dissemination to non-experts, the poverty headcount is more useful because it is *easier to understand*.

Another method that is relatively simple to understand is to look at figures such as GDP per capita – essentially this is the economic output of a country divided by its population. With this, the average standard of living can be estimated for that nation, at least in comparison to other nations. GDP is quite common to see but there are more accurate measures of a population's total economic activity such as Gross National Income (GNI), which includes the balance of foreign and non-national workers (Todaro & Smith 2011). The point of these measures is not to be sensitive to inequalities within a single country but to represent the differences between many countries or the change in at least one country over time.

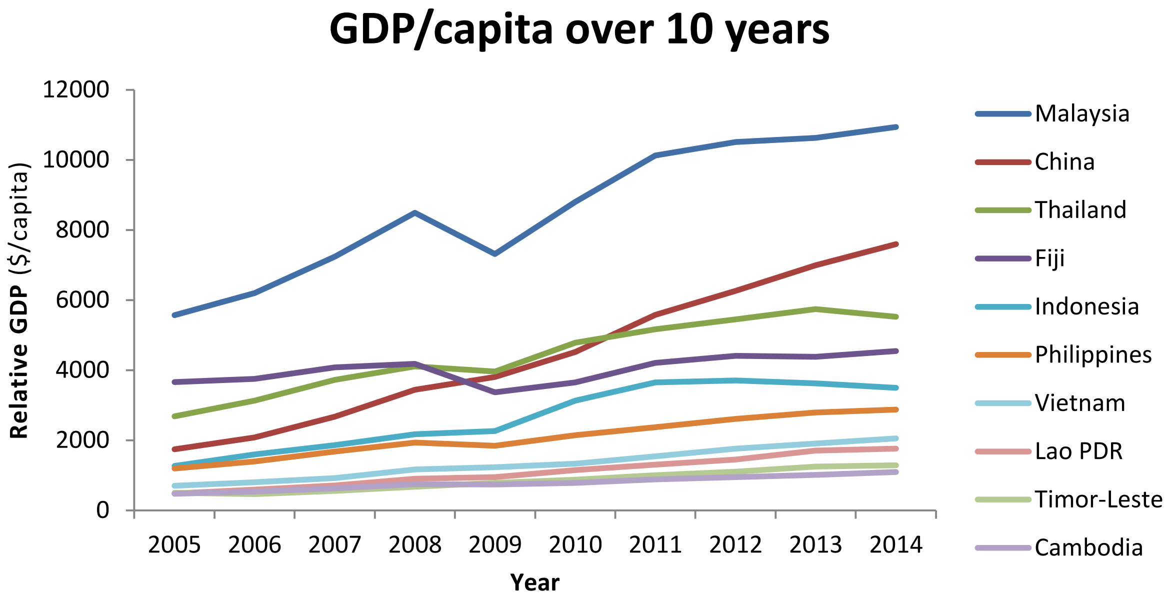


Figure 2.3: GDP/capita over 10 years

This measure does not explicitly show poverty, but it does give an indication of wealth. It can be seen that Cambodia and China which were in the mid-range of the previous graph are now more at the extreme ends. Notably, this data is far more complete, there is information available year-on-year which was not the case for the poverty lines. With such quantity of data, longitudinal study can be made. Observe the growth dip due to the 2008 global financial crisis – this shrank the wealthier economies more than the poorer ones.

The graph above tracks economic output which can be used to estimate a standard of living. This operates at a national scale, so gives an indirect indication of poverty for each individual citizen of those countries. Thus, GDP refocuses poverty to the nation’s economy rather than its people. For example, China’s GDP/capita nearly quadrupled in that decade, a reasonable expectation is that more products and services are available on the market – but this does not imply fewer people are in poverty or that for them poverty has become any less difficult.

Different measures are not better or worse, rather, *they have different purposes.* It could be argued that some are better at achieving the same purpose than others (like GNI versus GDP) or that an indicator with a different purpose should be used to achieve the same aim. For instance in recommending policy one might wish to assess *relative* poverty rather than *absolute* poverty, as income inequality has a detrimental effect on stability and the instruments of government (Soubbotina & Sheram 2000). If so, a method such as the Gini index would be more appropriate than GDP per capita. As a measure of inequality, the Gini index is constructed akin to the poverty gap: the function of cumulative incomes of a group is considered for its shortfall, in this case, versus the fairest distribution (Gini 1912).

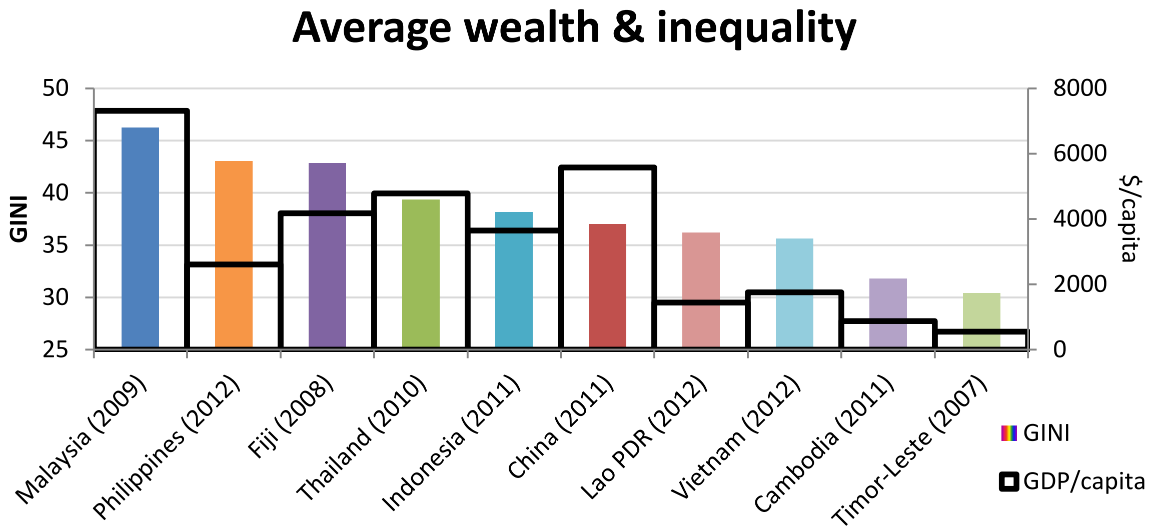


Figure 2.4: Average wealth and inequality

Here the previous data for GDP/capita (black) is superimposed over the Gini index of inequality (coloured) for the years indicated. Again, the Gini index uses a data source that is less available than GDP. A higher Gini index refers to greater inequality; whilst Malaysia may be wealthier, it is also less equitable in terms of the distribution of that wealth, the converse is true for the least wealthy countries – Cambodia has greater equality but a smaller economy – the correlation is fairly strong (0.77), calculation in appendix. Despite the inequality, the proportion of poor people in Malaysia has been shown to be slighter.

All the above measures fit into the perspective of poverty that sees it as a monetary issue. They give various indications: the proportion of people in poverty, standards of living as they have changed over time and national income-inequality. However, as they are monetarily based, these only relate indirectly to the social aspects of poverty.

The Human Development Index (HDI) is more direct; it comprises three elements in different dimensions: health and education as well as wealth (UNDP 2010). Wealth is indicated with GNI/capita, whereas the other dimensions are based on 'life expectancy' and 'expected and mean years in school'. The three dimensions are normalised: a calculation which rescales them to a common range, [0, 1]. This makes three separate indicators, though they are usually combined with a geometric average and this then forms an index (UNDP 2014). Via this method, a single value (which can thus be ranked against others) encompasses aspects of welfare beyond monetary-estimates of the standard of living:

> Rather than concentrating on only a few traditional indicators of economic progress (such as gross national product per capita), "human development" accounting proposed a systematic examination of a wealth of information about how human beings in each society live and what substantive freedoms they enjoy – Amartya Sen (UNDP 2010, p.vi)

The HDI is more closely aligned to capabilities-poverty. In data for this more 'human accounting' there is a plethora of choice, reflecting both the relation which that data has to poverty (GDP/capita only being an estimate of the average standard of living) but also to the size and scale of the study. As a positive, the HDI uses very few components to indicate its three dimensions so it is available for nearly every country. However, it is based upon averages for a population. Akin to GDP/capita, what it speaks about is a general standard throughout the country – more related to government policy than poverty for the individual.

An alternative is the Multidimensional Poverty Index (MPI). It is less widely available as it has many components, yet these are directly related to individual households. The MPI would be even more extensive and relate to a greater breadth of poverty were it not for the 'binding constraint' of data availability (Alkire & Santos 2010, p.9). This constraint is part of a trade-off in measurements and indicators regarding how easy they are to compile and understand, versus how much important information they contain. Again, the issue of scale is vital, the HDI draws from databases which are updated annually and nearly every year a new report is available. Conversely, the MPI is based on less frequently taken household surveys but it can be disaggregated in to regions within countries, finding overlapping deprivations, so it effectively locates the most problematic areas (Alkire et al. 2015). These tools are meant to be used in different ways but they have similar aims and are comparable.

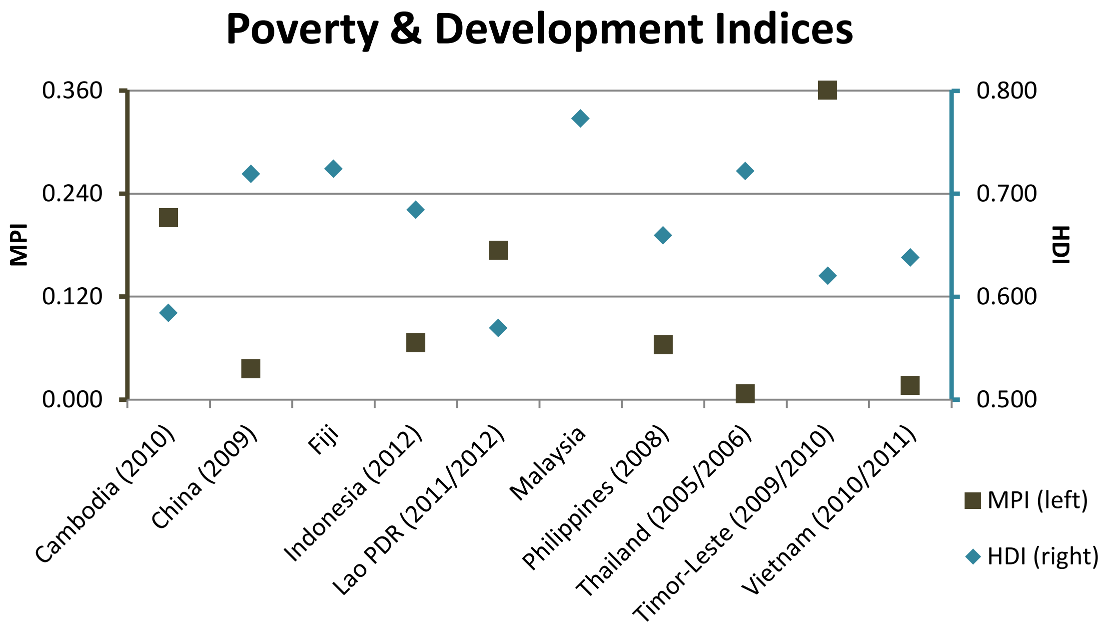


Figure 2.5: Poverty and Development Indices

High HDIs relate to better development and high MPIs to greater poverty. Accordingly, the HDI and MPI have an inverse relationship, Cambodia scores very poorly on both accounts but Lao has the lowest HDI and a midrange MPI, reducing the correlation to below that in the previous graph (-0.66). Dates are given for the year of household survey, relating to the MPI. Note that the HDI data is taken from 2013 datasets but the MPI comes from three different survey programmes that took place over many years – it is not even available for some countries, this emphasises the trade-off mentioned above. The data all comes from the UN's Human Development Report 2014.

Unsurprisingly, the measure of development is high where the measure of poverty is low, this correlation is fairly strong (-0.66). So, despite the fact that the methods are dissimilar, it highlights a link between the components of the HDI and MPI. This gives credence to the coherence of these indicator tools but also demonstrates that there are multiple ways of assessing poverty.

The range of methods is extensive: there are indicator tools which consider aspects such as hunger and malnutrition (for an overview, see (Masset 2011)); some interpret how progressive a country is, for example the Gender Inequality Index which looks at female reproductive health, empowerment and activity in the workforce (Turley et al. 2013); and other tools model the dynamics of the poor, such as the 'Time Taken to Exit' which estimates how long it takes for a person to escape poverty (Haughton & Khandker 2009). The diversity of methods is more evidence that poverty is complex, and whilst there are applications for each measure, these are only parts of a greater endeavour of assessing and tackling poverty through development.

2.1.5 Link to energy

The methods above serve as an introduction – the subject of indicator tools is revisited at length in chapter 4. Most of the methods here are not entirely aligned with the capabilities definition of poverty used in this thesis, even the HDI is removed from many of the basic needs discussed earlier. Nevertheless, these tools are still useful; they have a base purpose in indicating the situation of those countries, but also they can be used in analysis of other metrics, for instance, on energy. Figure 2.6 correlates GDP/capita and HDI, against measures of energy consumption. These correlations provide a link between the different metrics – the implication is that further study into measures of energy could produce a tool to indicate poverty. As will be argued, this is more closely aligned with capabilities-poverty.

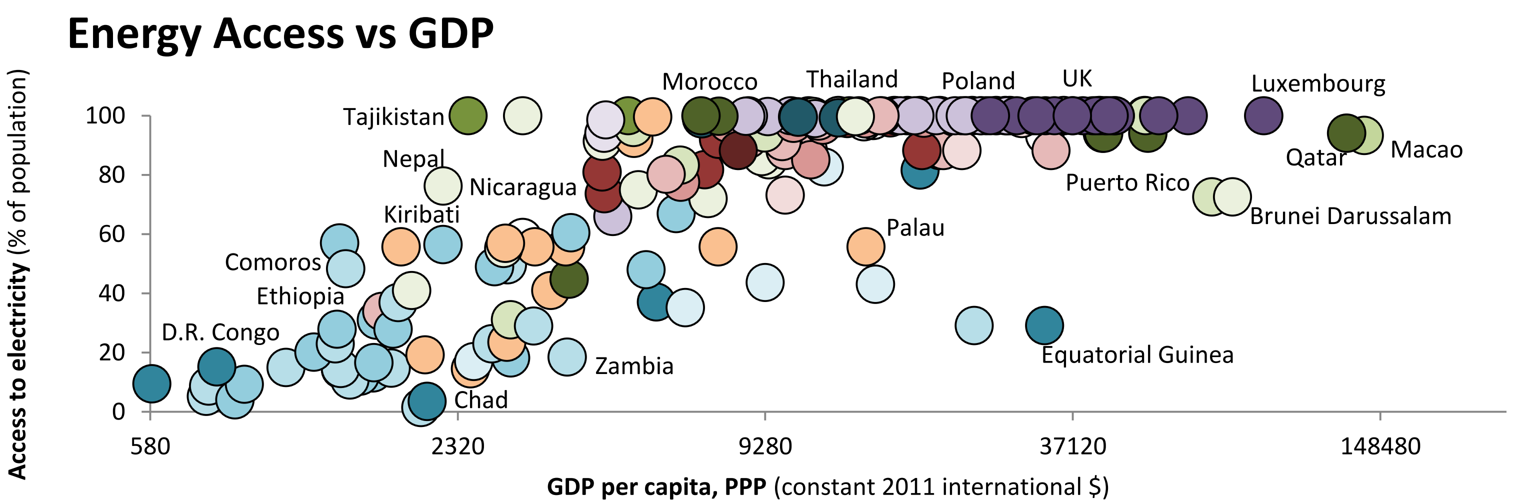


Figure 2.6: Energy Access versus GDP

Greater economic activity per person can be associated with increasing household connections to the electricity network. Note the horizontal axis is logarithmic for better visibility of the data; effectively, the relationship is more sensitive at the lower end of the graph. Also, African countries populate the bottom of the trend, followed by those in Oceania, then the less developed areas of the Americas. Asia and Europe have top rates of electrical access.

Legend for graph above			
Southern Africa	Southern Asia	Caribbean	Eastern Europe
Eastern Africa	South-Eastern Asia	South America	Western Europe
Western Africa	Eastern Asia	Central America	North America
Middle Africa	Central Asia		
Northern Africa	Western Asia		Oceania

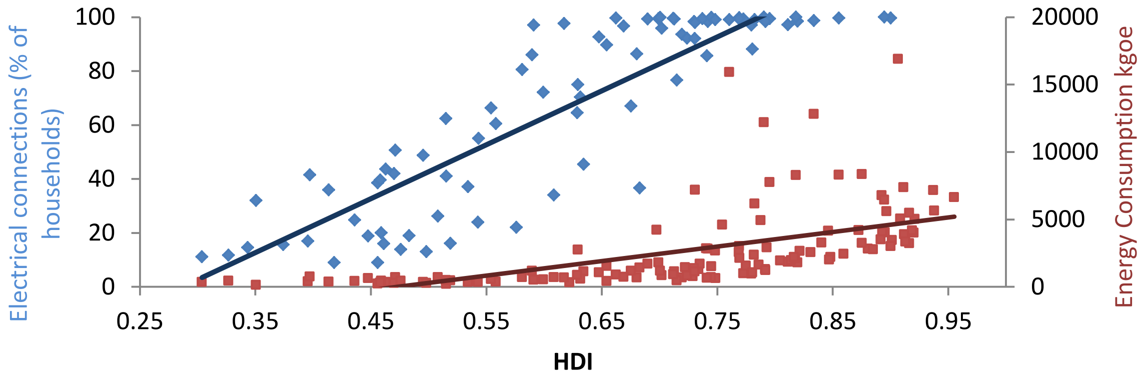


Figure 2.7: HDI versus Electrical Connections and Energy Consumption

The HDI composes measures of health, education and wealth. Each of these components benefits through the use of energy, not just wealth (GDP).

Regression analysis takes these correlations further, providing evidence that energy consumption can lead to economic growth (Lee 2005) and allowing the assertion that, at least in the long term, limited access to energy can hamper economic growth and development (Ouedraogo 2013). Of course, this relates back to the issue of the multiple options for measuring the different aspects of poverty, of which economic growth is just one. Yet, the link is clear and prompts study into how energy behaviours relate to capabilities and basic needs – this is covered in Chapter 3.

For now, the second half of this chapter studies development and frames this in relation to poverty. With this, it is easier to make the argument for how thinking in terms of energy can be used as a way to perceive both poverty and the means to tackle it.

2.2 Development

Ideas about development and strategies to promote it have changed over time. A message put forward through the rest of this chapter is that information, like the measurement tools considered above, is vital in forming an understanding of how development occurs, for planning particular initiatives and for designing policy in general.

Historically, development has taken several routes: industrialisation and modernisation; liberalisation of trade policy to encourage growth in poorer economies and, more recently; capacity building to help enable individuals and institutions. Within these paradigms, there is a clear role of information and perception: the 'backwardness' of poorer nations, esteem for monetary measures like GDP and lately the increasing appreciation of the knowledge of poor people themselves. As with poverty, there are many continuously refined perceptions of what development is or what it is to be developed. The literature in this section documents how these perceptions have been conducive to different approaches in foreign policy and studies their impacts. This builds a narrative of how development thinking has evolved. The chapter ends with contemporary ideas of participatory and sustainable development; the latter is very much concerned with energy though the former is not so tightly related – indeed, it is the combination of the two, a study of energy inspired by participatory methods, which this entire project is built around.

2.2.1 Actors involved in development

Before in-depth discussion of development it makes sense to outline who is involved in aid, both as donors or recipients. These groups vary in scale, nature and the way they function. Governments influence development as do members of private industry and civil society, with charities and altruistic individuals also playing their part. Much of the aid discussed below can be measured in financial terms (loans or grants), but alongside this may be human capital to organise and manage how the aid money is invested.

At the highest level of governance, the United Nations (UN) are intrinsically involved in development. The UN's main purposes are to foster relationships between nations, to improve the lives of people within them, and to encourage respect for rights and freedoms (UN 2013). The UN facilitates the movement of aid from donor to recipient; it coordinates separate agencies, such as the World Bank Group, as they manage multilateral funds that are given or lent from the North to the South (see definition below). Both the UN and World Bank are international institutions but individual governments are also directly involved. Countries in the North channel bilateral funds directly to those in the South, similarly, Southern countries mobilise their own resources bilaterally, notably through the New Development Bank of Brazil, Russia, India, China and South Africa (NDB 2014).

The North-South divide is one that principally follows the division of the first and second, with third world countries (Williams et al. 2009) but can also be considered along the lines of high-income versus middle and low income measured by a GNI/capita threshold of $12,736 per year (World Bank 2015a).

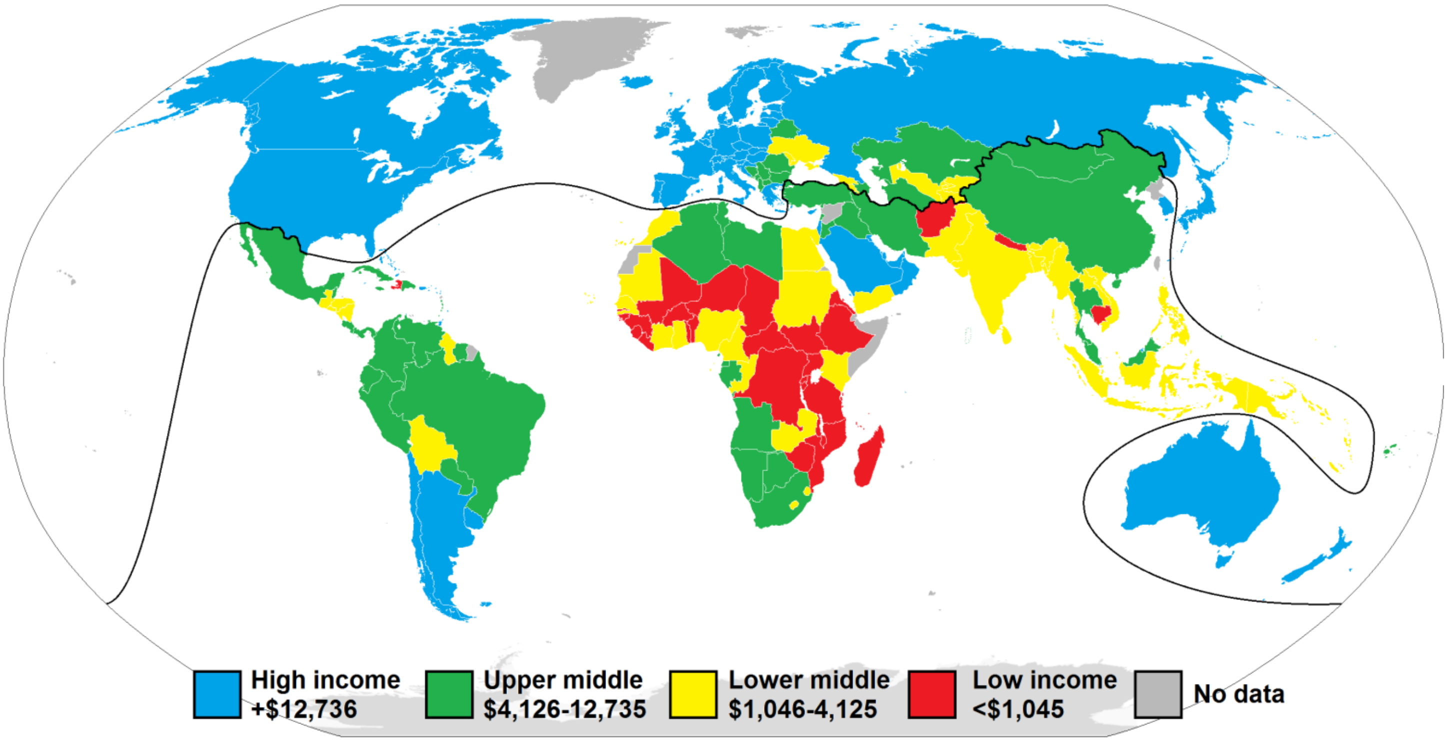


Figure 2.8: Global Gross National Income Per Capita

The North-South divide can be seen using Gross National Income per capita, estimating a standard of living (World Bank, WDI). The Brandt line is also drawn on the map, this division is not set by a measure but clumps 'poor' and 'rich' countries to emphasise the gap and to create a dialogue between them (Independent Commission on International Development Issues 1980).

The dividing line is illustrative, the Brandt report it comes from is a study into economic and social disparities which occur conspicuously at 30° latitude. The report argues that there is a marked difference in the North and South but that they are interdependent and development is a matter of mutual interest (Brandt 1980) – development is a global endeavour.

Considering now the entities and funds that are active: as well as the official development assistance (aid funding) that is associated with the state, money is also transferred within private industry and counted as foreign direct investment. Though this interaction is more driven by the financial motives of business rather than humanitarianism, corporate social responsibility is a commitment of some firms to use their technical knowledge and financial power for the public good. Whilst this may appear beneficial, there is call for such actions to be judged on a wider basis than just '*visible activities such as building hospitals or roads or the like*' (Dobers & Halme 2009, p.15).

Firms can have positive effects in stimulating economies but also negative consequences in the exploitation of people and resources. Particularly, big businesses have financial and political power that is a determining factor upon welfare in many people's lives:

> Multinational companies bring unique strengths: a worldwide reach, cutting-edge technologies, and massive capacity to reach large-scale solutions, which are all essential to success (Sachs 2012, p2211)

Figures show that 80% of finances to the South flow from the private sector (Valor 2011), yet, these flows have no intrinsic reason to lead to the kind of development which helps poor people. This frames the role of governing institutions to regulate or make guidelines for the way in which businesses affect the lives of poor people in the South, such as labour laws.

Many Northern countries have their own national bodies devoted to international development, these may be an arm of the government or they may be independent, for instance SNV, which separated from the Dutch government in 2002. Non-Government Organisations (NGOs) also include charities and aid foundations, for example MJP. Both of these groups appeared in the fieldwork of this PhD. Actors such as SNV and MJP can use their funding base to support them in organising and implementing aid initiatives.

As they are split from the state, SNV is an NGO. Such groups can operate without the same bureaucracy of government and with different behaviours than private companies – SNV do have to answer to stakeholders but they prove themselves by demonstrating poverty reduction, not profits (SNV 2015). NGOs role in aid and development increased towards the end of the last century (Rew 1997), they can bring knowledge to a variety of areas and form a bridge between policy makers and the poor (NGO forum 2012). Also, as noted with SNV, they may be financially sustainable where a private business is not.

Finally, poor people themselves should not be forgotten. They can alleviate poverty through the economic activity of small and medium sized enterprises (Mamman et al. 2015), there are also examples of informal support structures based upon charitable donations (Williams et al. 2009) and organised strategies such as microfinance – a kind of social banking. The groups which practice microfinance are useful institutions through which to promote development products, such as improved cook stoves (World Bank 2011). Also, the diaspora of migrant workers can act as a funding agent though not necessarily in an organised role, nevertheless, in many developing countries the flow of remittances outweighs aid funding (UNDP 2009).

2.2.2 A brief history of aid funding (post 1945)

This subsection covers the history of aid in recent decades. Discussion goes over how aid funding has flowed and how conceptions of its effectiveness have changed in that time.

To begin, consider the significant period of change after the Second World War. At that time colonialism receded and, arguably, was succeeded by an era of development (Allen & Thomas 2000). The UDHR composed after the war was both an assurance to prevent its reoccurrence but also a statement of equality and global cooperation. Aid of the time was aimed at rebuilding nations that had suffered in the conflict, though an ulterior motive for the West was in promoting capitalism and democracy (Milner & Tingley 2013).

A condition of financing infrastructure was that the target nations' opened up their markets to integrate into a globalised trading system so that they would thus benefit from foreign direct investment. This process continued on through economic turmoil of the '70s and '80s in the form of structural adjustment policies aimed at stabilising developing economies and reducing government spending (Williams et al. 2009). Historically, structural adjustment has produced little growth in poor countries and has often locked those nations into dependency on international finance institutions, moreover, where growth did occur it was not felt by the poorest people within those nations (Easterly 2003). Due to the visible failures of aid there was a waning faith that it could make a positive difference (Harms & Lutz 2004). This led to a 'fatigue' in donations, 28 of the OECD countries who together give an average of 0.29% of their GNI, dropped this to around 0.23% for the period from 1993 to 2004 (based on OECD (2014) and the World Bank's WDI)[1]. With the observation that aid is more successful in cooperative nations, Poverty Reduction Strategy Papers were introduced to give more ownership of the policy reform to developing countries. Though these have been criticised for being merely a 'theatre' of input from the recipient (Lazarus 2008), there is quantitative evidence to show that PRSPs help countries to meet targets for poverty reduction (Elkins et al. 2015). Today more than ever, aid faces the need of proving itself to be effective.

The success of aid strategy has been mixed. There are criticisms that a consistent commitment to neoliberal ideology has compounded poverty (Bush 2007). Indeed, the World Bank conceded flaws in their approach and admit that their method of assistance is a 'work-in-progress' (OED 2003, p.3). Though in defence of the finance institutions, there are models to show that foreign aid is effective only in good policy environments (Burnside & Dollar 2004), that is, with 'good policy' defined as openness to trade and aid effectiveness

[1] This figure of 0.29% is otherwise relatively constant, even in the global financial crisis of 2007 it only dropped to 0.26% and then only for that one year.

measured by GDP growth (Sachs & Warner 1995). However, this justification may be part of the problem due to its focus on economic indicators. Consider the cases where aid has not had measureable effect (according to tools like GDP) but individual initiatives provided tangible support to people who need it; this is coined the ‘micro-macro paradox’ (Mosley 1987). Partly, this readdresses the issue from the means of providing aid to the process of development itself and what it entails (section 2.2.3), but also it reinforces the need to study measures and indicators as they help to understand what is going on (Chapter 4).

Aid’s relationship to development can be debated in terms of aid-effectiveness, an argument much championed by two voices. The argument from Sachs (2005) is that pressing solutions, such as anti-malarial bed nets, upon the poor is an effective way to tackle poverty – once these solutions begin to take hold then people become liberated from the trappings of malaria and become economically active. With sufficient aid to overcome the deprivations of poverty, development will begin to sustain itself and aid can be withdrawn. This relates to the poverty trap discussed earlier (2.1.3).

Conversely, Easterly (2006) writes that aid failure is not due to the sufficiency of funds but how policies are determined and implemented. He argues that, funding governments (from the top) rather than the poor (from the bottom) leads to a gulf between how the donor intends their aid to work and what the results actually are. From free mosquito nets to free-market reforms, the best of intentions go awry and it is not due to lack of resources but an intrinsic feature of the top-down approach: the agent who plans and pushes their solution will not be as effective as the agent who searches for a solution and develops it in-situ.

Easterly and Sachs do not have entirely distinct perspectives on poverty. They both argue that solutions must suit the context and that a globalised market can potentially bring wealth to the poor who, with the right aid, will be lifted from poverty enough to support themselves. The difference is in determining suitable solutions: where Sachs calls for a prescriptive ‘big push’ coordinating an attack on every facet of poverty, Easterly advocates a searching approach with independent, accountable initiatives. Together, these differing views reinforce the fact that well-informed planning is pivotal in aid, though they open up the issue of what role different groups should play in this planning. This issue is covered more towards the end of the chapter.

The content given here (on the history of aid) is important ground to cover, it puts development into context. By its nature, intervention in foreign countries is a politically sensitive issue and due to fears of dependency or neo-colonialism and the indebtedness that compounds poverty, it is legitimate to raise questions about how to proceed with aid. As such, this motivates a more nuanced look at development itself – this being more than just a matter of loans and resource allocation.

2.2.3 Conceptions of development

This subsection refocuses discussion from the channelling of aid funding to the way in which development itself has been reconceived over time.

Recall the early period of aid that concentrated on building infrastructure; this can be associated with modernisation theory on development planning. Global powers considered themselves progressive and other countries to be ‘primitive’, their objective was to update ‘backward’ traditional practices with newer technology – though an effect was to sustain the hegemony of the North rather than to create self-sufficiency in the South (Andrews & Bawa 2014). Development is not simply an issue of technology and certainly reducing poverty does not happen where the value of that technology is not distributed fairly. Crucially, a barrier is the imbalance of power; unequal exchange between the North and South has tended to favour the former and ‘under develop’ the latter (Nhema & Zinyama 2016).

In an effort to tackle the problems of poverty directly, the basic needs approach to development gained momentum in the ‘70s. This was argued to be an efficient strategy for mobilising resources as it targeted the specific developmental ends of specifically marginalised groups (Streeten 1979). Like the UDHR, this approach extended beyond survivability and put emphasis on a person’s need for work, this being integral to the strategy such that economic output would rise globally and that this additional productivity would serve to meet the other needs of poor people (ILO 1976). In addition to referencing basic needs, this approach is relevant to discussion because it was an early instance of strategy calling for development targets that were both absolute and also relative to each nation.

In the ‘80s the World Bank in particular was part of a change from the basic needs approach towards structural adjustment (Peet & Hartwick 2009), as documented, this was to prevent the collapse of developing economies. Although with the difficulties imposed by these adjustment programs it became apparent that a purely economic style was blind to painful social issues. Thus, the aforementioned Human Development Index was constructed to deemphasise economic growth as the key marker of poverty reduction (Seyedsayamdost 2015). This signified a shift in thinking about development – whilst schools and hospitals were not new to the development agenda, incorporating their function into such a prominent tool examined how economic growth translated into human development (UNDP 1990).

The inclusion of education and health indicators was furthered in the assembly of eight Millennium Development Goals (MDGs) for the 2000-2015 year period. These goals were supported by numerous targets; an example of one (child mortality) is given below.

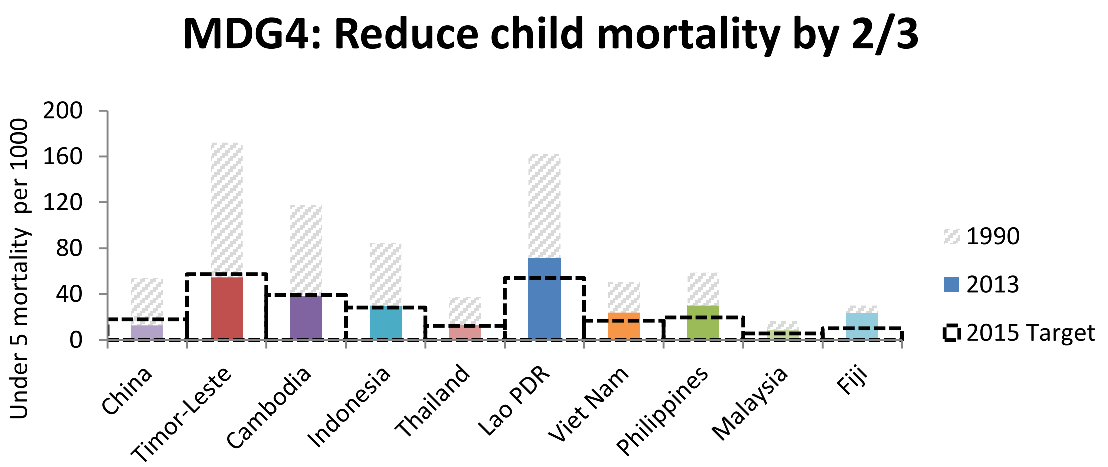


Figure 2.9: Progress towards MDG4: reducing child mortality by 2/3

The first three countries (from the left) met their target for MDG4 by 2013. The relative nature of the targets reframes this indicator of poverty into a goal for development: though Fiji has lower rates of mortality it has made the least progress proportionally, conversely for Timor-Leste. Data is from the official sources on the MDGs (UN Statistics Division n.d.).

This small set of goals was designed to be a concise but inclusive framework with a range of specific targets that would guide governments in developing countries to design policy for effective poverty alleviation (OHCHR 2010). In their time, the MDGs became all but synonymous with development, vitally, they signalled a departure from the 'money-centric' model by attempting to uphold a vision of a rights-based approach (Fukuda-Parr 2012).

It is helpful to monitor progress towards such goals to gain an indication of the difference between countries and their achievements over time. For example, it was the MDGs which were used to provide quantitative evidence for the effectiveness of poverty reduction strategy papers in the analysis of Elkins et al. (2015), as cited earlier (page 49). However, this conception of development can be problematic. Whilst in one sense the above MDG can be construed as a 'right to life' (OHCHR 2010, p.2) in another it is merely a right to healthcare facilities (Fukuda-Parr 2012). So, though they have the strength of being an inclusive framework, the MDGs do not entirely align with the capabilities approach to development as held in this thesis:

> The MDG agenda focuses on increasing public spending on social services, but does not incorporate broader issues of *human agency* … The agenda reconfigures the concept to a set of numerical goals to meet essentially material wants in the utilitarian perspective – (Fukuda-Parr 2012, p.6, emphasis altered)

Thus, the notion of development imagined by the MDGs is based around eliminating a small set of physical problems of poverty – this is only a step towards satisfying basic needs. As a successor, the Sustainable Development Goals (SDGs) are designed to sacrifice simplicity in favour of comprising more issues and also in reframing the subject to the concerns of humanity rather than an agenda of poverty alleviation (Sachs 2012). Fukuda-Parr (2016) reflects that the targets tied to the SDGs do not make the same mistake of simple, measureable outcomes but instead reconceive a more complex discourse on development with a broader vision of political and institutional reform. As a normative set of goals they are still separate from the capabilities approach but they do stress aspects key to it such as empowerment, energy and infrastructure.

The MDGs and SDGs will return to the discussion in the section on indicators. An immediate conclusion of this section is that development is an evolving concept and attempts to make a rigorous strategy around it ultimately alter what it is aiming to achieve and indeed how its success can be perceived. Goals and targets are a prime example.

It is of great importance that global concerns – for instance, protecting the environment – are highlighted as developmental ends. However, the message of the previous subsection was that it is equally vital to think about who gets to decide upon these development ends and how they should be achieved. For instance, though ostensibly the North-South divide is a neutral convention, as language it can still be construed as othering the recipient. Even contemporary development goals with their global emphasis can be questioned for the extent to which they address the needs of people and not just public services. Thus, the subject of the following subsection is to examine how rethinking the process of planning can lead to better outcomes for those who are supposed to be affected most by aid and development.

2.2.4 Participatory approaches

Whilst market-driven development was being pushed by financial institutions, elsewhere, practitioners and academics began to question the role of top-down policy in development. That approach was not engaging with people on the bottom, it turned them into recipients but not recipients of power (Narayanasamy 2009). Instead of the wisdom of outsider experts or the guidance of Smith's invisible hand, the "*local physical, technical and social knowledge*" (Chambers 1997, p.156) of poor people was recognised for its relevance to the development process, eventually, even by those finance institutions like the World Bank (Gorjestani 2000).

This 'participatory turn' was much propounded by Chambers (1983) as an upheaval of development practice: the poor became the priority and in many ways the authority, whilst development agents became more passive listeners. This turning point reframed who it was deciding what the poor needed and how to help them. With these new styles, partnership was fairer and the results were owned by those being helped, thus making the proposed development more relevant (Jennings 2001). Of the many ways of planning and coproducing knowledge that budded, it is in particular the method of Rapid Rural Appraisal (RRA) which influences the methodology of this project.

As argued, the methods of communication from areas of poverty and indications of the impacts of aid intervention are paramount. A novel approach that RRAs took was to avoid problems that beset methods of the time. Studies from, for instance, peripheral areas of rural poverty could be classified into large scale questionnaires, deep missions of anthropology or short works of rural development tourism – none of which could return timely, accurate, relevant data that could also actually be used (Chambers 2008). It is that aim of producing useful data that motivates the methodology of the thesis.

To give an example, Ellman (1981) describes some of his rural research projects in Sri Lanka: one, long-and-clean, study taking nine months (negotiated down from 30), and another, quick-and-dirty, taking just six weeks. Though the former was more comprehensive it took a further six months to write up and as the seats of government changed in that time, its impact became mainly academic. Ellman argues that the most important messages of that study could have been discovered far sooner – this influenced his other study to be briefer. The written report of the rapid study was a twelfth the size of the longer study and the recommendations defined much more clearly, these being timely enough to be accepted and implemented. His other examples talk about methods of data collection that are more 'impressionistic' than rigorous, these serving to give direction to the study, thus reducing the resources needed by allotting them more efficiently.

Despite its esteem, the process of a Rapid Rural Appraisal is not precisely defined, though this is perhaps part of its appeal and the key to its success. McCracken (1988) describes it as coming from a skilled, multidisciplinary group who iteratively refocus their efforts to study what seem like the crucial issues. Chambers (1981) posits it as losing the constrictions of professionalism and reorienting the data collection in terms of helpful sufficiency rather than excessive accuracy. His point is that RRAs can thus be a more cost effective way of extracting information from unfamiliar territory – but also that their brevity gives the researcher the time to spend in contact with, and to learn from, the rural poor.

The need to learn from the poor is at the centre of the participatory movement. It is a valuation of their voice in the process of development planning. Yet, in its transition to the mainstream, participation itself became a commodity to vindicate decisions made through existing power imbalances (Christens & Speer 2006). Such critique underscores a difficulty faced in this research project, the seemingly simple action of handing over the stick. The strategy I used to do that is detailed further in the methodology. The implication from this subsection is that when that action is done, it can lead to a closer understanding of what is by said by those being studied.

For now, this chapter closes with an overarching concept of development which combines economic and social issues mentioned earlier with that of the environment – this being especially crucial for this project's focus on energy.

2.2.5 Sustainable development

Discussion here moves away from those who influence development and instead addresses its bottom line imperatives. Within the sustainability framework, alleviating poverty is just one (societal) amongst several components (economic and environmental) which must all be balanced. Though earlier this chapter leant towards critique of an economic focus, that has its place in the framework as sustainable development is about meeting needs in this generation and the next (WCED 1987), so long term economic feasibility is fundamental.

Generally, thinking in terms of sustainable development is to take a holistic view of problems: to ensure personal wellbeing as much as prosperity and that all taking place within environmental limits (SDC 2011). Particularly, it is the recognition that society's drive to satisfy needs of food and housing, for instance, are exacerbating other problems by over intensifying agriculture and crowding cities. This holistic view can be seen in the transition from the MDGs to the SDGs. Whilst there has been progress in the global development agenda there is also mounting evidence that we are treading an ever deeper ecological footprint: more CO_2 in the air, fewer fish in the sea and an almost exponential growth of material and energy consumption (UNDESA 2012). This raises concerns over development as we are pushing planetary ecological limits.

Study into locating these limits can be traced as far back as Malthus (1798). He proposed that population growth would outstrip food production as, he posed, the former is geometric and the latter arithmetic. Turner's (2008) revisits that brand of modelling, showing that catastrophe might be postponed with new technology, or that growth could stabilise and collapse be avoided in the foreseeable future. Two issues are raised here, of cleaner technologies and reduced consumption, which echo throughout the next chapter as they are both tightly related to energy.

In terms of our proximity to the limits, the extent to which they're being pushed is widely debated. A report from the IPCC (2013) observes historic changes in environmental systems and unequivocally relates these to humanity's actions. However these systems are complex, as evidenced by observations of added vegetation growth due to higher concentrations of atmospheric CO_2 (Zhu et al. 2016). Nevertheless, the negative effects are just as visible, with an increase in the incidence of extreme weather events, ranging from floods to heat waves (NOAA 2010). Significantly, many of the poor countries who are least able to afford to cope with it are hit hardest by these natural hazards (Kasperson et al. 2005). Accordingly, the IPCC's 2014 report states that limiting such effects of climate change is an integral part of sustainable development and poverty eradication.

In line with awareness of the changing climate, an important part of the sustainable development agenda is that poor communities have *resilient capabilities* in order to meet their needs in an uncertain, or at least rapidly changing, future. This resilience comprises careful management of ecosystems; decentralised energy sources; and diversity, flexibility and security in resources (Green Alliance 2013). Study into the experiences of people living through extreme events has identified that their ability to cope in crisis is exists on many levels: the household accumulating assets, the neighbourhood developing support networks and the region benefitting from infrastructure (Jabeen et al. 2010). Gaining resilience can also be conceived as transitioning from vulnerability; for example, by being able to build dams to reduce flooding, having the choice to live in areas that aren't risk-prone or the endurance to build back after disasters strike (Pasteur 2011).

The concept of resilience is a core part of analytical frameworks used in the research; it can also be recognised in the study of energy in the next chapter. A vital implication to take from this subsection is that the environment reacts to, but also dictates, human behaviour. So efforts to alleviate poverty must account for the changing climate yet not worsen its risks via producing harmful emissions or pollution.

2.3 Conclusions

This chapter has explored poverty as a problem, aid as a reaction to it and what this means in terms of development. In particular, the message has been upon how the perspectives of poverty are related to the way it is measured and, through the example of the MDGs, how this can influence targets and planning. The intimation is that effective assessments of poverty can promote effective development by informing decision-makers – also, situating this development in a sustainability framework and including the bottom-up approach via participation can encourage the consequences to be positive, for those poorer people, in the long term.

Poverty itself can be considered as a lack of money, but a more sophisticated understanding comes through thinking of it as a lack of capabilities. It is not just a state of hardship where basic needs are scarcely met but a trap which inhibits movement towards a better lifestyle – this perpetuity implies the need for aid and effective monitoring mechanisms to make targets, plan intervention and track progress.

There are many methods of measuring poverty to account for its complex nature. Graphs in 2.1.4 covered ten developing countries in the East Asia and Pacific region; depending on the metric each may seem to have different poverty or standard of living. It is the data presented which determines the understanding of poverty in these areas, and indeed the availability of data which determines the visibility of the problems.

The brief history of development outlined in this chapter touched upon neoliberal economics and structural adjustment which have been largely unsuccessful in attenuating debt in the global South. Consequences of this are an impetus for more effective strategy in promoting development. The underlying theme of the discussion has been that communication is essential to development for visibility and empowerment – to have data on these problems and to hear the voices of those affected. Without monitoring tools, aid cannot be planned effectively nor its effects understood.

The components of this chapter have outlined the niche into which this thesis will make its contribution. In summary: this is to consider poverty in the sense of capabilities and construct a mechanism which measures them, this for the purposes of planning rural development initiatives using a strategy compatible with global concerns of sustainability and also local concerns of the people who are at the heart of that development.

3 Energy access

> Energy must be available at all times, in sufficient quantities and at affordable prices, to support the goals of sustainable development (WEHAB 2002).

3.0 Introduction

This chapter gives the rationale for using energy as a lens through which to see and tackle poverty. Particularly, it is people's *access* to energy which is explored. Content covers energy access in the home, community and at an infrastructural level. The contention is that access to energy is a prerequisite for capabilities, which in turn are necessary in the satisfaction of basic needs as outlined earlier. Thus the interaction between energy access and poverty alleviation is made clear.

Energy access is not precisely defined; the extent of what it means is studied throughout this chapter. The following ideas are a helpful start:

- Energy must be available to and affordable by the user; also it must be in an appropriate form (IAEA 2005)
- The user must have the facilities, knowledge and devices with which to use that energy (Practical Action 2013)
- Using energy must not cause health risks and it should preferably come from sustainable, low-emission fuel sources (AGECC 2010)

Energy based development gained momentum in its recognition as essential for progress towards the MDGs (Modi et al. 2005)(UNDP 2005a)(DfID 2002). It is argued to be a pro-poor growth tool (Ngepah 2011) and is championed by development groups (Practical Action 2012). More recently, "*access to affordable, reliable, sustainable, and modern energy*" has been named the seventh Sustainable Development Goal (SDSN 2015, p.157).

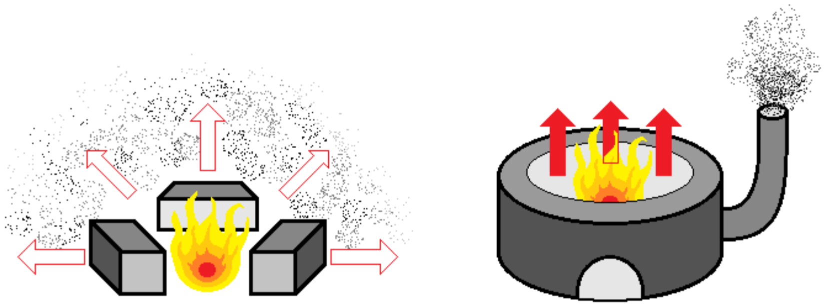
In sum, this chapter shows that thinking in terms of energy access is helpful in understanding poverty. Simultaneously, discussion explains the complexity of energy access. It is about the availability of energy and the potential gains from harnessing it, but also the people involved. There are vital issues of quality, quantity, form, usability and risk.

3.1 Energy in the home

This first section covers some of the most straightforward applications for energy, relating to the capabilities of and dangers faced by those in poverty. In doing so, this section introduces some key terminology used throughout the thesis; the terms 'modern' and 'crude' energy use are fairly obvious but finer terms are needed in describing energy access. The activities depicted below are examples of 'energy services': these are the tasks and reasons for people harnessing energy. Through these examples, the energy landscape can be described and this will serve later in the creation of an analytical framework (Figure 5.5 on page 143).

3.1.1 Making fire and cooking in the home

The basic needs of nutrition and warmth are underpinned by stoves and fires in the household. Solid fuels such as wood or some form of traditional biomass are used by 2.7 billion people worldwide (OECD/IEA 2015). They face two issues: the drudgery involved in collecting these fuels and the smoke emitted when they burn. A study of villages across sub-Saharan Africa (where solid fuel use is most prevalent) describes this practice: the task of collecting firewood is primarily undertaken by women on foot, and rarely with the aid of a cart or animal power; on average the gatherers travel 12.8km and spend 6 hours per week collecting fuel-wood (Adkins et al. 2012). In that same study, 80% of the households burned wood on a three stone fire, as portrayed in Picture 3.1 below.



Picture 3.1: Heat and smoke from both a three stone fire and an improved cook stove

This diagram shows a three stone fire (left) where a cooking pot is rested atop the stones, with heat and smoke going in all directions. The improved cook stove (right) has walls to protect the flame, direct the heat and smoke, and increase the efficiency of the combustion.

The smoke from crude biomass fires is dangerous. It has high concentrations of particulate matter, disproportionately affecting the health of women and children who, by social convention, are predisposed to be in kitchen spaces (World Bank 2011). Household air pollution, mainly from these sources, is estimated to kill 4.3 million people per year (WHO 2014). Reducing mortality and drudgery are drivers for developments in energy access.

Efforts to improve access to cooking energy focus on the stove and fuel used. Improved cook stoves (pictured above) can reduce fuel consumption. These can be manufactured simply, using local materials, and return 35-50% more fuel efficiency (First Climate 2011).

An option for improving the wood fuel itself is to refine it into charcoal. Partial combustion increases the energy density of biomass and the refined fuel releases fewer particle emissions (Practical Action 2010a). Practical Action explain how this can be done with non-edible agricultural residue, saving rural farmers the need to forage in the forest.

Charcoal use is prolific, it can be found in 80% of urban households in sub-Saharan Africa (Zulu & Richardson 2012). Without access to woodland resources these urban households import from rural areas, as it is a lighter fuel than wood it saves on transport costs. However, it still turns forests into pollution. Compared to traditional 'burial' methods, modern kiln production reduces emissions and consumes 40% less wood in the process (Kattel 2015). In the language of energy access, kilns give a more plentiful energy supply and impose less risk to the environment via cleaner air and a lesser toll on the woodlands.

‘Modern’ cooking fuels such as gas or electricity (Putti et al. 2015) allow for a further improvement on indoor air quality. Though cleaner, these are more expensive, so may be less desirable by those who traditionally forage wood. This highlights a recurring issue, the trade-offs made by poor people – in this case: to use either a cleaner fuel or a cheaper one. Low investment from these consumers affects the sustainability of infrastructure to supply electricity or gas; this in turn affects the income of the poor as they divert time to manually collecting fuel.

Biogas is classed as a modern cooking fuel (Putti et al. 2015). It performs as well as ordinary cooking gas but is derived from agricultural waste. With a digestion vessel, a farmer owning a couple of cows can, freely, produce enough biogas for their household cooking needs (SNV 2009). Though it is exceptional in terms of its low financial *and* environmental cost, the technology is hampered by the maintenance of the system (Putti et al. 2015). More about biodigesters is given in the empirical chapters.

Finally, another technically-effective way to access cooking energy is to use mirrors to concentrate sunlight to a smaller area for example, a kettle or oven. Solar cookers need no fuel and produce no smoke, so users can save time on collecting wood and cleaning pots (Practical Action 2010b). Despite its benefits, this technology is only partially embraced into rural cooking practices, thus having a small impact on health and time (Levine & Beltramo 2013). Barriers to adoption are that solar cookers only work when it is sunny and they can’t cook certain traditional foods such as flat breads (Putti et al. 2015). This is the issue of *appropriateness*: whatever its technical aspects, the cooker must fit in with the way the cook wants to use it.

3.1.2 Water to drink, to wash and for sanitation

It takes energy to move water. Transporting it to the home can be as simple as collection using human or animal power. This has obvious drawbacks: it is another example of drudgery and surface water sources have little guarantee of cleanliness. This subsection looks at how accessing energy can solve these problems of transporting water and keeping it clean.

More than 780 million people lack access to 'improved' sources of drinking water and 2.5 billion people lack 'improved' sanitation facilities (UNICEF & WHO 2012). Here, 'improved' refers to protecting the water source or toilet-user from contamination, particularly from faecal matter. Contamination contributes to more than 3.4 million deaths each year from water, sanitation, and hygiene-related causes, nearly all (99 per cent) of which occur in the developing world (WHO 2008). This is a core part of energy access: the energy needed for digging wells, pumping water, cleaning it and preventing contamination on disposal.

An advance on collection from surface water sources is to use manually-pumped wells to reach water further down. Using groundwater sources is cleaner than that from the surface, also wells can be dug closer to the home, but this in itself faces the challenges of creating those wells which comes at a high energy cost (Lewis 2012). There are simple designs: treadle pumps can draw from sources seven meters deep; and more complex designs, rope and disk pulleys can reach in excess of 50m (Stewart 2003). Other pumps use of non-human power sources such as wind, solar, electricity and diesel (Smet et al. 2002), these sources reduce the drudgery involved but can be too expensive for poor communities. Unfortunately, water pumps installed through development initiatives are often neither monitored nor maintained, lack of procedure for pump breakdowns means that people end up finding lower quality water elsewhere (Mackintosh & Colvin 2003). Also, whilst groundwater is protected from many bacterial contaminants, it can still suffer from naturally occurring pollutants such as arsenic (Ahmed et al. 2006).

Centrally managed water supplies, using pipes, are more convenient for users but they face dilemmas over subsidies and cost recovery (Le Blanc 2007). As such, piped water sources are uncommon in the rural, developing world. Like with cooking fuels, infrastructure is an effective means of provision but is not always a viable option.

For people who cannot acquire clean water the traditional method is to boil it. This is energy-intensive, especially where the stove is of the inefficient type discussed already. There are alternatives; a publication by Heierli (2008) covers the variety of techniques used in poor countries to make water safe and potable. Basic filtering through sand is partially effective though modern techniques use ceramic filters with better results. A more elegant low-tech solution is to use sunlight as prolonged exposure to UV radiation can effectively kill bacteria. Beyond this, simple interventions such as the promotion of soaps can make a huge difference, as measured by reduced morbidity from diarrhoeal disease (Unicef 2009).

3.1.3 Lighting homes and lives

The need for light is rudimentary; even the earliest civilisations used fire for this (Marshall 2016). Light can extend the length of the day, changing how people structure their time (Winther 2008). At night lighting allows for study, for families to spend more time together and feel safer (Wamukonya & Davis 2001)(Solar Aid 2014). Even within day time, artificial lighting may be required in enclosed indoor environments – though it is not a physical need itself, it allows one to work and is a platform for social needs of interaction.

A crude method of making artificial light is combustion, using candles or lamps that burn fuels like kerosene. Combusting fuels is an inefficient means of lighting in that it outputs fewer lumens (units of light) per watt than using LEDs, fluorescent or incandescent bulbs (ITDG 2000). Although the initial costs of a kerosene lamp may be lower, the operational costs are higher than with electric lighting (Mills 2003) – another trade off in energy access. Mills' research also shows that the quality of kerosene lighting is worse and depreciates faster as the lamp becomes soiled by the fumes.

The ITDG (2000) write that electrical sources are not only more efficient, but are safer as they do not involve flames. Rural households can access electrical lighting via lead-acid or dry cell batteries; alternatively, electricity from the mains grid is usually cheaper and can give higher quality supply but initial costs of connection inhibit consumers (Modi et al. 2005). More on electrical power sources is given in section 3.5.

Wamukonya & Davis (2001) study the effects of electrical connections in rural Namibia with reference to fuel lamps. They find that the prevailing change in the villagers' quality of life is due to the electric lighting being more available and of higher quality. In particular, this affects not just children's ability to study but also the teachers' ability to plan lessons – implying similar benefits from lighting to other service sector jobs.

It is important to understand that lighting has a value beyond the kind of 'task' lighting that a person might need to do a particular chore. It has a deeper significance, in that it allows *any* activity to occur outside of day light hours which are usually prioritised for work. This is a direct expansion of freedoms and capabilities, that is to say, an alleviation of poverty.

3.1.4 Cooling for comfort and to preserve food

In studying this energy service, two issues within access are outlined: the close link between basic comforts and basic needs, and also the trade-off between efficiency and effectiveness.

Controlling the temperature is an energy service, partly this can be for comfort, but significantly there is evidence showing that at temperatures above 32°C cognitive performance can fall by almost 15%. Specifically the heat can affect "*attentional and perceptual type tasks and mathematical processing tasks*" (Pilcher et al. 2002, p.695). So a cooler classroom or office might be more comfortable but it is also arguably a necessity for working. As with lighting, this has implications on how a space can be used.

Cooling can be as simple as building shaded areas with good ventilation, though with higher access to energy, one may use fans or air-conditioning. Fans are mechanical, they affect the air flow. Air-conditioning works by the principle of refrigeration and consumes a lot of electricity; also for the air to remain cooled there must be less ventilation. So in return, the energy which can be accessed for cooling has an impact on how spaces are designed.

Air temperature has other implications. In warm temperatures bacteria grow quicker and so food cannot be stored for as long. For farmers this can result in substantial loss of produce. For the consumer, being able to store food for longer is more hygienic, it can equate to less wastage and fewer trips to buy the food itself. This is *convenience*. Passive coolers make use of the principle that evaporation lowers the air temperature. A study in Sudan showed that they extended the shelf life of vegetables by around a factor of five (Practical Action 2010b). Although passive coolers are more efficient (in that the natural air currents which power them are free), they are not as effective as fridges powered by electricity.

3.2 Energy in farming

The topic of energy access is much related to people in developing countries, recall that a main thrust of these chapters' argument is that energy access underpins capabilities and thus can be used to perceive poverty. As over half the labour-force in developing countries are farmers (DESA 2007) it makes sense to give the energy access of that livelihood special attention. The areas raised here relate to how energy is used by farmers, to water their crops, till the land, store their harvest and ultimately get it to market. These energy services are the basis of agriculture – in particular it is the role of mechanical energy which is emphasised here. Also, transport is an energy service used elsewhere.

3.2.1 Irrigation

Good access to irrigation is linked to higher agricultural yields, increased incomes, more stable employment and greater food security (Hussain & Hanjra 2003). A study on small-holders in Africa and India showed that rainfall is insufficient for many farmers and reliance upon it alone likely does not lead to productive enough small scale agriculture to escape poverty (Harris & Orr 2014). This reinforces the argument of section 2.1.3: there are self-sustaining barriers to development like when farmers don't earn enough to irrigate their crops. This is partly a technical issue of reducing costs but also is also much related to water resources and their allocation.

One method to reduce energy costs is to distribute water directly to the roots of crops – this can increase yields by up to 100% and make savings on fertiliser, labour and indeed water (Burney et al. 2010). That study shows drip irrigation in combination with photovoltaic pumps, these are reliable and cost less than liquid fuel pumps even in the medium term. However, solar cells are expensive and difficult to repair. However, akin to the stoves, parabolic concentrators can harness sunlight for its heat, a machine designed by Jeffries & Bom (2011) uses this thermal energy to create a steam-powered pump. By avoiding transformation to electrical energy, the machine is within the technical grasp of small-scale farmers. As such, it is more *appropriate* than photovoltaic cells – this is an example of an intermediate technology.

A more widespread method is to use liquid fuel pumps, these do not require the same infrastructure as electric pumps and in recent decades the price of a Chinese-built exports has fallen dramatically to around $100 – this has been matched with a rapid increase in their use for small scale private irrigation (Fraiture & Giordano 2014). However, these authors go on to explain that the surge in private pumping, as opposed to hand-watering or responsibly managed canals, can negatively affect groundwater supplies. Irrigation may be beneficial for the individual but their behaviour should not be considered in isolation – this is part of the complexity of energy access and a reminder of sustainability.

Canals can serve communities of farmers, offering a more reliable water source than many natural passages. Seepage rates (water loss) in canals can be reduced to nearly a tenth by just using brick lining (Uchdadiya & Patel 2014). However, though large canal projects may have an effect to reduce poverty, their pro-poor effect is dependent on equal access – larger farms tend to benefit more (Lipton 2007).

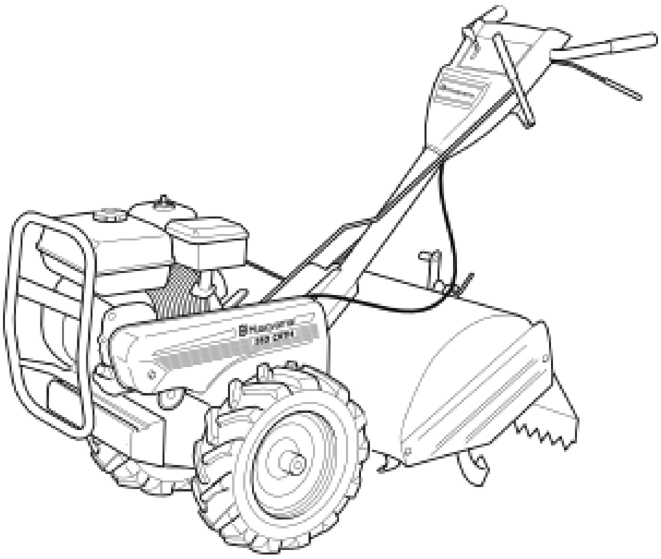
With this it can be seen that the energy farmers can access for irrigation depends on small scale issues, such as the assets at their disposal but also larger events, such as water politics and management of infrastructure. Part of studying energy access is to assess what technologies make effective assets but also to evaluate the impacts of policy and planning.

3.2.2 Mechanical power

Evidently mechanical power plays an important role in traditional or modern agriculture, from ox-driven ploughs and wind mills to tractors and electric threshing-machines. A difficulty in analysing mechanical power is that it has many disparate applications. The following discussion looks at a few notable assets rather than trying to map all these applications.

The multifunction platform is publicised by the UNDP as appropriate technology. It is a diesel engine with modular attachments that can dehusk, press and grind organic produce. The machine is self-sustaining as it can refine and run on biofuel. Other functions are as a food processor, water pump or manufacturing tool – it can even charge batteries and power light bulbs (UNDP 2005b). With these capabilities farmers are more self-sufficient and can become highly resilient.

A more popular tool throughout Asia is the power tiller. This also operates with modular attachments but is mobile so has the additional uses of ploughing fields or transporting produce. The energy needed for transport is significant in rural areas without good road networks. Due to their versatility, power tillers were a key part of modernising Japan's small scale agriculture – through the development of these machines in that context, they are highly suitable for low-income rice farmers (Francks 1996).



Picture 3.2: A power tiller

The power tiller is an engine with handlebar controls and a variety of mechanical attachments.

Decentralised mechanical energy is important for poor, rural farmers; they can get improved income by capturing more of the agricultural value-chain: from production and post-harvest processing, right the way to distribution and marketing (Practical Action 2012). In doing so, the primary sector of agriculture can merge with secondary and tertiary sector activities; this improves the rural economy and allows the workers to receive more income for their work.

It is important to consider access holistically as different forms of energy interact with one another. For example, electricity can be converted directly into mechanical energy. It is used in villages to power mills but also for electric welding. This allows metal repairs within the village, at least one study showing that renting tractors became more a reliable and common activity (Kirubi et al. 2009). Thus, the availability of electricity indirectly enabled greater access to mechanical energy. Availability and access are different issues, the former just being one part of the latter.

3.2.3 Storage

After harvesting, farmers need to preserve their produce, either to eat through the off-season or to sell at the appropriate time. Refrigerators and evaporative coolers were mentioned earlier. Food can also be dried: naturally in direct sunlight or by using a purpose-built wind/solar driers. These have been built in Nepal for as little $5 with materials as simple as transparent plastic (Practical Action 2009). These driers are akin to an oven but use natural power sources like wind or sunlight. With these devices the drying time can be cut by up to 50%, improving the quality of the food, reducing storage losses and preventing contamination (Esper & Mühlbauer 1998).

In addition to the process of preservation, the space that is used for storage is significant, this relates to the materials used in and methods of constructing granaries (Abass et al. 2014). In a case in Tanzania, the skills to build mud silos were waning with the adoption of plastic sacks which are easier to move, however as these bags are permeable they can lead to post-harvest losses (Zorya et al. 2011). The report explains metal silos can reduce post-harvest losses but their manufacture requires training the local metalworkers.

Thus, the capability of storing food post-harvest is linked to energy access both through the direct energy service of preservation or in terms of working with materials. Again, this draws focus to the assets that an individual uses and the more broad reaching effects of what materials are available on the market, also whether these can be manipulated by local artisans. Further, the environment itself is a factor (ambient temperature, humidity) which gives context to the problem.

3.2.4 Transport

Transport is a microcosm for much discussion of energy access. It is influenced by asset and resource availability, such as a car and fuel, but it is also framed within a system of other factors, such as road quality and the distance to a market. Especially in rural environments, it is these other factors which problematize the situation: something as routine as transport becomes quite difficult due to say, a bridge collapsing, and if is the only bridge around then the consequences are felt widely as trade and economic activity is hampered.

The ease in accessing the energy service of transport has many effects on agriculture: the cost of resources, such as fertiliser; the feasibility of what crops can be grown and sold; and notably the food security of people in the area (Bartholdi et al. 2013). A basic path may develop naturally from passage of pedestrians and lightweight vehicles, but for heavier traffic or across rougher terrain, firmer surfaces must be built – though this can be done with hand-tools (Taylor 1994). Larger scale road building is usually a responsibility of the government; a state-run project in Morocco found that only 43% of villages had easy access to rural roads, increasing this accessibility not only boosted farmers' productivity but allowed them to grow more cash crops as they could then reach markets quickly (Levy 2004).

As the backbone of transport, vehicle technology is always evolving. In the developing world the falling cost of personal transport (for example 'motos', small motorcycles, are as cheap as $200 throughout Asia) is enabling even low earners to own their own vehicles as opposed to relying on public transport (Sperling & Claussen 2004). Whilst cars are too expensive for many rural travellers, intermediate means of transport such as bicycles, motos or even animal carts are recognised for the important part they play, especially in their ability to traverse lower quality roads yet still significantly increase the weight of produce than can be carried to market (Starkey 2006).

3.3 Energy in the community

A benefit of thinking in terms of energy access is that it allows one to consider the details of many aspects of life for poor people. Aptly, it is a broad approach which matches the many varied factors that contribute to poverty. This benefit will be drawn upon throughout the thesis. Here, it is exemplified by looking at the core functions used to satisfy basic needs as they exist beyond the home – these are important parts of people's lives and can make a significant difference to their welfare.

3.3.1 Communication

Communication is the lynchpin of communities; it is tightly related to social needs and much used in business or economic activities. As with water, energy is accessed in providing communication rather than it being a kind of energy in and of itself. With this logic, the energy access approach is very flexible.

Communication technologies can improve livelihoods but they are also linked to participation in society and empowering people to interact with public institutions and businesses (Practical Action 2010b). This relates to Chambers' (1983) argument that isolation is a deprivation which exacerbates poverty. Whilst the effect of phone calls on a personal level is quite profound, telecommunications also have wider consequences. Evidence suggests that there is a two-way relationship between mobile communications and economic development (Curwen & Whalley 2011), moreover the positive impact of mobile handsets is reported to be more pronounced in developing countries – possibly compensating a weaker transport or telecoms infrastructure. Curwen and Whalley give details on how mobile communications improve trade, business, banking, government and even health services. In the last decade mobile phones have become smarter, they are now a powerful asset extending to more forms of media: photos, games, music and most especially news (Goggin 2012), this provides a plethora of capabilities. Also, money can be transferred using mobile technology – airtime is practically a form of currency, facilitating the use of mobile phones, but vitally, enabling a different form financial transactions. This shows how core capabilities are modernised with technology.

Figures from the World Bank's WDI show that in developing regions across the world, mobile subscriptions per person have grown between 17 and 40% year on year for the last decade. Communications infrastructure has grown in such a way as to allow many of these regions in the Global South to leapfrog the landline, saving on equipment costs and materials themselves. Electronic communications are now being used to disseminate agricultural information to rural farmers in at least a dozen African countries (Gakuru et al. 2009). Both farming practices and commodity prices can be communicated, allowing farmers to become more skilled and also more well-informed. By classical economics, this is healthy for markets as it brings prices closer to the most all-round satisfying equilibrium (Anderton 2004). Better methods of communication benefit not just a pair of users but they also strengthen the whole network.

In developing countries the availability of the internet and connections to it are rising (ITU 2013). Access to this global knowledge base is both informative and also estimated to boost economic activity in developing countries, especially if this access is given to female users (Kakar et al. 2012). However, the digital divide of who is and is not connected is felt keenly along lines of gender due to disparities in literacy rates and social norms preventing women from receiving formal training to learn to use internet devices (GSMA 2015). Accessing energy services is about having the assets and the energy to power them but also about the skills to use them and the social acceptance to do so.

3.3.2 Healthcare

Practical Action, in their 2013 report, write about the effects of energy access in the community; they detail how buildings, such as hospitals, are transformed with the provision of electricity. Essentials such as clear lighting for surgery are quite obvious. A few other examples are diagnostic machines, fridges for storing vaccines or using heat to sterilise equipment. Where these are not available the healthcare is less effective and that risk to people lives underscores the importance of being aware of energy access universally, not just in the home.

Immunisation saves an estimated 2-3 million lives every year and could save a further 1.5 million children annually (WHO 2012). Though it is a basic procedure, it requires modern energies for cold storage to keep the vaccines potent. Other drugs, including a leading anti-malarial drug, Artesunate, are most effective when stored in refrigerated conditions

(Agnihotri 2013). Consider also that half of the world's population is at risk from malaria (WHO 2013) and the estimate that it reduces economic growth within Africa by up to 1.3 percentage points per year (Malaria Foundation International n.d.). These consequences of ineffective treatment hinge upon decent energy supplies for cold chains.

A study into the dissemination of solar technology in the Gambia explains that it is cheaper per potent-vaccine to use solar energy rather than kerosene to power the cold storage (Able-Thomas et al. 1995). Running fridges on kerosene is costly and dangerous, there are many forms of energy that can be used in development pathways and it is important to know the difference between accessing each of them.

Using energy, and specifically electricity, has many benefits in healthcare, quite notably, reducing child mortality and improving maternal healthcare through better medical facilities (DfID 2002). Sachs (2005) talks about how family sizes are generally bigger in Southern countries due to poor family-planning services, higher birth rates in response to higher mortality rates and that with no social care, children are needed for security when the parents age. Thus, he infers, improved healthcare can increase the stability of a population. This is not done through one electrical appliance, but *better enabled by a medical sector which can use modern technology*.

Essentially, healthcare reduces sickness and sorrow. Mortality can be quantified but the effect on the family cannot. Without making emotional appeal, it can be said that a person's agency is subdued in bereavement. Health is a basic need, and healthcare facilities that have access to energy allow for capabilities to meet that basic need.

3.3.3 Education

Schools are another community building that benefit from electrical energy. The basics that electricity can provide such as lighting or pumped water are vital for almost any building, so too for schools to benefit students and teachers:

> UNICEF estimates that one in 10 school-age African girls either skips school during menstruation or drops out entirely because of the lack of proper sanitation facilities – (AIGA 2009)

This drop out may be due to knowledge of sexual health as opposed to just the bathroom facilities available, yet it shows that the basic provision of hygiene is not universal and that this dearth is a problem, not least, because girls dropping out for this reason contributes to the gender gap.

In schools, computers are useful tools for teaching and indeed computer literacy is a skill that should be available to anyone. Many households are unable to afford computers so it is important that children have the opportunity to learn to use them at school.

> It is estimated that more than 50 per cent of children in the developing world go to primary schools without access to electricity; this affects more than 291 million children worldwide – (Practical Action 2013)

In a school without electricity the students can't learn to use computers nor can the staff use them for teaching or administrative tasks. Even basics such as fans or lighting are unavailable. Though schools aren't the only place to receive education, they do form a connection between the state and its citizens (Chambers 1983) and secondary education is linked to improved earnings (Practical Action 2013). This is one of many examples where the financial implications of an action are used as its main justification; although money is often decisive, it would be myopic to reduce an education to its multiplier of income. During schooling young people learn to behave and socialise in a way that is not possible in the home, also, in school they find opportunities, practise skills and prepare for later life. Schools need to encourage students to attend, they need the right facilities to teach them and also provide basic comforts.

3.3.4 Business

The capability of earning income is all but essential in most societies. For business, access to energy is important: from the fuels and stoves used in restaurants to the electricity needed by internet cafés. Energy tends to be used in all businesses as part of the products or services that they sell but there are also indirect uses. A workplace needs light, toilets and channels of communication – though these are possible without modern fuels or electricity, it is much easier with them.

Practical Action (2012) explore some of the ways in which small and medium-sized enterprises can be enriched through electricity: hair dressers using electric razors, shops selling refrigerated goods, mechanics using electric welders or even cafés with TVs. These kinds of business are not limited to urban centres; they are part of the rural economy and often run from the home as cottage industries.

Even in very traditional livelihoods it is beneficial to examine how people are accessing energy, for instance, the mechanical energy of the tailor or the thermal energy of the potter. The insight of energy access is to find ways in which their energy behaviours can be improved. Moreover, the process of improving energy access can stimulate the economy as well, for instance, technologies such as biogas require the skilled labour of masons, engineers and agronomists (Mengistu et al. 2015).

If energy becomes more available then there is a wider selection of opportunities for enterprise. This can be through enhanced productivity, better products and also through more advanced markets (this effect is quantified in subsection 3.5.2.2). As an example, consider large factories set up in developing countries, these may not have the best worker protection but they do have a high level of energy access (using electricity and machinery) and so allow far greater productivity than cottage industries – rurally, these factories can be a valuable source of employment (Sachs 2005).

3.4 Interim remarks

So far, this chapter has dealt with the energy people access in their daily routines, community and livelihoods. The energy access perspective relates to many basic needs – quite directly to physical needs but also to other social and progressive needs. Essentially, the right access to energy can mean clean air, safe water, timely lighting and the use of important electrical appliances for income generation or otherwise. These capabilities have a significant effect on reducing mortality, in improving what a person can do but also in allowing them to enjoy more convenience and comfort in their lifestyle. Energy access is about the mechanical power needed for farming and transport; the quality of public services needed in the community; and the electricity that powers basic functions of buildings, such as water pumping, lighting, fans and communication devices. As an approach to alleviating poverty, it is flexible and can incorporate issues from smoke in the home to infrastructure around the country.

This exploration has focused upon energy and the access to it, in terms of basic needs and household demands. This links energy access to the capabilities theory of poverty. Yet, such an essay on linkages has no limit. The implicit message so far is that there are a myriad ways in which energy access can be related to the important parts of any lifestyle or livelihood. Likewise, the explicit message is that energy access is not simple: there are many parts of energy access and they interact with each other. Just as it is useful in its relation to capabilities, this thesis contends that energy access is a useful lens for a broad and system-wide approach. With this, it should be easier to plan effective and well-aimed development initiatives to alleviate poverty.

In the vein of this broad approach, the following section moves away from energy consumption and considers the other significant issues relating to energy access. These issues are more related to the supply side of energy, both in terms of how it is harnessed and the planning done around that.

3.5 Further issues within energy access

Recall the issues of sustainability outlined in the previous chapter. Immediately a concern arises in promoting energy based developments as they could jeopardise the environment. However, such fear can be assuaged. An initiative set up by the UN called Sustainable Energy for All states that access to modern energy services can be made universal whilst only increasing carbon emissions by 1% (IEA 2013). Though this rests upon assumptions of what state of access is satisfactory, it does decouple energy-development from unacceptable pollution. Accordingly, this section studies sources of energy for their sustainability. Unsurprisingly, renewables are a core part of this. Electricity is also discussed at length. This is an energy carrier rather than a source but due to its versatility it is highly significant in the capabilities approach.

3.5.1 Sources of energy

3.5.1.1 Renewable sources of energy

A prime example of a renewable is biomass, that is, wood or other organic matter, and its derivatives such as charcoal or methane. These are used extensively in the South and have great potential. In developing countries, biomass accounts for 22% of the energy mix; in the poorest countries it accounts for more than 80% (IPCC 2012). As a resource biomass is renewable and carbon-neutral. For many applications its consumption requires no specialist equipment or training. However, it being renewable does not preclude it from being irresponsibly managed or extracted without environmental damage; deforestation is a concern. Growing populations and their demand for fuel are a major driver of this (Allen & Barnes 1985). Though for rural consumption a common practice is to gather dead wood rather than cut down live trees (Practical Action 2010b)(Practical Action 2014). Also, the rise of charcoal production is linked to a socio-economic safety net as its production is a livelihood (Zulu & Richardson 2012).

The uses of biomass can be divided into small-scale thermal applications (such as the residential demands as covered in 3.1.1), industrial thermal demands, or conversion to electricity or mechanical energy via its refinement into a biofuel (Vakkilainen et al. 2013). The business of producing biofuels has a double-gain impact as biofuel feedstock could potentially be a cash crop for poor farmers – though these projects face issues of land use and the sheer difficulty of growing relatively wild crops (Duvenage et al. 2012)(Wendimu 2016). Whilst biomass has great potential, focus on it in terms of rural development is currently limited to its use as a cooking fuel in the home.

Bypassing the plants and going straight for solar energy is more direct way to harness heat or generate electricity. Analysis from Trieb et al. (2009) finds that converting the sunlight hitting unused land in Africa alone would be enough to supply the world with electricity 68 times over. The issue is not one of quantity, there is clearly more than enough energy. Rather, the logistical issues of transmitting that energy and the economic sustainability of building and maintaining the infrastructure. Nonetheless, solar power is perfect example of decentralised source of energy: during the day at least, it is available almost everywhere.

Light can be converted to electricity or it can be concentrated for use in cooking, heating water and space which account for the majority of rural household energy demands (Kaygusuz 2011). Though as mentioned, converting light to thermal energy for domestic uses is not ideal – householders typically 'stack' (combine) the use solar cookers with other stoves such as gas rings or wood burners (Kaygusuz 2011). Solar home systems, converting light to electricity at the household level, have little impact on cooking (Karekezi & Kithyoma 2002) and are more suited to cost-effective lighting or similar low-demand applications (Diouf & Pode 2013).

Other renewables have their own strengths and weaknesses, carving them their own niche applications. As they did not appear in the fieldwork of the PhD they are not relevant to discussion here. Suffice to say that modest capture of these renewables is enough to satisfy the global primary energy supply (IPCC 2012, figure SPM.4, p.12). Though abundant, these forms of renewable energy aren't as readily harnessable as fossil fuels. Of note, India with its rapidly growing economy and concurrently rising demand for energy has been forced to make very ambitious targets for installing renewables despite their large coal resources (World Economic Forum 2016). There is disparity in that countries of the South face limitations in imitating the fossil-fuel powered development that the North did in the industrial revolution, yet, arguably, the environmental imperative takes precedence.

3.5.1.2 The (un)viability of fossil fuels

> We're not going to be able to burn it all – Barack Obama (Friedman 2014)

This argument will now work towards setting a boundary condition in energy planning, that fossil fuels are not viable as a staple energy in the long term. There is much debate around their use in the future but the point made here is that it would be problematic to allow their continued central role. The issue is exacerbated by the phenomenon of carbon lock-in (Unruh 2000). The path of scientific advancement has led to fossil fuels becoming ingrained through generations of interlocking technological and social development. This affects everything from big business in the North to small-holding farmers in the South.

The first part of the argument for the boundary condition is that fossil fuels are a finite resource (in any reasonable timeframe). Due to lock-in there is a compulsion to find and extract more fossil fuels as opposed to transitioning to non-fossil fuels. For instance, the recent shale movement has significantly the increased supply in the USA market, partly due to this, the price per barrel of crude oil has dropped below $50, a dip unseen since 2008 (Baffes et al. 2015). Though this does spell out a benefit in terms of energy security it would be unwise to put faith in the stability in oil prices for which volatility and uncertainty are the norm (BP 2015a). The bottom line is that these fuels are becoming harder to extract, their viability is dependent on the energy-return-on-investment for them, which is declining:

> …in the race between technological advances and depletion, depletion is winning (Hall et al. 2014, p.151)

The second part of the argument for the boundary condition is that fossil fuels are so tightly linked to climate change. Demand for energy has increased as society has developed; since the 19th century fossil fuels have become dominant in the energy supply and these fuels are responsible for the majority of greenhouse gases emitted in this time (IPCC 2012). Now, these emissions are affecting the environment: the air is getting warmer, heat waves are more common, the oceans are rising and becoming more acidic, the icecaps are shrinking and snow cover is decreasing (IPCC 2013). As such, any recommendations made for improving the way in which energy is accessed must take into account that burning fossil fuels on a large scale is linked to unacceptable damage to the environment. For the purposes of this project, the implication is that fossil fuels are double-edged, though their use may encourage economic development and alleviate poverty, this may exacerbate over-arching problems of sustainability.

3.5.2 Electricity

Having dealt with sources of energy and their potential, attention is now given to electricity which plays a pivotal role in energy access. With the correct devices, electricity can be put to nearly any task so is clearly relevant to the capabilities approach, though its generation and transmission are problematic.

The infrastructure needed to handle this energy tends to come in three forms: broad reaching national-grids supplied by large power plants, mini-grids with smaller generators that cater to fewer consumers, or non-grid systems with micro- or pico-generators providing for a single building or device. The scale upon which these different systems operate runs from centralised-to-decentralised and the associated technologies have their own performance issues – affecting the quality of electricity and the consequences for the user.

3.5.2.1 Grid and off-grid technologies

Electricity can be transmitted over long distances. In a well-built system only a small fraction will escape as resistive-heat (around 7% of supply (EIA 2013)). This allows generation to take place far from the densely-populated areas where, in the case of fuel-burning plants, it would do greater damage to people's health (Martin 2009). However, the costs of transmission and distribution can account for 30% of the price of electricity – for households this can be over 40% (IEA 2012). Mains grids are expensive infrastructure, they are effective at providing electricity at voltages which can power very demanding devices such as water pumps.

Extending the grid bears a cost relative to the distance from the generator. At some point, the cost of wires and pylons outweighs that of a stand-alone system, so it becomes financially logical to commit to decentralised generation (Kenfack et al. 2009). This can save on grid costs and transmission losses; using multiple generators can also remove the reliance upon a single power source (Martin 2009). Dispersed generation is an independent activity, freeing the user from the caprice of the electricity market, but only to the extent that the user can manage and repair their own home or mini-grid system. Indeed, customers who prize reliability may invest in decentralised generation for precisely this reason (Pepermans et al. 2003), such as hospitals or other enterprises sensitive to blackouts.

Due to these differences, there is no best option for how to provide an electrical connection to homes, businesses or public institutions. The mains grid performs better in many ways (higher output and centralised maintenance) but these systems may not be economically feasible for poor consumers. The prohibitive cost can be reduced using technology such as the Single Wire Earth Return; this is much cheaper than using 3-phase lines as in conventional transmission. This cheaper infrastructure played a large part in facilitating South Africa's very successful electrification scheme (Marquard et al. 2007). Nevertheless, the expense of grids inhibits their expansion.

Currently, diesel generators are the most popular choice for decentralised, rural electrification. They are commercially available from sizes less than a kilowatt (enough to run a few electrical appliances simultaneously), up to over a megawatt (enough to provide power for a small town).[2] At least for the smaller units, this popularity is due to the ease with which they can be installed, operated and maintained. Many generators are quite portable and there usually is a good network for spare parts even in rural areas (Practical Action 2002).

For the user, receiving electricity from a centralised grid or their own decentralised source has mixed benefits. A study by Wamukonya & Davis (2001) in Namibia looks at the opinions users had of power from the grid versus that from solar generators, one difference being that users disliked the limited energy available from decentralised solar power but complained less about the shocks and short circuits that come with the grid. Though the grid had the advantage that it could be used for electric stoves and fridges, the main benefit of electricity is lighting, a service that lower wattage systems can also perform. Thus, Wamukonya & Davis couldn't conclude that either system was crucially better than the other.

A problem of electrification is matching an appropriate energy system to the needs of the consumer and their ability to pay for it:

> Off-grid solutions appear to cater to limited needs of the consumers for lighting and some entertainment through radio/TV connections. Very limited efforts have been found where these solutions have promoted productive use of energy for income generation – (Bhattacharyya 2012)

Off-grid energy systems can be a more cost efficient way to electrify rural and remote users, however, electricity of a lower quality or quantity may not enable the user to access energy in a way that is conducive to development, at least in the economic sense. The energy supply is the supporting platform but the energy behaviours take time to adjust. In Wamukonya & Davis' (2001) study there were few reports that electric cooking was a favoured advantage (which is a competitive edge of the mains grid), though the level of

[2] Assumptions: 1MW generator operating for 8 hours a day can supply 3926 people with an average annual per capita electrical consumption of 743 kWh, such as that in India – this value from the World Bank's WDI.

ownership of electric stoves indicated that it was slowly growing trend. Significantly, without being able to use the high demand appliances, users' favour of them is unlikely to grow. Effectively, off-grid electricity can meet low demand; mains grid electricity can encourage, but not force, higher demand through the adoption of many and more powerful appliances.

3.5.2.2 Financing electricity

Electrically powered devices can give the user very high access to energy. Yet electricity can be expensive, certainly for initial outlays such as generators. This subsection covers value of electricity and the recovery of costs.

Access to energy services has the potential to free up people's time and so is an *enabling* factor in local income generation (Legros et al. 2009). For example, electric lighting extends the working day so more hours can be worked. In quantifying electricity's effect, Barnes et al. (2010) found that what rural Bangladeshi households spent on electricity was returned 3.5 times in their income, and 5 times for nonfarm income. Another study, in Nepal, found that households that created enterprises in response to electrification profited by an average of $912 per year over the $150 gain from those that didn't (Legros et al. 2011). The Bangladeshi case shows that the use of electricity is associated with higher income – the Nepali case confirms this but makes the point that it is with electrified livelihoods that the benefit is maximised. *Electricity is useful but it needs to be used well* – at least for financial sustainability.

Nonfarm income for households often comes though small/medium-sized enterprises, as explained earlier, these can gain from the use of electric tools. A study on micro-grids in rural Kenya showed the productivity of artisans increasing by 100-200% – the increased supply benefitted consumers as prices fell, yet still left the artisans with 20-80% more income (Kirubi et al. 2009). Electricity has a value above its cost, this is not just for the user but also for the markets in which they operate – higher productivity leads to lower prices and greater availability of products.

The evidence above indicates that electricity is beneficial, but there are complications. A study in the Philippines found the effective income-result of electricity only when policy encouraged “*extensive nation-wide coverage”* to mitigate power shortages (Ramos et al. 2012, p.1637), this places a condition on the value of electricity. This extensive coverage is not just a connection for everyone, but also a consistent and useable supply too. Instability in the energy supply can lead to uncertainty in business or direct losses of products and services. The graph below charts reports from various countries in terms of value lost due to power outages versus losses from crime, both given as a percentage of sales. Data is from the World Bank’s WDI.

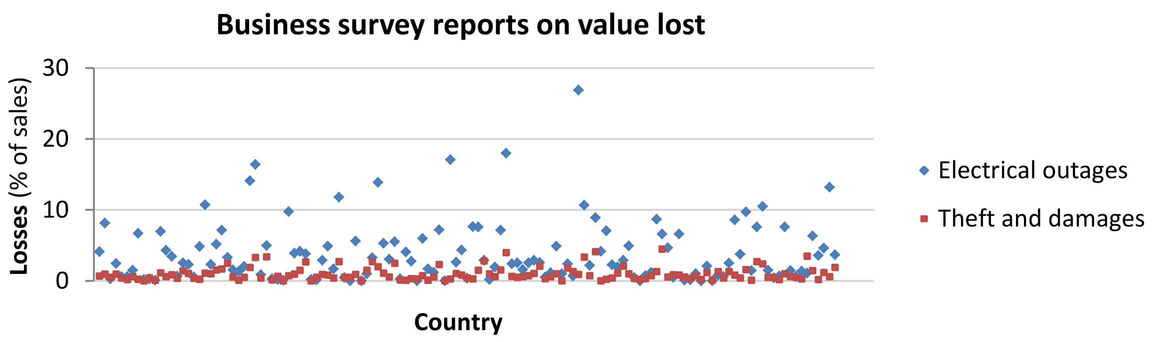


Figure 3.1: Business surevy reports on value lost

Value lost due from theft and damages doesn’t exceed 5% of sales, outages cause far mor loss than this.

Clearly more value is lost due to power outages. Utility companies can schedule blackouts to cope with the high load on a poor supply and these rolling blackouts can be less inconvenient and/or costly for users. Yet, if outages are a daily occurrence (as indicated by surveys on Bangladeshi enterprises reporting 64 per month (WDI)) then instability may be expected but will always be either inconvenient or debilitating.

Power outages have various causes. A case study in Kenya of a community managed mini-grid describes a series of power outages. Firstly, a generator broke down due to unaffordable maintenance. This then lead to load-shedding (planned blackouts) because the other generator couldn’t cope with all the demand. Finally causing sporadically shut downs during heavy rains due to the risk of short circuiting the system (Yadoo 2011, p.124). In this case, the infrastructure was poorly financed; adequate funding could have provided maintenance and safer construction.

In terms of funding, users can be hesitant about contracts and there are also initial costs like light bulbs or appliances that act as a barrier. Again, it comes back to the 'risk-averse' characteristic of the poor (Chambers 1983); with few savings and low income, connecting to an electrical grid can be daunting if the consumer doesn't know that they'll be able to afford the bills in the future; confidence is a big part of investment decisions.

For those who can't (or won't) afford a legal connection, theft of electricity is not unheard of. Termed 'non-technical losses', theft does not claim a large portion of the electricity produced but it does incur other costs in pursuing the incidents and repairing damage of illegal hook-ups (Suriyamongkol 2002). To cope, the utility provider must generate a larger buffer than it needs for technical losses alone, this is a stretch on supply and it adds an additional difficulty in managing and correctly pricing a financially sustainable network.

3.5.2.3 Planning electrification

The content above illustrates that electricity is a key component in development but its provision is not straightforward, nor is the choice of what system is best for a given location. Moreover, electricity is only one of many factors:

> Countless failed initiatives show the futility of premature rural electrification. Providing an electricity supply will only make a significant contribution to sustainable rural development when the other necessary conditions are present.
>
> Security of land tenure, availability of agricultural inputs, access to health and education services, reliable water supplies, and adequate dwellings are among the more obvious of these conditions – (Barnes & Foley 2004).

Clearly there is a need to understand context when planning systems for the provision of electricity. There is an issue of priority in planning, whether a village needs water more than they need electricity; moreover there is an issue in who decides what the village needs and to what extent, this relates to the discussion on development in Chapter 2. The planning of energy access developments must be guided by the ‘right’ information, that is, of sufficient quantity and quality to make decisions which prove effective. Chapter 4 discusses the indicators which give this information. It is that process of guiding development of energy access which concerns this project. For now, the remainder of this section gives historic examples of electrification projects and extracts salient points from these.

Worldwide, electrification has been the lynchpin of economic and social development. In Russia it merged lifestyles in the town and countryside, bolstering productivity, in Cuba it allowed the government to reach out to remote schools with solar cells (Barnes 2005). This provision is a way to tackle the ‘powerless’ and ‘isolation’ deprivations outlined by Chambers (1983) as rural areas become less peripheral in relation to the urban centres of activity.

In post-apartheid South Africa, with the political will to engage in rural electrification, the government could subsidise the electricity tariffs of the villagers from a productive industrial sector. This provided villagers a lifeline of electricity services and urged transition from wood-fuel for cooking (Bekker et al. 2008). Though in India, subsidised irrigation (through electric pumping) had the effect to reduce costs for individual farmers but nationally was of little gain: no additional land was irrigated, the electricity utility was strained and energy imports increased (Foley 1992). Though the scenario was different in both countries, the effect of subsidies was similar: to make electricity a more attractive energy vector, and whilst this may have benefitted the individuals involved, broader consequences were mixed.

China’s electrification strategy was more complex. They used phased development: local grids were installed to cater for low demand consumers, later these were upgraded to central grid systems (Bhattacharyya & Ohiare 2012). China had adopted a bottom-up approach where the responsibility was upon the local community to decide what system they needed. Although the country’s economy could give substantial funding, localised self-reliance was integral:

> Strong state support and the ability to engage the local communities to the creation of local infrastructure have surely contributed to the success – (Bhattacharyya & Ohiare 2012, p.685)

The subject of ownership and the business model of the electrification project have significant implications for the reliability and robustness of the energy system as it determines how operations and maintenance occur. Self-governed projects (such as the Kenyan case study on page 79) have less bureaucracy. The state may have better expertise, more equipment and financial options (cross subsidies). Alternately the private sector can be more efficient but is less disposed to the low returns of rural electrification (Alliance for Rural Electrification 2011).

Similarly to the Chinese model of independent ownership, a successful and on-going intervention in Bangladesh is to support local energy organisations with an expert external body that provides training in capacity building. Local organisations then pass on knowledge about maintenance and productive uses of electricity; consequently electrical connections (via solar systems) are rapidly proliferating and used for income generation (Urmee et al. 2009). The key here is matching the appropriate system to the user, which is possible by engaging them in discussion – again, this links back to the development strategy in section 2.2.4.

Though electricity is a modern and clean energy, its availability does not equate to its adoption, nor does its adoption imply that poor people are enhancing their capabilities and escaping poverty. Planning and policy are fundamental to the success of these projects, though these processes are in turn reliant on a sound appreciation of how energy is accessed. Electricity, and any energy, must be available in a way that matches the needs people have for it. For the planner or policy maker there is a need for data upon which to make their decisions. The next chapter focuses on indicators which provide this.

3.6 Conclusions

This chapter has gone into detail on the energy access perspective. The overall idea is that an attack on poverty can be made by improving people's supply of with energy but also enhancing their associated behaviours. A foundation for the argument takes the capabilities-approach in discerning poverty and couples this with recognition that energy is fundamental to capabilities. Thus, the energy access perspective becomes attractive.

Problematic issues in energy access can be seen where people burn unrefined fuels on inefficient stoves causing pollution and respiratory illness. Or where people cannot dig wells or pump clean water, risking disease and debilitation. These issues of health relate to ideas of resilience in the previous chapter; lifestyles beset with risk are not resilient. Behaviours which harness energy to avoid these risks are basic capabilities, lacking them confines a person in energy poverty. Conversely, making use of electrical devices is an example of more advantageous access to energy. These allow users to perform many more energy services: bright and clean lighting, modern communication and in effective public services.

A severe problem in energy access is where unnecessary drudgery is involved. For instance, manual collection of wood fuel is a time consuming task and requires much labour. For the user this is inconvenient, not only requiring tiring effort but also displacing time they could use to work or relax. Free time and the opportunities it opens up is directly associated with expanded freedoms and poverty alleviation. Promoting healthy and convenient lifestyles is part of energy access, though discussion in this chapter has repeatedly affirmed that any promotions or intervention to 'improve' energy access must also fit in with what people want in their lifestyle and how they want to access energy.

In addition to the complexity of energy behaviours of the user, the content of this chapter has covered issues of supply. The use of electricity, and increased energy consumption in general, is double edged. There are energy behaviours which are unsustainable and it is part of the energy access perspective to be aware of them. An unsustainable supply of energy, or uses of energy which cause environmental damage, again imply an access to energy which lacks resilience. Part of energy access planning is in promoting behaviours which make use of cleaner power sources (for the individual and the environment); this has implications not just for the technical choices of what energy to harness, but also for the socio-political choices of how the infrastructure is managed.

Whilst poverty is complex, energy access can yield a means to understand it. This will be clarified through the next chapter by examining the way in which energy access and energy poverty can each be measured or indicated. The content given in this chapter on the supply side of energy is briefer than that given on the users' energy behaviours – it is important to be aware of supply issues for the context of this project which is mainly concerned with the demand side. In particular, it is finding ways to indicate these demand side energy behaviours that the rest of the thesis attempts.

4 Measures and indicators

> In view of the role and importance of energy in world development, one would expect basic energy information to be readily available and reliable. This is not always the case and — strange as it may appear — it is precisely at a time when more and more energy is being produced, traded, transformed and consumed, when energy dependency is increasing and when greenhouse gas emissions are high on the international agenda that it has become increasingly difficult to provide a timely and reliable picture of the energy situation in many countries and therefore for the world - (ECOSOC 2005, p.3)

4.0 Introduction

The bearing of this literature review now changes to concentrate on tools of measurement such as indicators; particularly, content covers how it is possible to assess and represent energy access. The motivation is to see how the energy access of a certain area can be communicated. From the last chapter: energy access is a diverse and multifaceted concept, it does not submit to a simple measurement of say, joules or watts. There are many aspects of energy access to consider, such as reliability and damage to the environment. An advance upon measurement is to use indicators which can capture more complexity. They do not seek to pin down the exact quantity of something – instead, they are used to give an indication of what it is like or how it is changing.

Recall the measures and indicators of poverty introduced in section 2.1.4. The poverty headcount *measures* how many people live on less than $1.25 per day; this gives an *indication* of how many people struggle to afford an essential basket of goods in that population. These measures and indicators were not covered in great detail but their overview did uncover some aspects such as ratios within populations, relative and absolute quantities, weightings, and the choice of how to consolidate information from several dimensions – these are expanded upon in 4.1.2.1. Throughout the chapter, language around energy access indicators is developed by studying theory and examples.

Studying the theory and analysing examples achieves two purposes. Firstly, this continues the message of the previous section with substantive content on energy access. Secondly, it clarifies how the associated indicators function, what their purposes are and ultimately, what they cannot do. The final sections review what themes emerge from this study into energy access, and also reference the qualitative literature on the subject. Finally, after evaluation of contemporary indicators, this project's objectives are definitively stated.

4.1 Theory on indicators

4.1.1 Purposes of indicators and properties of good ones

An indicator is used to depict conditions, track changes or set goals (Heink & Kowarik 2010). As an ensemble, they can form an image of a system, including the interaction of its components, the trade-offs between important issues and the long-term consequences these have (Vera & Langlois 2007). They are essential tools to promote dialogue between and with people and institutions (IAEA 2005):

> The indicators are not merely data; rather, they extend beyond basic statistics to provide a deeper understanding of the main issues and to highlight important relations that are not evident using basic statistics – (IAEA 2005, p.2)

Indicators are information and their principal function is to inform, not simply by conveying data on tangible events but by creating more sophisticate meanings that we can use to interpret them. Beyond their base function indicators also have political and symbolic roles. Just the process of deciding upon goals and indicators in the UN's Millennium Declaration is an example of great international and interagency cooperation between the many hundreds of actors involved (United Nations Development Group 2003). Also the Human Development Index (introduced in Chapter 2) is telling of the narrative of development, how the conception of it evolved to include more than just monetary measures and this was a response to feelings at the time (Seyedsayamdost 2015). With implications beyond their base purpose, indicators can be very meaningful tools, if they are well-constructed and understandable.

Heink & Kowarik (2010) look at the relationship between the indicator and the indicandum (that which it is indicating). They draw a distinction between an indicator as a sensor or as a measurement. For example, a poor economy can be *sensed* from a small marketplace or *measured* by an audit of the trades that take place. Though the latter is more direct this is not to say it is better:

> The proper question to ask of a procedure of measurement for measuring some quantity (say weight) is not 'Is it a true measure of the quantity or not?' but 'How good an indicator is it of the phenomena it is supposed to give information about?' – (Adams 1966, p.142)

With this, the message from the prior discussion of indicators is emphasised: fitness for purpose determines how good an indicator is. So, indicators should be meaningful but not necessarily in the sense that they carry great volumes of meaning, rather that they can give the reader the information they need to know in order to improve their understanding of the phenomena in question. A simple indicator may be less technically-accurate but as it is more easily understood, it may communicate more effectively – or perhaps it doesn't because it is an oversimplification. The nature of indicators is to convey a select set of information and the good indicator is one where this selection is helpful (Khalifa & Connelly 2009).

Though indicators are used to convey some truth, it is inescapable that the construction of the indicator is subjective. Patterson (1996) demonstrates this by explaining that when computing efficiency there are value judgements made about what is 'wanted' and what is 'wasted' energy. It is clarity and justification of its design that makes an indicator trustworthy, more so than pretence to be entirely objective.

Heink & Kowarik (2010) explain that the indicator exists at a lower level of complexity than what it represents, thus the designer must appreciate the interrelations of underlying factors to create a good, representative indicator. Indicators are used to establish baselines, to monitor changes against this baseline and possibly evaluate the progress towards targets (Church & Rogers 2006). The indicator has a function and in doing that it becomes helpful. Where that function is for planning development, it is the role of the designer to choose the right indicators and manipulate them appropriately, so that the figures can guide the policy maker to an informed decision, the results of which can then be monitored (IAEA 2005).

Given this purpose for indicators, several criteria of good indicators can be selected; these have been expanded upon (in italics) from a manual by Ilskog (2008)

- Simple to understand and apply
    - Users must feel comfortable using the data, be able to appreciate the architecture of the method and understand the nature of each indicator within. *If information is hidden or obscured then the indicator is not serving its purpose.*
- Transparent and inter-subjective
    - Underlying data should be available and traceable. The indicator definition should be unambiguous so there can be agreement between measurers (inter-subjectivity). *If users have a different conception of the indicator, then they are not using the same tool.*
- Robust
    - Indicators should be formulated clearly enough to be replicable in their application. *A robust set of indicators will be applicable in a variety of locations and over long periods of time.*
- Comprehensive
    - The decisions about which indicators to use must be taken such that they cover all major aspects of the phenomena which are being studied. *A decent set of indicators will arise from a strong analytical framework so that core or principle components can be identified.*
- Fair
    - The indicators must emphasise, or at least be aware of, issues that are sensitive with respect to different social groups, such those defined by gender. *The results of indicators may differ even in the same location depending on who is studied.*

These criteria were chosen by Ilskog as pertinent to sustainable development indicators, but they have been refitted to describe indicators in general and they are certainly suitable properties for considering energy access indicators. This language will be used to describe indicators throughout the rest of the thesis and guides the indicator-design in chapter 8.

4.1.2 Specification of indicators

From the above it can be understood that indicators serve a particular purpose. The following distinction is taken from Jesinghaus (1990, 1.2.4)

- Statistics or measures are used to describe phenomena according to exact definitions, they often require some interpretation
- Indicators are used to inform the reader more succinctly, they send a message without need for further elaboration
- Reports are embedded with statistics and indicators, these are analysed and used as a basis for in-depth discussion

Indicators function as standalone pieces of information but they also stand as an intermediary between bits of data and larger volumes of discussion.

In their article, Heink & Kowarik (2010) build up a set of different styles an indicator can have, it may:

- Be descriptive or normative
- Related to a phenomenon entirely or partly though its components
- Be built of elements existing in one or more dimensions
- Consider instances or longer periods of time

These styles would be determined by methodological decisions made in the construction of the measure, thus the right indicator can be built for a particular job. For example, consider again the HDI. Its normative aspects are in assuming development can be perceived through the dimensions of wealth, education and health. By choice this leaves out other components such as inequality. In combining indicators from those three dimensions makes it an index (which still functions as an indicator). Finally, the HDI is taken year on year to understand the extent and rate of development in different countries, as such, it operates on a large scale and over long time periods.

As mentioned earlier, the HDI was constructed with a specific purpose in mind: a more 'human' indicator of development. This reason drove the above decisions that were made in its construction. As indicators are tools built for specific purposes, it is these purposes which must be held in mind to determine how the indicator functions.

The UNDP (2003) have a handbook for indicators, differentiating types by their function: to measure outputs, outcomes or impacts. Outputs are direct measurements against a baseline, outcomes assess progress towards targets, and impacts indicators study what changes have happened and the effects that they have in context. These methodological decisions relate to the purpose of the indicator, whom it is meant to inform and how it is intended help in planning. Output indicators are almost definitively quantitative, whereas impacts can be measured qualitatively – again, the choice relates to purpose and audience.

The difference between quantitative and qualitative indicators is, essentially, that the former are numbers (continuous or discrete) and the latter can be anything from words defining categories up to detailed descriptions as verbal/textual information. Quantitative data can be taken from surveys or records, manipulated mathematically and possibly tracked for changes over time (Parsons et al. 2013), however:

> …indicators that are based solely on counts can be misleading and it is important to ensure that valuable information is not lost in the process of turning complex concepts into a numerical measure – (Parsons et al. 2013, p.17)

Conversely, qualitative information can be taken from interviews or observations; they are sources of narrative information and due to their flexibility and subtlety can be more suited to complex issues where there is little existing information to provide a basis for quantitative measures (Parsons et al. 2013). However, many sources in the literature agree that a judicious mixture of both quantitative and qualitative information in indicators gives the better detail (Bazilian et al. 2010)(MIF & BNEF 2012)(Vithayasrichareon et al. 2012).

The use of quantitative data allows a greater scale to be achieved as it is easier to interpret larger volumes of numeric data. Also, sources of quantitative data can be easier find, whilst they are more generic than qualitative data, they are more transferable from one study to another. Qualitative data tends to be more specific and anchored to its context, but it can be more descriptive about this context (Parsons et al. 2013).

4.1.2.1 Mechanisms within indicators

Before reviewing examples of indicators, this minor section will study some of the mechanisms in which indicators manipulate data. Again, recall the poverty headcount, this took the proportion of people below an income threshold to the whole population. This is a *ratio* of the extreme poor. By taking a sample of the population (usually from household surveys), and calculating the ratio of poor people in the sample, extrapolation can be made to the whole population. The headcount is also an *absolute* measure, as it specifically defines those below a threshold to be in extreme poverty. However, other tools, such as the Gini index are *relative*; they compare people within the sample to one another as opposed to a predetermined threshold. The Gini index considers the percentiles of income in comparison as opposed to focusing on the size of the sample either side of a partition.

Another mechanism is to combine potentially very different sets of information. The HDI, for instance, does this through a process of *normalising* each component then *averaging* them. Normalising finds the relative position of a point of data within the range of data values. This is done in the HDI because the values in its components: wealth, health and education, are otherwise difficult to compare. Averaging then combines the three normalised components, in the HDI this is through the geometric mean, which is just one of many mathematical functions that can consolidate data to an average.

Recall also the MPI, like the HDI this has three components but within each there are many indicators. To combine these fairly, each indicator is given a particular *weighting*. These weightings mean that when the indicators are combined, their influence on the final result is moderated – so the MPI's two indicators for 'health' have the same weight, in total, as the six indicators for 'standard of living'. Thus, neither of those two dimensions takes undesired precedence over the other, although they could by redistributing the weighting.

4.1.3 Summary

Indicators are tools of communication. According to Ilskog (2008) they must have some simplicity for the people acquiring the data and interpreting the results, though they must also have rigour and be comprehensive.

The construction of the indicator must be transparent – both in its architecture and also in the rationale for that architecture. This is especially important for ill-defined concepts such as energy access. In the creation of an indicator, an early step is to clarify the intent for that tool of communication, be that setting targets or assessing impacts. Only with a clear sight of what the indicator is for, a transparent methodology and thoroughly defined terminology can the indicator become a good one. The previous chapters began the foundation of this terminology and the rationale behind constructing an energy access indicator. Armed with the theory on indicators, it now makes sense to examine some examples. These provide a basis for further study of indicator theory. Also, by analysing what they do and don't say, the substantive content of energy indicators can be evaluated, setting up what this project's contribution in terms of its own energy access indicator.

For clarity, the aim is to indicate energy access in terms of electrical, cooking and mechanical energies, but to shift the focus away from the purely technical side. Methods will mimic those below, but will do so critically, in order to avoid making the mistake of pure adherence to the quantitative method. As will be demonstrated, though quantitative information is very significant in conveying meaning – simple headcounts or percentages just don't express the enough nuance of energy access to do the concept justice.

4.2 Examples of indicators

This section covers the most prominent indicator tools in discourses related to energy access. Studying these tools for their purpose, what information they focus upon and the mechanisms they use in manipulating data, will set up the research of this project. Predominantly, this section is to outline that there are many large scale tools but few that use qualitative data or really appreciate the perspective of poor energy-users. In the following, several different kinds of indicator can be seen:

- The single figure indicators used by the UNDP
- The composition of several indicators into a single index such as the MEPI or the EDI
- The multi-tier approach that Practical Action use in their ESI and later for their assessment of community buildings
- The dashboard of many, uncombined indicators used in the SDG monitoring system and as accumulated by the World Bank's WDI

These are different tools for different purposes, none is more accepted than another and there is no internationally accepted definition of energy access nor commonly accepted standard for its measure (OECD/IEA 2012a). The variety in these indicators comes out of decisions made about what information is available, how it can be retrieved and what is the intended effect of its communication. Their methods operate on different scales, use different data sources, work with different conceptions of what energy access means and have many approaches in representing it. Discussion in the final section goes over these differences and considers what the many methods can say versus the complexity of energy access propounded in the previous chapter.

4.2.1 Modern and high level monitoring frameworks relating to energy access

The review of indicators begins with the large scale tools that are used by the bigger actors involved in reducing poverty through energy access.

4.2.1.1 Sustainable energy for all

2012 was named as the international year of Sustainable Energy for All (UN General Assembly 2011), this led to the creation of three objectives to be met by 2030:

1. Universal access to modern energy services
    - 100% availability of an electrical connection at home
    - 100% reliance upon non-solid cooking fuels (as primary fuel)
2. Doubled rate of energy efficiency
    - Based upon energy intensity (total energy consumption divided by GDP)
    - In terms of Compound Annual Growth Rate (a model to smooth the growth curve)
3. Doubled proportion of renewables in the energy mix
    - Renewable energy includes biomass but not nuclear or fossil fuel sources
    - Proportion is taken as part of the Total Final Energy Consumption

(UN-Energy 2014)

This framework uses the three 'time-bound' objectives as targets for development initiatives; each of the three is supported by two output or outcome indicators. Progress is monitored as part of a Global Tracking Framework (GTF), designed to make a clear link between targets and indicators, thus setting goals for the international community. In the GTF, over 180 countries have their individual progress monitored, locating the energy poor and following their development. As this is part of a global initiative with an undertone of cooperation, the tool is partly political: in encouraging nations to adopt the three objects into their policy. The indicators compare the development of different countries, so the global community can see who is growing fastest and where growth is needed most.

Using only a handful of indicators the GTF is of medium complexity. With the inclusion of renewable energy, the indicators are related to overarching environmental issues – though through these alone it is difficult to appreciate the experiences of people on the ground. For example, large hydroelectric dams generate renewable power but worldwide they are responsible for displacing nearly 60 million people from their homes, this further marginalising indigenous people (Bartolome et al. 2000); clearly the issue is complex.

Household data contributes to the indicators but the scale of the framework is global. Focus is on international regions not at the household level. Thus, a trade-off can be observed, the GTF operates at a large scale and is influential upon policy. However it is blind to the smaller scale, though no less important, effects upon welfare.

	Access to electricity (%)					Access to non-solid cooking fuels (%)				
	Total			Rural	Urban	Total			Rural	Urban
	1990	2000	2010	2010	2010	1990	2000	2010	2010	2010
SEA	71	81	88	80	97	29	40	48	27	77
SSA	23	26	32	14	63	14	17	19	6	42
World	76	79	83	70	95	47	54	59	35	84

Table 4.1: Access to electricity and to non-solid cooking fuels

The global tracking framework uses these indicators for its first objective; the regions considered here are south-eastern Asia (SEA), sub-Saharan Africa (SSA) and the World. Noticeably, scores for SEA are higher than for SSA. For electricity but not fuels, SEA has overtaken the world average in the 1990 to 2010 period. Partly this is because SSA has improved less by these indicators, lowering the world average. Also note that rurally, energy poverty rates are higher.

	Level of primary energy intensity (MJ/$2005 PPP)		Change in rate of primary energy intensity CAGR (%)		
	1990	2010	1990-2000	2000-2010	1990-2010
SEA	9.1	8.2	0.17	-1.16	-0.5
SSA	15.5	12.4	0.03	-2.19	-1.08
World	10	7.7	-1.61	-0.99	-1.3

Table 4.2: Levels of and changes in primary energy intensity

The intensity indicator shows how efficiently energy consumption is converted into economic output. The lower values for SEA than for SSA imply that in SEA each joule used can produce more dollars of output. The Compound Annual Growth Rate indicator expresses how the intensity changes year-on-year, notice that SSA's economy became far less intensive over the 2000-2010 period.

	Total final energy consumption (PJ)	Share of renewable energy in TFEC (%)		
	2010	1990	2000	2010
SEA	14741	52.2	37.9	31.1
SSA	16368	72.5	74.6	75.4
World	329834	16.6	17.4	18

Table 4.3: Total energy consumption and share of renewable energy

SEA and SSA have similar values for their energy consumption, though these indicators do not show that per person, SEA consumes more. These indicators demonstrate the renewable content of energy consumed, which for SSA is markedly higher – this due to the greater consumption of biomass in that region.

The data above comes from the 2013 report of the SE4ALL Global Tracking Framework.

4.2.1.2 The Millennium and Sustainable Development Goals

Recall the MDGs introduced in Chapter 2. These eight goals are broken down into 18 targets and 48 indicators so they are more comprehensive than the GTF outlined earlier. Also they are ‘fairer’ (Ilskog 2008) as the MDGs recognise gender and rural/urban divides. Upon review of the goals, the UN have stated progress towards them to be substantial, success has been met in part but is not seen in all goals or felt all regions (United Nations 2015).

For example, the achievement of goal 1A required a 50% reduction in people living below the poverty line. Globally, this reduction stands at 68% – a successful achievement, yet China’s impressive reduction of 94% goes some way to offsetting Sub-Saharan Africa’s slimmer reduction of 28% which is not enough to achieve the target in that region (United Nations 2015). This compensation reinforces the need to decompose indicators by location.

At 17 goals and 169 targets, the SDGs are less succinct. This list was adopted as part of the 2030 agenda by the UN General Assembly (2015). Notably, it adds several aspects specific to sustainability: agriculture, water sources, consumption and the climate. These all tie into the energy access concerns flagged in the previous chapter, but of special note is the seventh goal: “*Ensure access to affordable, reliable, sustainable and modern energy for all*” (UN Economic and Social Council 2016, p.23). Indicators for this goal draw from the GTF and include a target for investment into the energy sector. Moreover, as they are nestled within a larger body of indicators relating to poverty, wellbeing and equality, the SDGs are sensitive to wider repercussions of energy developments that the GTF may not see.

The committee responsible for designing SDGs recognise the need for disaggregated data and innovations in the data gathering techniques. They explain that household surveys are vital when seeking to measure human behaviours. It is endeavours such as these large frameworks that are crucial to the development of good quality and highly available data:

> The SDGs will provide an important impetus to drive available innovations into all major survey programs, thereby filling a critical gap in today’s MDG data (SDSN 2015, p.95)

4.2.1.3 World Development Indicators

The third example considered here is the array of World Development Indicators (WDI) proposed by the World Bank. This is a set of over a thousand individual indicators, representing over two hundred countries for periods of up to fifty years. It is a meta-database: drawing from other sets of data such as those belonging to the GTF, the IEA, the International Panel on Climate Change (IPCC) and the Carbon Dioxide Information Analysis Center. Energy is just one amongst many sectors covered, including: social, political, technical, economic and environmental issues (World Bank 2015b).

Given this scope and mixture of sources it is to be expected that the data for each indicator is not available for every year in every country – more significantly, some sets of data are calculated with underlying assumptions and these are not necessarily consistent throughout the WDI. This means that a degree of care must be taken when manipulating these figures or comparing different countries. Despite this, the WDI are an extremely useful tool due to their magnitude, verification by an accredited authority and, in cases, the work that has been done to fill the gaps in the data. This makes it easier to research a particular set of countries and track their development over time. For this reason, the data used to create graphs and tables within this thesis often comes from the WDI.

4.2.2 Measuring energy supply

As opposed to the large frameworks above, the following indicator tools have a narrower focus that addresses a more specific area of energy access: the supply of energy. The UNDP use the following definitions (paraphrased) in their measurements of energy access from the supply side:

> Access to electricity: the percent of people that have a household electricity connection. The electricity connection may vary by quantity, quality and use.
>
> Access to modern fuels: the percent of people that primarily use electricity, liquid fuels, or gaseous fuels to satisfy their cooking needs. This includes biofuels, but excludes all traditional forms of biomass.

Access to mechanical power: the percent of people that use mechanical power for productive, non-industrial applications, such as water pumping, agricultural mechanisation, and small-scale agro processing (e.g. grinding, milling).

(Legros et al. 2009)

These three categories of supply cover most energy services from the previous chapter so they can capture the breadth of energy access. Yet, they function as headcounts, so reducing a complex issue down to a simple and binary indicator. This stance does have merit: simpler data is generally more robust and more available. Indeed, the UNDP were able to represent 136 out of 140 developing countries with data on access to electricity. They used this headcount of electrical connections to highlight priority: showing that despite only constituting 14% of the population of developing countries, sub-Saharan Africa was home to almost 40% of those without electrical connections.

An example of the UNDP data is given below for the ten countries in the EAP region studied in chapter 2. Data is extracted from (Legros et al. 2009).

	% with electrical access			% with access to modern fuels			Mechanical energy
Country	National	Rural	Urban	National	Rural	Urban	
Cambodia	24	12.5	66	7.5	3.5	30.9	
China	99.4	99	100	42	22.5	64.3	
Fiji	60			52			
Indonesia	64.5	32	94	45.6	22.5	76.6	
Lao PDR	55	42	84	2.6	0.2	8.5	
Malaysia	99.4	98	100	96.7	95.3	97.4	
Philippines	86	65	97	49.4	29.5	73.3	
Thailand	99.3	99	100	63.1	52.7	88.6	
Timor-Leste	22	10.5	52				
Vietnam	89	85	99.6	34	20.4	73.6	
	Data sources used: 2			Data sources used: 12			No data

Table 4.4: Access to electricity and modern fuels

The UNDP collected data from various sources: for electricity the IEA provide this in most countries; for fuels data is usually taken from national statistics but for mechanical energy there isn't any data available from any source as it is not the kind of data that national statistics offices collect.

From this international perspective, a sense of priority can be established as to which country has the least access to modern energies. The report also gives information on whether or not countries have targets for energy access. However, some data on access to is slightly less easy to obtain, for example, regard modern fuels. Data on the adoption of improved cooking stoves is available for only 67 out of 140 developing countries. More elusive still is data on mechanical power, which was available in only three countries, none of which appear in the table above.

There is a need for data on a global scale, to locate the densest and greatest incidence of poor energy access. However, when that has been found and the scope is narrowed to examine a particular country, region or village, then the assessment tool needs to shift from identification of energy poverty (lacking the modern energies) to interpretation of energy access (how that crude/modern energy is being used). The following method operates on a narrower scale and is more comprehensive regarding the energy access of that context.

Practical Action (2012) use an Energy Supply Index (ESI) that assesses the same criteria above: electricity, household fuels and mechanical power – though this tool operates on a village level. The different parts of supply are graded on a scale from 0 to 5, a step away from the binary take on access outlined above. This makes the index more comprehensive whilst still being simple to use. Each level on their scale indicates how far the household is along "*transition pathways towards cleaner, healthier, and more convenient supplies*" (Practical Action 2012, p.45).

Methodologically, there are a few issues here. First, the different dimensions of supply overlap: electricity is a class itself but also labelled as a sophisticated cooking fuel and indeed it can be used for mechanical power. In assessment, this overlap is difficult to avoid due to the ease with which electricity is converted into other forms of energy, the effect is that the dimensions of the ESI are not independent. This difficulty in considering convertible supplies of energy highlights the need for a demand side tool to measure energy services (given in the next subsection).

As a second point, the ESI uses discrete measures; this risks the misinterpretation of a household's supply when it doesn't fall neatly into a predefined category. Also, the categorical/numerical nature of the data affects what mathematical operations can be used to find its average. In effect, they add a weighting to each category, then take the mean of those – this is different to the original discrete data.

Lastly, the ‘transition pathways’ that Practical Action write about assume linearity in development, yet there is evidence against this idea of an ‘energy ladder’ where a newer, modern energy replaces the older one. A study of rural households in Bangladesh found that biomass is a dominant energy across all levels of income (Barnes et al. 2010). Even when modern fuels are adopted, biomass is still retained; this makes it inappropriate to classify the energy supply into discrete categories. The transition behaviour has been labelled ‘fuel stacking’, whereby a household will introduce a new source of energy into their supply incrementally, beginning with minor tasks and working up to the most energy consuming activities, cooking and heating (IEA 2006).

Given this observation, it makes sense to pay heed to energy behaviours. By changing the nature of assessment, consideration is given to how the energy is used rather than whether or not it is simply available.

4.2.3 Measuring energy services

The Multidimensional Energy Poverty Index (MEPI) aims to appreciate the deprivation of access to energy service, and in doing so, to assess the ‘incidence and intensity’ of energy poverty (Nussbaumer et al. 2011). It is very much a cousin to the MPI (covered in Chapter 2) in that it uses a diverse batch of yes/no indicators to see which households are suffering from a single or multiple deprivations – likewise it is simple, transparent and robust. It complements supply side tools by representing the demands for energy, namely: cooking, lighting, household appliances, entertainment/education and communication.

Practical Action (2010) also make assessment of energy from the demand side, their list of what constitutes Total Energy Access (TEA) is akin to the MEPI but adds the following services: heating space and water, cooling, and earning a living. For each energy service the TEA has at least one condition to be met.

These tools have similar purposes and regard similar issues but they have dissimilar functions and mechanisms. For example, the MEPI uses ‘ownership of a fridge’ as an indicator whilst the TEA considers the energy service itself by measuring how long food can be preserved. This mirrors the assets-capabilities debate on poverty from section 2.1.1.

The TEA assessment is more comprehensive whilst the MEPI is robust. There is no disagreement about whether the fridge exists in the household (MEPI) but it may not be used effectively or equally. Conversely, the rate at which food perishes (TEA) can be contested and will surely vary with the seasons, though it is more directly linked to the effects of using energy.

The MEPI uses the ownership of other assets as variables in its index, for example, owning a television is used to represent access to entertainment. Such indicators are known as *proxies* – owning a TV does not imply that one is entertained but it can be used as a rough indication of this, so, over a large sample, the MEPI can suggest the quality of entertainment people enjoy in that area.

Practical Action’s tool differs in that indicators are based upon a physical measurement or provable capability – not just the ownership of an asset. So, they measure what is occurring rather than using a proxy, it is more direct than a suggestion and can be used on a smaller sample.

The proxies for the MEPI are found within a pre-existing database, the Demographic and Health Survey carried out by USAID. Few resources are spent and a measure is taken of over twenty countries in Africa. Conversely, in piloting their TEA and for later assessments, Practical Action need more intensive study in the field. Finding proxies or conducting bespoke studies are different approaches in data collection and ultimately lend themselves to different purposes, though there is an interaction between the two. Part of Practical Action's work is to encourage energy access related information to become part of census and national survey data. They do this by demonstrating the value of tools such as the TEA so that that kind of information will eventually become more widely available.

4.2.4 Energy in the community

Indicators up until this point have been reliant upon household data; this scope will now be extended to the community. As was explained in the previous chapter, many basic needs are met through energy services accessed outside of the home.

The International Energy Agency (IEA) developed a tool for assessing energy access that uses this wider scope. The Energy Development Index (EDI) looks at access to energy with both 'household' and 'community' indicators. The former is subdivided into electricity and cooking fuels in the residential sector, and the latter into public services and productive uses at the national level (OECD/IEA 2012a).

For the public services indicator, the EDI uses data on the size of the service sector, the electricity it consumes and what proportion of the sector is public – these figures are combined to estimate the per capita public services electricity consumption. The energy accessed for productive uses is calculated from the ratio that the sectors of industry, transport, services, agriculture/forestry and fishery take in total final consumption of energy.

These indicators are combined to form an index; information about very different indicanda is normalised, then merged through averaging. Data on household access is found through direct measurement whereas the community access is inferred through estimation. In combining numbers with different origins, an index becomes a mix of 'apples and pears' (Roberts 1979), though this obstacle is inevitable if the aim is to meld information about the household and community when the same form of data is just not available for both sides. Choice of indicators is influenced by availability of "*regular, reliable and robust data"* (IEA 2012, p.9). There are trade-offs within the selection of indicators – at these junctures, the core purposes of the indicator must drive decisions (in this case, frequent and consistent reporting over a long time period).

Practical Action also consider the wider community, they have two approaches in their assessments. First, they developed a tool based on ecosystem modelling of the markets related to energy access (Practical Action 2010b); later, they examined the role of energy within key entities in the community: schools, hospitals, government offices and in infrastructure services (Practical Action 2013).

Using the ecosystem-analogy for business markets is an established method. Ecosystems and markets have similar growth and both contain a highly interrelated and interdependent network of members (Iansiti & Levien 2004)(Moore 1993). Indicators in the model focus on the 'health' of the ecosystem, reflecting how well the energy access market is doing. Ecosystem health is defined by the variety and activity of members and the linkages between them. Practical Action translate these factors into indicators that quantify the investment into energy access infrastructure, identify if a country's government has energy targets in its policy and also audit the number of members in the energy access market (Practical Action 2012). Though insightful, this tool is difficult to use or even to interpret.

The other tool that Practical Action promote for assessing the community looks at communal buildings in a village (for example, schools and hospitals). The tool uses a tiered scoring system that models energy in progressively improving states of access. This is reminiscent of their method for the ESI except that the tiers in this method are inclusive of the services and devices specific to each community building, such as teaching and medical equipment. At lower tiers there is only access to lighting or handheld devices like radios; tiers beyond this represent batteries, improved stoves and eventually grid access. Higher tiers are associated with increments in the quality of the electricity delivered and reliability, until the top tier when all energies, equipment and services are accessible. Similarly to the ESI, this assumes that energy develops in a unilinear manner or at least that it can be represented by scores in one dimension. This tiered approach is easier to use, it can set targets for the energy access of individual community buildings but its overarching mechanism of linear stages of progression lacks nuance.

The tools above have various effects in their inclusion of community energy access. The EDI has a broad visibility which strengthens its purpose as a monitoring tool. Practical Action's ecosystem analogy recognises the many interrelated actors and forces affecting them – difficult to indicate but not insignificant in terms of encouraging development. Similarly, their tiered approach highlights feasible applications for energy with respect to each community building, thus adapting the scope of the tool to the subject in question. Any indicator must be selective about what elements to include and those elements should tie into the purposes for the indicator – these examples show that considering just the unit of the household can miss out on crucial energy behaviours.

4.2.5 Quantification of energy

These are the last examples of energy access indicators and this subsection finishes the theoretical discussion of them. Content here reflects upon quantifying energy behaviours and what implications can come from that process.

Kemmler & Spreng (2007) write about large indicators sets critically, maintaining that they can cover any number of issues but truly provide little insight into what is going on in the world. As such, they recommend a small set of indicators that are neither 'exhaustive nor exclusive' but cover those issues that are of 'paramount importance'. They design and analyse a framework of the whole energy system, from resources to end uses, to identify which aspects of the system need indicators. Using these, Kemmler & Spreng demonstrate a principle advantage of quantitative analysis: in correlating their energy indicators to other measures of poverty. As in section 2.1.5, this process clarifies links such as that between energy and finances. Consequently, the study finds strong correlates but states that a single energy-indicator is insufficient to represent the complexity of poverty. Ultimately, because their data is sourced from another party's survey the conclusions drawn are limited to pattern recognition. Though these patterns can suggest underlying relationships, the analysis is only superficial.

In another quantitative study, Adkins et al. (2012) surveyed households in ten rural locations across sub-Saharan Africa; as a bespoke study, the authors are more able to reflect upon the people involved. Their results show the villages' energy portfolio in terms of which energies households use for which services, the labour and costs involved, and further details of how they are accessed. The data is diverse and spread over many tables; these are 'statistics', not 'indicators' (Jesinghaus 1990). Sifting through this information, a sense of priority can be established as to which location is in the direst need of aid. For example, data on the time spent collecting fuel-wood or the exposure to smoke from cooking can show which households are burdened with the most drudgery and are at the most at risk of lung disease, so corresponding initiatives could prioritised for those areas.

The data set is large, comprehensive and does not rely on proxies; a detailed picture emerges revealing many aspects of access to energy. For instance, it distinguishes the gender of the fuel collector, adding fairness to the overall message conveyed. However, because there are so many dimensions considered, it is implausible to consolidate them without risking 'compensability' (Munda 2005) – loss of significance in combining data as high values excuse low ones. So, Adkins et al. are not giving an energy access indicator – they are presenting empirical household data but they do supplement this with a brief explanation that cannot be conveyed quantitatively.

Factors within the qualitative explanations provided could be analysed for quantitative variables that represent them, then these could be adopted to bolster the database. Indeed, this is the concluding remark of the paper, that follow-up surveys would not only monitor the changes in the data, but also include new indicators relevant to the energy sector. Yet, it must be noted that much of the communication about those households in the data set comes from the written explanation beside the tables. For example, the table on cooking energies says that only the Senegal village used LPG, the following annotation explains why:

> The high level of LPG use … is linked to Senegal's national policy promoting LPG, which was initiated in 1974 with the aim of replacing 50% of charcoal consumption (Adkins et al. 2012, p.255)

Thus it is apparent that quantitative data has a purpose but that it also benefits from being paired with qualitative data.

4.2.6 Significant themes or aspects within energy access

Previous subsections have dealt with the different strategies in indicating energy access and simultaneously covered theory on indicators. This subsection deliberates in more general terms what *aspects* of energy access the indicators consider. This will feed directly into the research methods. Obvious aspects are quantity and affordability; some approaches use figures for these to declare a minimum consumption in energy units for households (Srivastava et al. 2012) or to base an energy poverty threshold upon spending (Barnes 2010). The cost and amount of energy consumed are important factors but so too are other, less readily measurable aspects. Practical Action (2012) cut across their divisions of energy supply with the following *themes*:

- Reliability: the availability of energy supply throughout the day or year, including the predictability of this supply
- Quality: relating to the factors of supply which would change the performance of the energy service
- Affordability: energy is considered in terms of its proportion of total operating costs or total labour of the user
- Adequacy: this concerning the quantity of energy supplied, possibly at its peak

As each of these themes can be applied to every form of the energy with which the user is supplied, it makes a makes a complete matrix, facilitating analysis. Thus, it can show that a cheap and abundant supply is not the whole story, other factors make a difference. To the list above, the IEA (2012, figure 2) would add ‘availability’ and ‘convenience’: these relate to the technical possibility and practicality of the user having the energy when and where they want it. Using cross cutting themes creates a rubric for assessing and representing energy access – it is a tactic employed later in the thesis.

The Global Tracking Framework also uses cross cutting themes; these are for a separate assessment it uses at the household level. The themes of the GTF are spilt into two distinct sets of attributes, one for the supply of electricity and another for the primary cooking method (other energy supplies, such as mechanical energy are not covered in this arm of the approach). By doing this the GTF considers the energies for electrical appliances and for cooking as separate entities, for the user these forms of energy have different meanings despite the fact that they can be measured in the same units.

For a household’s electrical supply the attributes used in the GTF are roughly the same as Practical Action’s themes above but with addition of ‘evening supply’ and ‘legality’ (World Bank & IEA 2014). Both offer an important insight into the users’ experiences of using energy. However, through these indicators issues such as an illegal connection are only given to be symptomatic of low energy access and do not express how it affects the user. The themes in the GTF give focus to supply and infrastructure, not personal experience.

The other set of attributes, for cooking supply, are subdivided to consider the stove itself but also how it is used, these are taken from the GTF report (World Bank & IEA 2014).

- Actual use
  - Conformity – proper use of parts like the chimney, and cleaning as required
  - Convenience – time for fuel collection and preparing fire
  - Adequacy – unconstrained fulfilment of cooking needs

- Technical performance
  - Efficiency – conversion of the fuel's chemical energy to useful thermal
  - Indoor pollution – smoke within the household
  - Overall pollution – emissions into the environment
  - Safety – risk of burns or accidents not relating to air quality

These attributes are what the GTF measures, with the technical performance taking priority over the actual use in determining the overall score. So, this method has a guideline for what the important factors are and how to combine them, in this sense it is an effective tool for assessing the health effects of cooking practices.

A weakness in all of these strategies is that though a set of qualities is specified, and though these qualities are credibly of great importance, they are still represented by quantitative indicators – even a very well-chosen quantity cannot hope to be fully representative of a quality. When these qualities are accepted as relating to the experiences of people, it becomes even harder for them to be quantified. For example, the GTF chooses convenience as an important part of access: they measure this in terms of time which tells nothing of the effort exerted by the user or the bind on their freedom. Essentially, the attributes outlined above do not lack significance but in the process of becoming quantifiable indicators their meaning is diminished.

4.3 Discussion of the energy access indicators

Several topics of discussion arise from the review of energy access indicators. The first is to consider what facets of energy access are missing from the approaches above; this will outline the purpose of the energy access indicator constructed in this project. With that purpose in mind, an outline will follow of what kind of indicator is needed in terms of its scale and data source.

The image below gives an overview of the content considered so far relating to energy access. It is the beginning of a framework that will be used to select indicators (as in (Kemmler & Spreng 2007)).

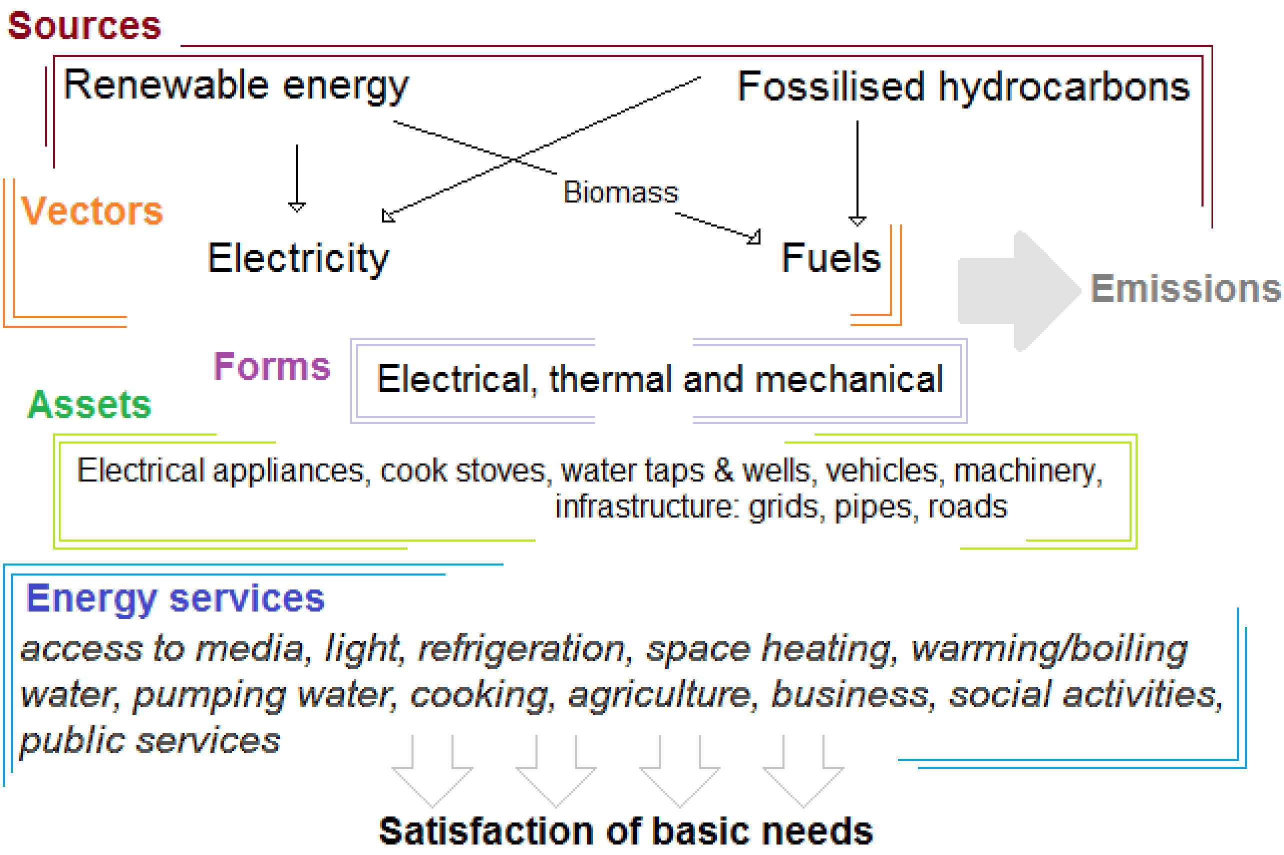


Figure 4.1: A map of the energy access landscape covering the physical side of energy access

By designing the map from 'sources' to 'services' the remit of energy access can be seen and with those groupings, the feasible architecture for an analytical framework becomes apparent.

4.3.1 The missing elements within energy access indicators

Comparing the content of Chapter 3 with the indicators of this chapter reveals gaps in the assessment of energy access. Communication, as an energy service, receives little attention but the more striking failures are in representing the mechanical energy for farming and providing water. The UNDP's indicators of energy supplies do have an indicator for mechanical energy but this has alarmingly little data coverage. Another candidate is the WDI statistic on the number of tractors used in agriculture but this offers a very limited message – it is linked to industrialised farming but less so to the mechanical energy access of small scale farmers. Additionally, the WDIs and SDGs also pay attention to water sources, but these indicators represent if the source is 'improved' (see 3.1.2) as opposed to the way it is accessed by the users. Whilst there is a great level of depth for studying cooking behaviours (as seen in 4.2.6), there is no equivalent for mechanical energy – the closest is Practical Action's ESI which considers a linear ranking of ways in which to access mechanical energy, but this has methodological limitations and a reliance upon the disputed premise of an energy ladder.

There is an impetus to study mechanical energy, its role in farming is vital to the income of rural people as are clean water supplies essential in satisfying basic needs. Thus, this form of energy is a significant element that should be monitored by suitable indicators.

Practical Action have a sophisticated approach but they too leave out access to water due to the difficulties in constructing indicators around it:

> Water supply (for drinking and irrigation) is another important service often linked with energy, but is omitted as it is more strongly dependent on water resource availability and pipe infrastructure (often gravity flow) than energy – (Practical Action 2010b, p.1)

In later publications, Practical Action return to the concept of water, but keep it in terms infrastructure rather than the energy service of its provision (Practical Action 2013). Here, it can be seen that the difficulty in decoupling an energy service (providing water) from the geography of the landscape (water resources) changes what goes into their assessment, thus, it warps what is understood to be part of energy access, at least from the perspective of institutions and policy makers relying upon the indicators. To avoid this difficulty another approach must be taken, one that focuses upon the user for the quality of their need satisfaction. In doing so, the energy a person accesses can be evaluated in their terms rather than being tied down to direct measurements of physical characteristics. In essence, this is what is missing from all of the energy access indicators – the perspective of the energy user.

In 3.3.1, the energy service of communication was explained to be important in business, for personal interaction and ultimately for participation in society. The indicators here only look at the ownership of communication devices. Practical Action's TEA and the MEPI rely on a single question about the presence of a phone or internet enabled device; also the SDGs have only one indicator for this, the number of mobile connections per 100 people. These narrow enquiries are merely proxies to the complex behaviours within the energy service of communication. A more sophisticated approach is needed than the mere existence of the device and energy to power it; rather, attention should be paid to how people use the devices in order to understand how effectively the energy is being accessed as part of that energy service.

The strength of the energy access perspective is that it can see a broad range of the capabilities related to basic needs and poverty. However, too few capabilities (and the corresponding energy services) are represented by indicators on energy access. Moreover, the representations that do exist strive for objective data that does not really express if the users are satisfying their basic needs (as in Srivastava et al. (2012) on benchmarks).

4.3.2 Methodological issues

Thus far, attention has been given to suitable indicandum for energy access indicators. Now, discussion brings to the fore decisions that must be made in the construction of indicators so that they can suit a given purpose. A recurrent message in this review has been that the purpose of the indicator must drive the methodology – the following four minor sections will lay the groundwork for this.

4.3.2.1 Scope and scale

Indicators work at various levels, whilst two methods might draw from the same household data, one may speak for just the village but the other for the whole country. From the work of

Kemmler & Spreng (2007) it is clear that the less complex indicators are more suited to data which is aggregated over a larger area. Conversely, village level indicators, like the TEA, can have a more complex mechanism. Though in either case, care must be taken in constructing mechanisms to avoid compensability of too much data. Effectively, there is a limit on how much can be said about a given number of people.

This is the subject of scope. When the purposes of the measure are to monitor many people over a long period of time, then the indicators used should be based on data which it is easy to capture – both temporally and spatially – otherwise the potential to make comparisons is weakened. This is a constraint on the actor who carries out the assessment: they must adhere to consistency in data acquisition, even if this means relying upon proxy indicators which are more available (recall that the UNDP relied upon fuel type and not cook-stove type due to limited data availability, table 4.4). The UNDP measures describe energy poverty based upon binary definitions relating to consumption – this is a practicality mandated by scale when locating the world's energy poor people.

For their tool, the IEA use consumption databases to project future demand on a global scale estimating the growth of energy-economies worldwide (IEA 2013b), navigating pathways to decarbonisation (IEA 2014) and universal energy access (IEA n.d.).

On a smaller scale a different purpose can be seen for indicators – showing what it is like to be energy poor. Kemmler & Spreng (2007) were able to use a database from the National Sample Survey Organization to do just that. Their work shows the relationship of energy with other factors that affect the energy poor. However, as a consequence of zooming in from the global scope, the details about the energy-poor that Kemmler & Spreng produced are specific to their Indian sample, limiting the transferability of conclusions. The scope of an assessment is crucial and must match the intentions. Consider Practical Action's TEA tool which concerns itself with household data to represent individual villages – the comparisons this tool makes would have very little meaning if the scope were larger than a village as the areas of deprivation would become obscured in a big enough set of data.

4.3.2.2 Data source used

Proxies are a powerful tool allowing for new analyses at a low cost. The country-level monitor of the GTF runs on existing databases, using access rates and residential electricity consumption from the IEA. It estimates a tier of energy access to which each country belongs – showing for instance, that southern and eastern Asia have, since 1990, been below the world average for electricity access but that recently the east Asian region has grown to par with the world average.

It is for purposes such as this that Practical Action, in all their PPEO publications, make the call for more data to be made available, specifically on energy access and the state of it in places that are unnoticed, such as community buildings. To work around this deficiency in the data sources, the EDI manipulates existing data by permission of several assumptions, notably that efficiencies of energy conversion are similar in the sectors across every location. With better data sources (for instance, on energy efficiency or access within each sector) then a more direct indicator could be constructed.

Clearly, the meaning and purpose of a measure is influenced by the data sources and indeed, the methods available to gather more data. When using information from a database one must be aware of where the numbers come from:

> … statistical systems in many developing economies are still weak; statistical methods, coverage, practices, and definitions differ widely – (International Bank for Reconstruction and Development 2013, p.318)

There is more to a clean table of figures than meets the eye; information is lost through quantification (Parsons et al. 2013). The core issue becomes whether or not the data source can communicate meaning about the indicandum with suitable context – when using quantitative data this is difficult.

The MEPI developed by Nussbaumer et al. (2011) uses another party's survey data. Evaluation relies upon checking the robustness of the model (altering parameters, not variables) and comparing the results to a measure that already exists (such as the EDI, which uses some of the same components). On the other hand, it is possible to use data which is more directly related to the subject being studied. Practical Action and Adkins et al. (2012) acquire this kind of data by carrying out household interviews as opposed to mining surveys databases. They developed indicators by talking to the energy-poor and observing their environment. The indicators they selected could then be embedded within a contextual understanding of the energy poor that they studied.

The trade-off here concerns the quality and quantity of data, and also, if it is qualitative or quantitative data that is used in the study. For this reason, it is essential that purpose of the indicators is fully understood in the methodology so that the right data source and type can be chosen. The data source and type dictates what information can be used in the indicators, which ultimately determines what message they can convey.

4.3.2.3 Audience

The motivations behind indicators, whether they act on a large or small scale, are to do with conveying information in order to allow astute decisions. This may be to plan an intervention or conduct an impact assessment of one already in effect. That can be done by measuring the progress towards a specific set of goals (as in, outputs, outcomes or impacts (UNDP 2003)). The issue raised here is whom the indicator is intended to inform. An example of goal-tracking comes from the GTF and also the set of indicators that underpin the MDGs/SDGs. These are all programmes that stem from big actors in the field of development, such as the World Bank and the United Nations. They exemplify how international organisations influence national policy. Also, as they manage large channels of funding it is clearly important that they monitor the effect the spending is having, so whilst the core aims that the tools display are in sustainable development and poverty reduction, an overriding message that comes out of reports on those tools is the coordination and cooperation of the international community (World Bank & IEA 2014)(United Nations 2015).

These large frameworks are designed to provide coverage of the important aspects of energy poverty and they appeal to planners and policy makers at the national level by monitoring progress at that scale. Conversely, Practical Action's ESI is aimed at the level of the individual village, tracking progress at the smaller scale. Though their tool relies on the notion of a linear development pathway for energy behaviours (this being fairly reductive for a small scale approach), the motivation is for the ESI is to gain a broad enough understanding of how energy is being accessed so that suitable initiatives can be planned for particular locations. This village-level information is unsuited to larger frameworks – the intended audience is the local arm of some organisation acting in the area or even an individual within the village seeking the best way to plan energy based development.

For other indicators, such as the EDI, their effect is best realised over time. The EDI does not have a threshold where poor performers are given special attention, rather, the scores are tracked over time so that decision makers can be aware "*important elements of a country's energy development"* (IEA 2012, p.13). The motivation the IEA have is for a long term project; like the GTF and SGDs, this monitoring is more top-down and policy orientated.

4.3.2.4 Perspective on energy access

A difficulty faced in the study of energy access is that it is not defined in a way that it internationally accepted (OECD/IEA 2012a). Immediately, it can be inferred that as there is no commonly accepted definition then no measure is conventional. Energy access is a useful lens through which to assess poverty, this can be seen via the momentous proxy that is the connection to a source of electricity. This quantitative approach is used in the yes/no connection to electricity indicator in the WDI or as used by the UNDP. Alternatively, energy access can be perceived from the broad span of capabilities and assets associated with the user and evaluated by the extent to which that energy access is used to satisfy their basic needs – this being a more qualitative approach.

The more in-depth take on energy access is not forged by the need to represent and monitor access on a large scale. Such an assessment could be imbued with a fuller conception of energy access and as such, will be able to comprehend it to a greater degree, that is, with more breadth and fidelity. For example, Practical Action's ecosystem approach accepts that energy access is not representable by a mere few indicators because there are significantly more than a few aspects of energy access to represent. Their style is not to shy away from a perspective on energy access which is difficult to indicate, because the reasons that induce this difficulty – multiple, interrelated factors across many dimensions – are exactly those which the reader should be aware of in the study of energy access. If the ultimate intention is to plan and design anti-poverty interventions then complexity must be visible through the perspective of energy access.

Further, Practical Action's use of a tiered approach gives a less vague and more informative perspective than the binary approach of yes/no connection to electricity. However, as these tools are still in the development stage, each set of findings is heavily annotated in order to explain to the reader what is being shown and the reasons behind what may be a statistical anomaly or statistically significant finding (Practical Action 2013, p.27-33). Thus, it is this description which conveys a fair proportion of the information and not the figures. The figures themselves are not clinching proof but part of the evidence in Practical Action's report. Whilst it is almost inevitable that a novel tool must come with some kind of instruction manual, it is also clear from Practical Action's numerous publications that the qualitative accounts have an irreplaceable and significant part to play in the indication of energy access. This is also seen in the work of Adkins et al. (2012) – it is so hard to distil the information and implications within their mass of data, that the reader must use their written accounts to understand the reality that the figures are indicating. At times these accounts are little more than a crutch but at others they form the crux of the message conveyed.

As a final point, the large scale efforts to monitor energy access are fallible when examined more closely; though simple yes/no definitions seem to induce rigour, this is not certain:

> India used to consider a village electrified even if no households had access. In Cambodia, the government counted only grid-connected villages even though a large number of villages had micro grids served by independent operators (Pachauri et al. 2012, p.2)

The use of a quantitative indicator here was interpreted differently in India, Cambodia and elsewhere – the analysts had a different perspective on energy access. Simply using a quantitative approach is not enough to align perspectives of local agents carrying out the data gathering. Moreover, considering electrical connections as a yes or no variable is a narrow insight into the associated energy access. As a lens to view poverty, energy access has greater potential, and is deserving of more, than just a single yes/no indicator.

4.3.3 Input from anthropologies on electricity

As stated in Chapters 1 & 2, an overarching aim of this project is to conduct a Rapid Rural Appraisal of energy access. Ultimately, the kind of tool created is an indicator, but in that it draws on a RRA's mixture of statistical and ethnographic methods, it also makes sense to consider what themes emerge in anthropologies into the much related subject of electricity.

The literature here is thin, in part promoting this PhD's qualitative study. Notably, Tanja Winther (2008) is prominent in the field with her book 'The Impact of Electricity', studying its arrival to villages in Tanzania. She writes that it brought a 24 hour day with artificial lighting, it re-established family interactions with devices such as TVs, and through the power provider, it even affected the villagers' relationship with the government. Some of the key issues echo what has already been argued – that electrical assets enable capabilities and convenience – but the significance of Winther's study is in the awareness of who in the household owns those assets, who actually accesses them and what are the social repercussions in terms of status. These are the kind of aspects that energy access indicators entirely fail to perceive.

Boyer (2004) writes about how electricity is hidden in plain sight: its role is in making spaces correspond to our desires and powering countless 'at-the-ready' appliances so we are both dependent yet unaware of it. Moreover, through the rise of personal computing, we are institutionalised in an environment of electronic information. It is these insights of the 'material-social entanglements of electricity' which warrant the need for in-depth study of what effect energy is having as opposed to headcounts of its availability.

In his ethnography of energy consumption in Kerala, India, Wilhite (2012) finds that changing consumption patterns are part of a process of normalising modern electrical appliances. Wilhite argues that understanding this normalisation must come through some contextualisation in the social relations and cultural practices of those energy users. Again, this is what purely quantitative studies struggle to achieve as they look at the volume of energy consumed, not the consumers themselves:

> Our accounts of the everyday lives of people in the global South are incomplete because they do not pay attention to the different ways in which people encounter the partial presence of modern infrastructure (Gutpa 2015, p.563)

Gutpa writes that energy behaviours from North don't transplant seamlessly to the South as the infrastructure, policy and energy needs are different. Rolling blackouts and fluctuations are the norm, baseline power is indeterminate due to illegal connections and, he explains, the growth of electrical appliances in the household is not just an increase in energy consumption but marks a different kind of consumption and lifestyle. Though these are significant issues to study from the perspective of the energy user, and they resonate vibrantly with sustainable development, they have received little attention. By partially incorporating this anthropological style into a rural assessment of energy access, this project will produce a meaningful, original and useful indicator tool – this aim is elaborated in the conclusions to the literature review that follow.

4.3.4 Conclusion: appraising energy access

From this chapter it is clear that there has been substantial work done by academics and international development agencies with the aim of finding some way to assess energy access. Similarly to poverty, it is possible to use a simplistic definition and create a very direct 'headcount' measure from that, as in the yes/no connection to electricity. Though ostensibly easy to measure, this 'electricity-headcount' is limited – electricity is a versatile energy but it alone does not imply access to safe cooking and drinking water, which are all very much part of the energy access framework. More complex methods exist that indicate different forms of energy, the various services accessed in the household or in the community. Equally, anthropologies of electricity reveal that there is much which is significant in understanding energy in the context of the South.

In terms of energy access indicators, the most evident gap in the literature is not just the lack of an accepted definition for energy access but the crucial elements that are missing from attempts to indicate it. They all lack a sense of what it is like for the user to harness energy and how they feel depending on the nature of their access. Crucially, the indicators reviewed here are almost all quantitative and lack subjective or social focus. Physically, electricity can be considered as an interaction of charged particles and fields; but in social terms, one may think of it as a plug socket or a light bulb. The social perspective is needed to comprehend how *people* interact with energy and how that interaction affects their state of deprivations and poverty. The indicators in the literature are restrained to technical issues, which is why they lack depth and their meaning is limited. Though the most of the contemporary indicators are effective in making implications at the national or regional scale, by merely counting connections or appliances they do not speak much about the people who have or do not have those assets. Practical Action do promote an indicator tool for use at the small scale but they are alone in doing this and their method has its limitations.

Building on the ESI from Practical Action, this project addresses its problem of reduction. All too often in the discourse on energy access, 'low' and 'high', are used as principle descriptors. Though it may be practical to use those terms in discussion, it is naïve to use them candidly when describing a concept so tightly linked to something as complex as poverty. Energy access and poverty both exist over more than one dimension and it is a gross simplification to consider them as merely high or low. As expressed in 4.2.6, the literature is ripe with themes that underpin energy access but the resultant indicators often lose focus on these properties in the attempt to create a reliable, quantitative scoring mechanism. The reviewed indicators can be used to compare energy access scores in one location to that in another but they do not convey much about that access itself. As such, an objective of this project is to show that supplementary qualitative tool is needed to describe in detail what the quantitative indicator can identify and count. Combing approaches does justice to a concept as complex as energy access, thereby, it effectively inform the planner or policy maker. It is this planning of energy access development that motivates the research, and it is towards that end that a new method of appraisal is created.

The appraisal designed in this project draws from the literature, specifically, the themes and aspects of energy access discussed above. At least for cooking behaviours and electricity supplies, these aspects are inclusive of a diverse set of experiences and concerns that the user have in regards to their access, for example the convenience and adequacy of the energy. However, as the purpose for many of these indicators is to be part of large scale operations in monitoring, these highly interpretative aspects are reduced to a single number. This project will show that there is such significant meaning to indicators which retain a fuller and unreduced account of people's experiences, that these qualitative indicators have a valid place in an appraisal of energy access, at least when the purposes are to plan and evaluate energy related development initiatives.

Energy access is accepted as fundamental to development and relevant indicators are a valuable tool in the planning of that development. Yet, there is more to consider in terms of exactly how access relates to capabilities, not least from the perspective of those people in or near energy poverty. It is those people who must be studied before any rigorous, comprehensive or fair indicators can be constructed around their energy access.

In order to gain a fuller appreciation of energy access and how the state of this can be communicated to actors outside of the energy-poor area, a more sophisticated tool than just an indicator set is constructed. Going back to the development approaches considered in chapter 2, on bottom-up planning and rapid rural appraisals, this project applies the essence of these methods to the field of energy poverty. The intention here is to study villages with an immersion into their environment, to participate in their lifestyle and use these experiences to form an appraisal of energy access that is supported by both quantitative and qualitative indicators. Thus, the objectives of the research are as follows:

- Gain participatory experiences and engage in dialogue within energy poor, rural communities

- Appraise the energy access of these places with reference to the fullest span of the energy access perspective

- Identify the key elements and aspects of energy access and with these construct quantitative and qualitative indicators

- Find the comparative advantage of these indicators within a rapid rural energy access appraisal and discuss the use of the tool in planning

5 Methodology

> Now, in the latter 2000s, with an exploding variety of participatory approaches and methods, it is difficult to remember and realize again the pervasive tyranny of methodological rigidities and resistances in the 1970s. Social anthropologists believed that only their approach could yield in-depth understandings. Economists and statisticians believed that only questionnaires could generate the numbers needed in rigorous research. The researchers and practitioners who improvised and innovated outside these traditions were a heretical fringe and their methods disparagingly dismissed as 'quick and dirty'. They were trying to avoid the long-drawn-out, costly, and often irrelevant, misleading or confusing findings of anthropology or surveys. Their approach and methods came to be known as RRA (rapid rural appraisal) – (Chambers 2008, p.70)

5.0 Introduction

The interests underlying my research are in the collection, analysis and representation of data on rural poverty. These interests were pursued via techniques similar to an RRA applied with the energy access theme; so, constructing an energy-based capabilities indicator with the participation of the people it represents. Thus, an output was a rubric for studying rural energy poverty, imbued with the voice of those people.

This is an advance upon the reviewed energy measures in that a social theme was applied, entailing the use of qualitative research methods and with close attention paid to the people who are accessing the energy rather than just the physical aspects of their energy access. The methods employed to design the appraisal tool made use of a flexible interview structure backed-up by observation and participation. The intention was to mix technical data with ethnographic interpretations, providing a broad perspective of energy access. Vitally, this forged a tool which, as is later argued, outperforms contemporary measures in what it can perceive, indicate and above all, communicate.

A qualitative and social study on energy access is rare within the literature, at least for the reason that the field is quite dominated by large development actors such as the UNDP or IEA. The intent of these actors is to compile complete vast data sets for an array of developing countries (as in (Legros et al. 2009) or (OECD/IEA 2012a)). The indicators they need lean towards quantification because their purposes are for international comparison –

consider for instance the Global Tracking Framework (given in 4.2.1.1) which entirely consists of measured values about things and not people. Since this de facto position is that energy access is something to be measured then the meaning of energy access is that of a statistical construct – this is less conducive to smaller scale but more intensive studies which seek to engage local people in participatory development.

This methodology details a plan for a small scale appraisal of energy access, followed by documentation of its execution in the field. In brief, the fieldwork gathered data through household interviews and surveys; the structure of these evolved over time with respect to on-going analyses and input from other more ethnographic methods. It is the attempt to combine the in-depth quality of anthropology with the rigour of a quantitative study which characterises this project. The intention was to refine a method for doing this rapidly, so that the prominent narrative of energy behaviours could be ascertained without a drawn out and costly research program. Accordingly, a two-part strategy was employed: 1) the scoping phase: exploring energy access for what the users considered important and also how they would analyse their own consumption; then using those findings to inform 2) the appraisal phase: compiling a comprehensive set of relevant and coherent data. In the first step a tool was refined for appraising energy access and then this appraisal was put into practice in the second step. The research used multiple case studies; each case served to test and refine methods for final demonstration in Samlout. There, the most reliably informative methods were used to acquire high quality data – this is covered extensively in Chapter 9

5.1 Research philosophy

The section goes over the aims of the project, which follow on from the objectives stated in the literature review. Below, the aims are translated into research questions. These then instigate discussion of what kind of knowledge can answer those questions and how it can be acquired from the field.

5.1.1 Aims and questions

Main aim

- Develop a tool to appraise rural energy access

Sub-aims

- Discover more about people's interaction with energy (assets, capabilities and opinions)
- Design methods for rapid description of the state of energy access

To turn these aims into research questions, the salient concepts are interrogated: energy access, people's perception of it and how this can be indicated. People play a significant part in their energy access, yet contemporary measures tend to focus on the technical aspects alone. My aim is to broaden this tradition of measure into an appraisal, one which interprets energy access in a more social context and also moves away from a purely numerical description.

In doing so, the research acknowledges the significance of both the physical state of energy assets in a given location and also the subjective accounts people express of their energy behaviours. It is only by examining both of these that energy access can be understood. In the reviewed literature, energy access is described by both the devices which one uses and the capabilities which one has. Notably, the latter is influenced by one's knowledge, beliefs and opinions but the literature was thin on these grounds. With this, I am suggesting that though energy access can be measured on the basis of physical evidence (*does this household have a connection to grid electricity?*) it may be more meaningful to combine this with a social interpretation (*how do the people in the household use that electrical connection?*).

Effectively, there is a technical state of energy access: all that can be feasibly achieved with the physical assets at hand. Yet, thinking in those terms overshadows the actual condition of energy access, which can only be understood in relation to the people who would harness that energy. Understanding this ‘actual’ energy access is thus a consultation process, explicitly calling for an awareness of how the user talks about their energy consumption behaviours. Extending dialogue with energy users across the topics related to access (that is, those raised in section 4.2.6) provided data to satisfy the first sub-aim in the list above; analysing recurrent themes in those conversations satisfied the second. The information sought was in the language people use and what they talk about.

The research was motivated by the need for indicators to succinctly represent people’s energy access, but given the complexity of the concept, also to capture as much meaning as is helpful. The thrust of the project was to discover what a qualitative approach meant for data generated in a rural study, in terms of how that data can inform the policy maker or development actor. Accordingly, it was through qualitative methods that a set of indicators for energy access was constructed. Methods drew from ideas about participatory development; this anchored the qualitative interpretation of energy access to values of the people represented in the study. To balance this qualitative tool, a quantitative counterpart was also constructed, this to appreciate the synthesis and comparative advantage of both tools. The contention was not that one tool was better than the other, but rather, to find out if and how their combination is stronger.

In light of the above, a set of research questions are stated. These underpin the data gathered in fieldwork and discussion in the following chapters. In effect, they are the groundwork for the knowledge contribution that will come out of the project as guided by the aforementioned aims.

1. How do people access energy in selected case studies in Cambodia?
2. What are the strengths and weaknesses of the qualitative and quantitative approach to data gathering with respect to energy access?

3. For an analytical framework built during fieldwork, what indicators or methods can be used to assess energy access and what are their limitations?
4. What kind of implication can be drawn from using an RRA style of assessment into energy access?

The answer to the first question appears in Chapters 6 and 7 which summarises the data on the way that people access energy – evaluating that data also answers the second question. The empirical chapters revise an analytical framework, which in chapter 8 is translated into assessment tools to satisfy question 3. The application of these tools in 9 then sets up the answer to the final research question.

5.1.2 Epistemology and Ontology

Given these questions, the methodology can truly begin once those questions are examined in terms of my own philosophical standpoint. This reflection makes the reasoning behind the data gathering more transparent (as in (Lombard 2009) or (Chilimo 2008)). Any contribution from the thesis ties into a theory of knowledge, equally, the research methods fit into a stance on how the world works. With this groundwork, the design of the methods can cogently follow.

The epistemological and ontological position taken in this research is best laid out by study of the discussion in the previous subsection. A dominant message there is that the subjective accounts of people are valued as information worthy of study and representation. This appeals to a constructivist theory of knowledge which would state that the world can be understood through meaning that is socially constructed (Creswell 2003). Creswell states that the focus here is upon the researcher interacting with other people in their native context in order to understand the underlying mechanisms of what is being studied. It is through dialectical interchange that the construction is formed and made more sophisticated (Guba and Lincoln 1994), essentially, a back and forth conversation between the researcher and participant. Thusly, the theory about energy access will come out of interpretation of what users say about that access.

Returning to that prior discussion, the other main topic within the research is indicators. The purpose of indicators is to describe the real world, this rests upon the assumption that it is meaningful to make such a description. Implicitly this is to say that a real world exists, in order to be described independently of one's own understanding of it. Explicitly in this thesis, it is argued that our means of describing this real world are fundamentally limited – which is what motivates the search for better indicators that can more helpfully inform us about the world. This ontology is critical realism (Guba & Lincoln 1994), with the outlook that "*reality does exist but can never be perfectly apprehended*" (Perlesz and Lindsay 2003, p.29).

With the perspectives above, the methods that this project will employ are mixed. The point of the research is to find a practical synthesis of the qualitative and quantitative approaches, that is to employ 'critical methodological pluralism' (Danermark et al. 2002): finding how to make complementary use of very different methods and to vouch for each through comparison and reflection. The application of these methods and evaluations of them are statements that speak about reality and ways to operate in it. The endeavour of interpreting energy access lends itself to more open ended interviews that seek complexity, whilst the desired indicators that represent this energy access are motivated by a need to simplify this information. However, it is through both approaches that energy access is understood, locally and more globally:

> Qualitative and quantitative approaches are complementary rather than competitive methods [and the] use of a particular method ... rather must be based on the nature of the actual research problem at hand (Wilson 1982, p. 501; cited in (Flick 2009))

This is to say that diverse methods can, and should, be used if the information studied is of a diverse nature. Triangulation of many methods, rather than the domination of just one, permits better analysis. On the one hand multiple methods allow for enhanced exploration of the field and on the other they act in mutual support to add coherence (Perlesz & Lindsay

2003). As advocated in Chilimo (2008), the combination can be justified since the dichotomy of qualitative and quantitative methods is not indomitable; they relate to different approaches but towards the same end. Quantitative and qualitative methods are bounded by their ontological basis. However, because they are both interpretations, the critical realist approach permits using them in tandem where their bounds overlap. This helps to describe a subject such as energy access which has its physical basis in the real world (that is, as energy) and also a crucially social nature (that is, what it means to people and their capabilities). The limits of this mixing and the sphere in which each approach can legitimately describe energy access are running themes expressed throughout the empirical chapters.

5.1.3 Combining qualitative and quantitative data

The two approaches and associated forms of data are critically different but not incompatible in forming theory. The reasoning process that combines them will be outlined in this subsection. For this project I had a base of knowledge to draw from but this was on the nature of poverty, how accessing energy can alleviate it and how that energy can be measured – this was not a manual for applying qualitative approaches in gathering data on energy access and precisely that gap in the literature is what motivated the research. Accordingly, any hypotheses taken into the field or methods used to extract data needed to react to ongoing analyses.

The literature provided a starting point and this was taken into the field; see the map of energy access in 4.3. This prototype guided the design of the initial, qualitative, empirical methods. There was no expectation for this framework to be sufficient to cover all observations made in the field, but it did serve as a starting point to be continuously reformed as data on/around energy access was excavated – "*the sooner inappropriate hypotheses can be abandoned or reformulated on the basis of new information, the faster one learns*" (Khan Kaen University 1987, p.10; cited in (Chambers 2008, p.80)).

In this project, the processes of data collection and analysis were not distinct phases. Thus, the data and theory were developed simultaneously and symbiotically. Energy access is not well-defined and I was engaging in a dialectical process of generating data for possible indicators for it, whilst also exploring what *it* is. As described by Mason (2002), this process is somewhere in between the more traditional reasoning of induction and deduction – data is obtained to propose theory, then this theory goes on to guide further gathering of data. The movements between analysing data and constructing theory are covered in detail in the procedure section, 5.3. This reasoning process makes use of abduction:

> … assembling or discovering, on the basis of an interpretation of collected data, such combinations of features for which there is no appropriate explanation or rule in the store of knowledge that already exists (Reichertz 1995, p.304)

According to Reichertz, these abducted explanations lead to a 'multi-stage process of checking', whereupon the abductive 'leap' of logic is then combined with deductive and inductive reasoning. If this creates premises consistent with further observations then credibility (but not certainty) can be given to the theory. In line with critical realism, this reasoning process is trying to attain certainty to the stage of 'practical adequacy' where it is more convincing than alternative explanations (Sayer 1992).

Combining both qualitative and quantitative approaches is done so as to better inform the reasoning process. The methods used to extract data may be associated with either tradition, they run in parallel. In analysis, the approaches are more entwined – the same data can be interpreted or counted and the effect of doing both influences the conclusions.

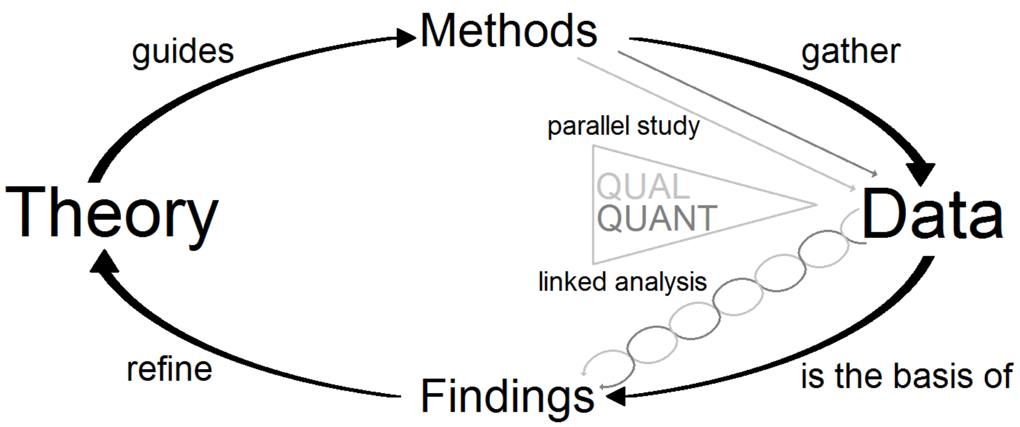


Figure 5.1: The interaction between processes within the research.

5.2 Research design

The rationale for the project has been proposed; this section now begins to deal with the more methodological issues of how such a project was carried out. To test approaches of extracting data I found several case studies, employing various techniques of interview and observation. The mainstay of the data is 110 household interviews in six rural communes.

5.2.1 Location for fieldwork

5.1.1.1 Case studies

> It is only because of experience with cases that one can at all move from being a beginner to being an expert. If people were exclusively trained in context-independent knowledge … they would remain at the beginner's level in the learning process – (Flyvbjerg 2006, p.222)

To learn more about energy access in rural environments of poverty I needed to go into the field – both for the first-hand experience of attempting participatory appraisals and also to make my own interpretations of the way that people interpret their energy access. Being immersed in a natural setting allowed for fuller access to the underlying mechanisms which were the subject of the study, "*anchored in real-life situations, the case study results in a rich and holistic account of a phenomenon"* (Merriam 2009, p.51). From the literature review, it is evident that energy access for a person within a particular location is inseparable from factors of context, for example the local geography, climate and economy. Due to the importance of contextual conditions and because these are inextricable from the subject matter itself, a case study approach is appropriate (Yin 2003). Moreover, since the findings are intended to be robust (that is, an energy appraisal that can be conducted elsewhere) multiple case studies were chosen as many cases provide a platform for analysis within and across several settings (Baxter & Jack 2008). To balance the need for diversity but the practicality of consistency, a two-level case study was designed: multiple locations within the one country of Cambodia.

Since the overarching aim of the research was to learn *how* to conduct rural energy access assessments, rather than just the lesser aim of finding *what* such an assessment would say, the selection process of the case studies was not random (as desired for statistical significance) but instead driven by the need to observe many ‘polar types’ (Eisenhardt 1989, p.537). These polar types (differing in resources, remoteness and infrastructure) are discussed in the next subsection. The motivation for selecting them was to appreciate a variety of contexts, although to facilitate analysis, a slim degree of similarity was desired. Consequently, there were six cases studied in the research, each of these was a commune (a cluster of villages) in the Western and Southern regions of Cambodia (see map below). Other regions (or polar types) were not studied simply because this project had its limitations on time and resources.

5.1.1.2 Cambodia

The choice of Cambodia was dictated primarily because the country shows outward evidence of suffering poverty and low energy access (as explained in the following summary). Secondary factors were that it has few barriers to entry for a researcher and a high proportion of development actors – this meant that there were many interventions to observe and also many organisations willing to help through logistical support or otherwise (as in obtaining official permission, providing a base, sourcing a translator (Desai & Potter 2006)). The main partnership in the research was made with a Dutch non-government development group, SNV. They are connected to Cambodia’s National Biogas Programme (NBP) who provided the initial databases for selecting research participants in the first two case studies. Later, SNV also helped me to secure the final case study in a region managed by the aid foundation, MJP. The remaining three cases I selected myself based upon their suitability as comparators, this decision making process is detailed below.

5.2.2 A brief summary of the fieldwork location

Cambodia scores low on many indicators but even in South East Asia it doesn’t have the lowest scores, at least not by *every* indicator in the literature review. The country has idiosyncrasies, as does anywhere else – in this sense there is no perfectly typical country. However it can be argued that within its group of 48 Least Developed Countries, Cambodia is not too atypical. It has high but not extreme levels of poverty and is making steady progress according to the MDGs. Many of Cambodia's characteristics, specifically those of energy poverty, it shares with other places in the Global. Accordingly, the findings of the research can, to a large extent, be transferred elsewhere, thus, Cambodia makes a good case study.

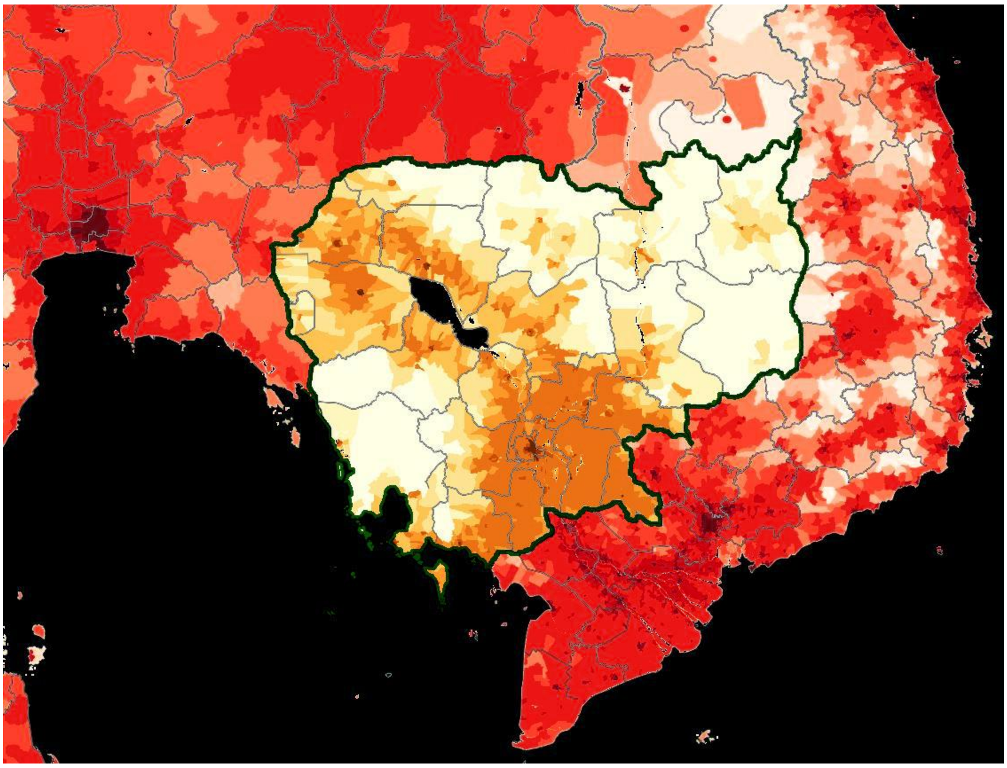


Figure 5.2: Population distribution in Cambodia

Darker hues represent a denser population. Neighbouring Thailand, Laos and Vietnam are coloured red. The populous region of Cambodia aligns with the green belt of lowlands which traditionally have been the most suitable for rain fed rice agriculture. However, that region is also highly prone to droughts and flooding. Data is from NASA Worldview and boarders are from OpenStreetMap. Colour edits by the author.

The country has a falling poverty rate with an economy boosted by growth in the sectors of garment manufacture, tourism, rice farming and construction; though the majority of Khmer people are out of extreme poverty, most are still very poor and vulnerable (ADB 2015). It has a GNI per capita of $1020, making it the second poorest country in the Pacific region after North Korea and the fourth in Asia after Nepal and Afghanistan (Atlas method, WDI). Its low GNI, coupled with poor scores on an Economic Vulnerability Index, puts Cambodia into a class of 48 Least Developed Countries (LDCs) – mainly due to indicators on natural disasters, remoteness and the high share of agriculture in its GDP (DESA & CDP 2015).

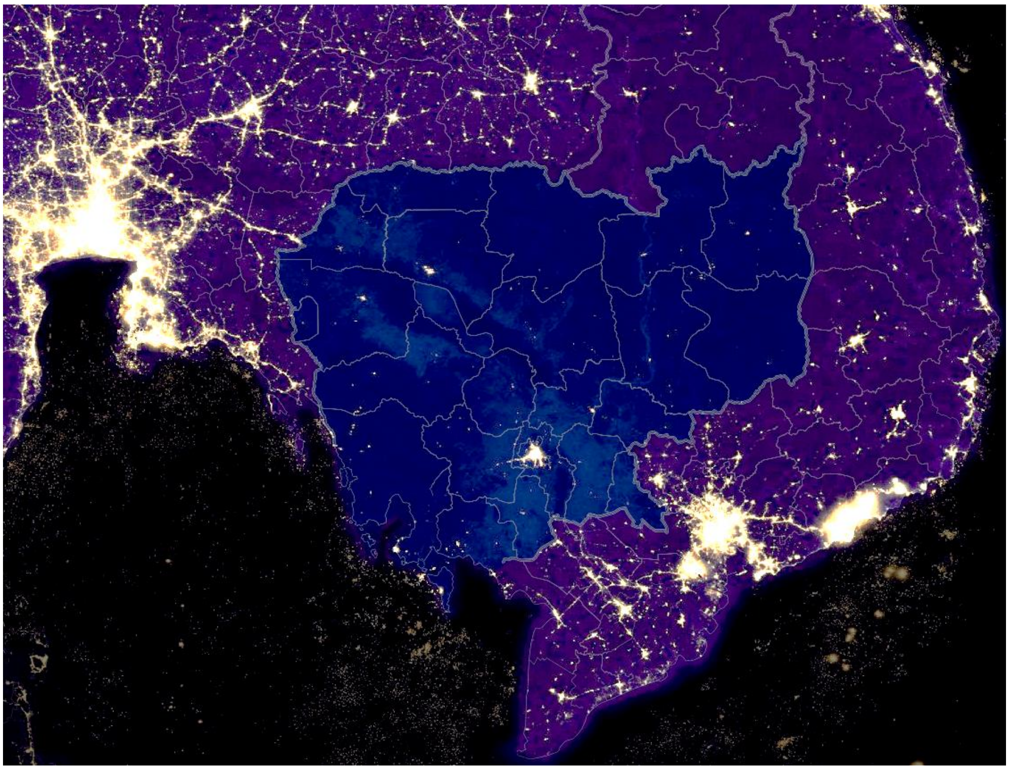


Figure 5.3: Satellite imagery of Cambodia by night

Neighbouring Thailand and Vietnam (tinted purple) have more light emission from their cities and roads. In Cambodia the bigger cities are clearly visible but other locations are almost obscured at this resolution. This perspective can be used as an indicator of energy access and overall development. The 'Earth at Night 2012' is from NASA Worldview and boarders are courtesy of OpenStreetMap. Colour edits are by the author.

Cambodia suffered civil war, genocide and dictatorial rule at the hands of the Khmer Rouge then subsequent liberation and occupation by Vietnam. It is now a democracy under president Hun Sen. The reign of the Khmer Rouge bore a severe toll on the population, culture and infrastructure. Psychologically, Cambodia has been posited to be a post-war society (Bockers et al. 2011), though others argue that a generation after the conflict, it is '*re-created … through the everyday actions of people going about their lives*' (Ledgerwood & Vijghen 2001, p.1). Today the government is stable but widely criticised for corruption (Transparency International 2014). Administratively, the country is organised into provinces, districts, communes and villages. Within each village a chief is selected by the state, though sometimes elected by the people. These chiefs are ordinary peasant farmers but widely regarded within the village as mediators and protectors (Kim & Henke 2005).

At 13 degrees latitude, Cambodia has a tropical climate: alternating between monsoon (June-November) and dry seasons (December-May). Terrain is mostly low flat plains which are divided by the Mekong and Tonlé Sap rivers, supporting traditional rice agriculture. Forest cover has decreased from 73% in 1990, to 59% in 2005 (FAO 2006) and recent satellite imagery estimates a further fall to 48% (ODC n.d.). A main driver of this is illegal, large scale, agricultural plantations (Lawson et al. 2014).

Population	15,328,136
Rural	79 %
Urban	21 %
Area (sq.km)	181,040
Agricultural land	32.9 %
Terrestrial protected areas	26 %
Under 5 mortality rate	28.7 per 1000
Adult literacy rate	74 %
HDI (UNDP 2015)	0.555
Rank	143/188
MPI (OPHI 2013)	0.212
Official development aid	$52/capita

Access to electricity	31.1%
Rural	18.8%
Urban	91.3%
Electrical power consumption	221 kWh per capita
Energy use per capita	396 kg of oil equivalent
Access to non-solid fuel	11.4%
Rural	3.7%
Urban	41.9%
Access to improved water source	75.5%
Rural	69.1%
Urban	100%
MEPI (incidence) (Nussbaumer et al. 2013)	89 %
MEPI (intensity)	0.71
EDI (rank, developing countries) (OECD/IEA 2012b)	56/80

Table 5.1: Various statistics about Cambodia, specifically relating to poverty and domestic resource access

5.1.1.3 Locations

Two phases of fieldwork took place for this project, one in the spring (scoping) and the other in the autumn (appraising). The methods employed and data recovered from these two stints differs, as will be described. This subsection gives a synopsis of those locations with reference to the rationale as to why it was chosen as a case study. Though sometimes referred to by the name of the province, the case studies are all communes: clusters of villages, each containing around a hundred households.

Spring fieldwork

For this part of fieldwork, the project relied upon NBP to choose case studies. As I was unfamiliar with Cambodia, their local expertise was sought to guide me to locations with the characteristics I desired for the research: rural farming communities with and without electrical connections. To simplify logistics, NBP chose locations in provinces close to the capital, Phnom Penh, which acted as a base of operations. For two months I alternated, week by week, study of these two locations using mainly interviews.

Location 1: Kampong Speu – 38 interviews (village population ~ 300)

Of the two spring fieldwork locations, people in Kampong Speu were generally the poorer and less likely to have a connection to the mains electricity grid. This region is more densely forested though has less wetland.

Location 2 Takeo – 30 interviews (village population ~ 700)

This province is further away from the capital but closer to the Mekong River and adjacent to the border with Vietnam. The whole province is more densely populated with fewer protected forest zones – though it also has fewer large garment factories.

Autumn fieldwork

In this second half of fieldwork the choice of locations was not guided as much by the project partners. I chose the locations myself based upon what kind of area would make for good comparisons due to outwardly evident differences from the data set thus far: in availability of natural resources, access to infrastructure and proximity to urban centres. Studies in most of these cases were supplemented with surveys but they had fewer interviews.

Location 3: Kandal – 10 interviews, 51 surveys (village population ~ 1000)

Similarly to the previous locations, this province is adjacent to Phnom Penh. Overall it is more developed and was chosen for its high access to markets and infrastructure but low access to woodland areas, making a contrast to the previous two. A notable feature of the location is the main road running through the villages.

Location 4: Chambok – 5 interviews, 38 surveys (village population ~ 350)

Chambok is a commune by the borders of the Kampong Speu province; it is situated within the Kirirom protected forest region, far west of the villages in location 1. This commune is remote and the terrain is crucially different from previous locations – mountains and jungle as opposed to plains and paddy fields. Conversely to Kandal, the quality of infrastructure is low but access to natural resources is high – the protected forests are why it was selected as a case study. As an ecotourism, it village has unique access to energy, a mixture of traditional practices yet also substantial use of solar cells from NGO activities.

Location 5: Peri-urban Battambang – 5 interviews, 0 surveys (low population density)

Outside of the green belt, the northern area of the country has drier conditions and less availability of wood. This made for contrast to the cases so far. To make a comparator with location 3, villages near to the urban region of the city were targeted; unlike in Kandal they were not adjacent to a main road so connectivity to the towns was far worse.

Location 6: Samlout - 22 interviews, 57 surveys (village population ~ 1000)

The Samlout commune lies near the border of Thailand. It is outside of the green lowland belt that runs across Cambodia. At the time of study (late 2015) the area was going through a process of electrification making the location very interesting to the research. Similarly to Chambok it is surrounded by protected forests but this area is much drier.

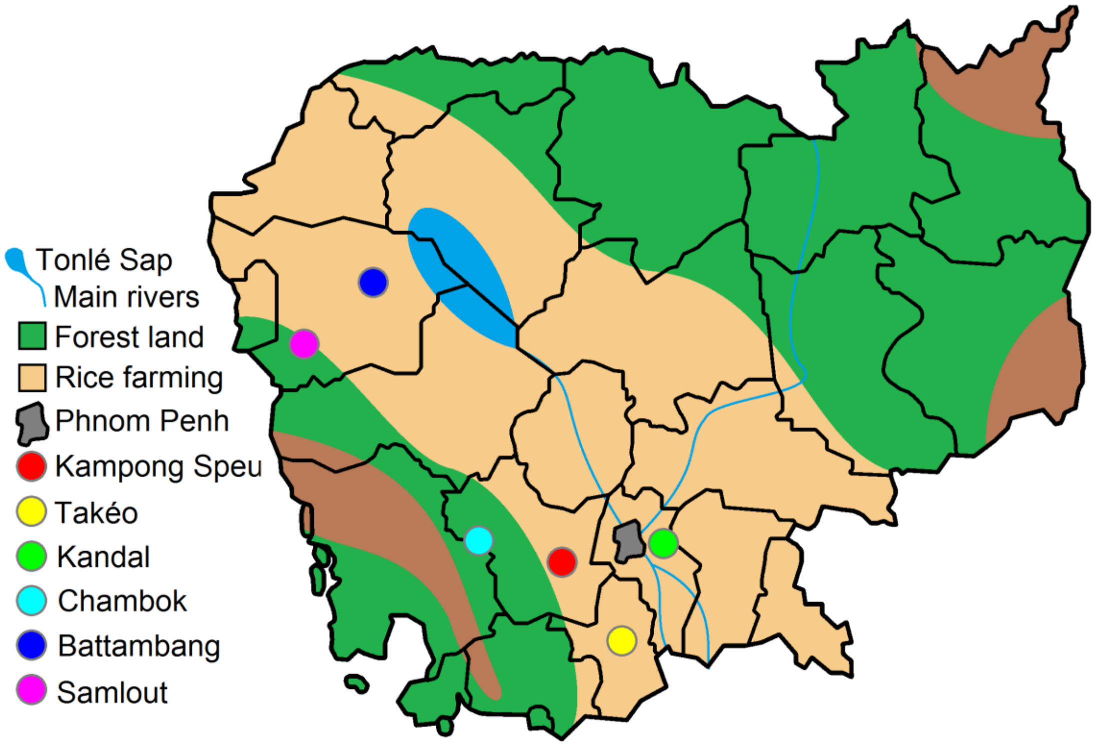


Figure 5.4: A basic map of the provinces, case study locations and main geography in Cambodia

5.2.3 Participants

In the spring fieldwork 68 interviews were conducted, in the autumn a further 42 were carried out along with 146 surveys. Notably, I came into contact with many people who had valuable knowledge but were not in this set of interviewees: two of these are treated as informants and referred to by their initials in a later chapter. The household interviews which make up the bulk of the data are referenced by the interview number, gender of the interviewee and their location.

In the spring fieldwork, participants were selected using NBP's database of households who had purchased biogas digesters. Using this as a means to locate a commune of villages and make a point of entry, more participants (who didn't use biogas) were then selected by referral sampling. The participants in spring were mostly biogas users (two thirds); this is not statistically representational of the population in those villages as most of the villagers did not use biogas. This skew is not too problematic as the aims were to interview many different types of participant rather than an even selection of biogas and non-biogas users. The ownership of a biogas system was independent of other issues – participants could be selected in areas with and without electricity, ensuring that variety. Biogas users and non-users were each internally varied groups and to a similar degree, though a bias may have been that the former were wealthier as they could afford the system and benefit financially from its operation – thus generalisations from the whole dataset may be biased in that vein.

In the autumn fieldwork sampling changed as part of the project's development of methods. A small set of surveys (10-15) were given to a local in the village who acted as a research agent, they then distributed these to the villagers under the instruction to visit a diversity of households; full details of this process are given later in the chapter (5.3.4). These surveys were then used to select participants for interview, with this selection again driven by the want for variation: survey responses with high/low values or which otherwise stood out from the rest. In addition, a few interviewees were chosen because they were specialists in the village; these were located by referral from villagers or village chiefs.

The key informants in the research were recruited from the organisations that aided the project. Unlike the other participants, these people were not interviewed for their knowledge about their own household but rather for what they could say about energy access relating to a particular device (biodigesters) or particular area (a whole village or commune). Overall eight informants contribute to my data, though only two are mentioned in the thesis.

5.2.4 Methods

This project takes much inspiration from Rapid Rural Appraisals. The principle of an RRA is to gather data without an encumbering methodology that would limit the practicality of the findings (Chambers 2008). As reiterated, the methods of data gathering in the project were both qualitative and quantitative; predominantly this was through semi-structured interviews and surveys. Interviews were deemed to be the best means of getting to participants' knowledge and opinions of their energy access – through this dialogue, I could construct a theory of what energy access means. Later, once a stable and sophisticated theory had been built, surveys were used as the initial step to extracting data on energy access. They formed a basic image of the fieldwork locations – these surveys were then followed up by interviews to both confirm the survey data and find finer detail. More coverage is given in the procedure (5.3).

Additionally, there were methods used that are found in an ethnographic style of research: "*observing and interacting with a social group*" (Herbert 2009, p.551). Interviews are effective, though not necessarily the best way to get a certain kinds of information (Desai and Potter 2006, p.146), for instance, with questions and answers that are hard to articulate (for example, the severity of smoke in a kitchen). That information was easier to observe through participation. An advantage of the case study design is that it is an easily accessible arena for such methods; by living in areas with poor access to energy I could hardly avoid doing some hands-on research of domestic life – "*one of the most effective, though time-consuming, ways of learning is by doing"* (Chambers 2008). As explained towards the end of the next section, these methods were not the primary mode of research – their function was auxiliary, they didn't form the principal data extraction but rather informed it.

The format of the interviews and surveys is given in the procedure section below. Section 5.3 explains what topics were brought up and how these evolved over time as the theory on energy access developed. That section also itemises the auxiliary data obtained through observation, participation, conversations with informants and note-taking.

5.3 Procedure

5.3.1 Brief

The core form of data extraction was through interviews, though observations (backed up by field-notes and photographs) also played a large part. Two excursions into the field were made, the first from February to April and the second from October to November in 2014 (spring and autumn fieldwork). During these five months, twelve weeks were dedicated to interviews and homestays with rural families in Cambodia. This generated 110 interviews (semi-structured with audio records and transcriptions), 8 [key] informant interviews (mixed structures and annotated), 60+ surveys (mainly self-assessed), two books of notes and a large album (+5GB) of photos.

The first field trip (in spring) was mainly of an exploratory nature, interviews at this point were geared towards answering the first research question on language and ways in which people measure their energy consumption. Fieldwork took a hiatus over the wet season, giving time for some preliminary analysis which began to answer the second research question on indicators. This reformulated the methods for the autumn fieldwork, specifically in shedding much of the exploratory style and replacing it with surveys to supplement the now more directed interviews.

The output is a family of conclusions existing at various levels of conceptuality: on a base level is a description about the physical nature of energy access in fieldwork locations, surrounding that is a story of how people feel about that energy access, and beyond that are the inferences on how research methods can get at that information. This leads to a final section on ethics before the empirical chapters.

5.3.2 Spring: Interviews

As stated earlier, participants were selected initially from NBP's database and then by referral. The interviews were semi-structured and the basic script was edited over time; each version of the script is given in full in the appendix – the overall layout is outlined below. In the beginning this semi-structured flexibility was essential in order to accumulate a general awareness of energy behaviours in rural Cambodia. After some scoping, parts of the structure became standardised – not having to improvise every question put less strain on the research team (me and my translator) so more time could be given to interviews each day. However, a degree of freedom was kept in every interview and time allotted to wander from the script. For example, I would ask an interviewee for a description of their livelihood if it were one I had not encountered before and, equally, specialist knowledge on a key topic would take priority over routine questions. This part of the methodology is vital as it underpins the qualitative tool built in chapter 8.

5.3.2.1 Content

The basic interview layout consisted of three sections: the introduction to 'warm up' the interview and get details of context, then an overview of the physical assets that the household used to access energy (including a list of electrical appliances), and finally a more thorough discussion that sought details on their capabilities and opinions of their energy access. The first section would ask for who lived in the household, their livelihoods and the scale of their agriculture – this was a rough indicator of their wealth. The second section would ask about cooking fuels, lighting, electricity and water (the four divisions of the analytical framework I, given below); questions would ask where the energy came from, how they used it and how much it cost. The third section would pry further into their energy behaviours, for instance, finding out if and why they stacked their fuels; this is where interviewees' opinions or the specialised knowledge that they had would be drawn out.

As fieldwork progressed the dataset grew larger and denser – more things and more detail about those things. Concurrently, the topics of conversation within each section evolved. Partly this was through refinement of the questions I asked such that they were more compatible with the interviewees' language, but also this was done when the topic became familiar and could progress into something more sophisticated. For instance, many of my interviewees used car batteries for electricity in the household; this would be determined in the second section. Questions in the third section would pursue this: early on in the project, I might ask how they charged the battery, later, I would instead ask about how this would fit into their routines or what they did whilst it was being charged. More general examples are given in the table below.

Section	Pilot	Redesign	Final
1	Opener	Opener (including 'who is the head of household?')	Opener (including land & animals)
2	Using energy	Demands for energy	Methods (cook, light, water)
2	Costs of energy	Methods of 'keeping track' (monitoring their own use)	Consumption (in local units)
3	Effect of behaviours	Details of specific behaviours	Change in lifestyle
3	Strategies used	Opinions of strategies	Comparison to other strategies

Table 5.2: The Evolution of the Interview Questions

The three sections mentioned above are denoted by some example topics; the table shows how these changed over time. Simple questions on that topic were used to develop a basic understanding; these then they gave way to more direct questions on that subject or more inquisitive questions around it.

Analytical framework (I):

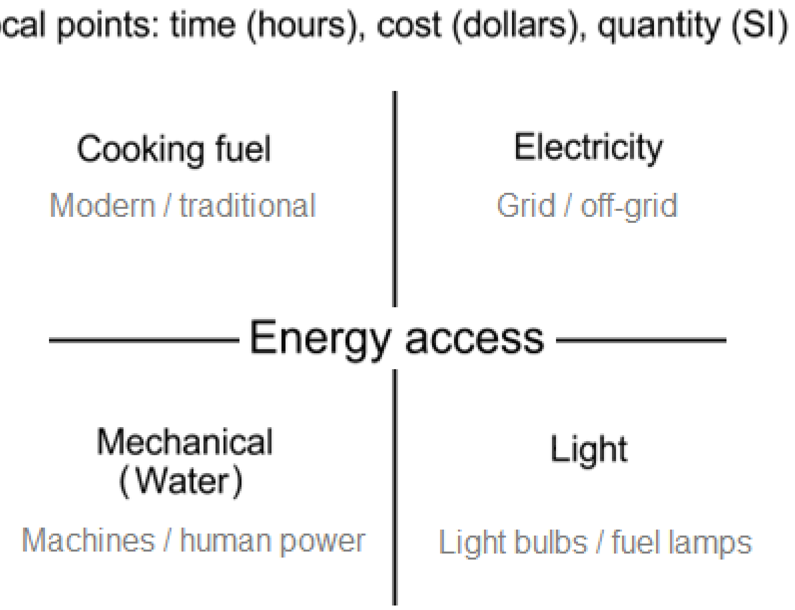


Figure 5.5: The first analytical framework

This framework addresses what data to gather on rural energy access; it is based on the literature review and guided interviews in the early stages of fieldwork. Interviewees were asked about the form of energy in each quadrant, with those questions in the style given in the table above. Though useful at first, this framework was revised later on.

5.3.2.2 Evolution of the interview questions

The table above shows how a topic of conversation became more directed or otherwise changed as the interview script was redesigned. At the outset I had a set of energies and energy services to ask about but was unaware of what they meant to the people I was interviewing. So interviews towards the beginning of fieldwork were more occupied with identifying and obtaining descriptions of the methods by which they accessed energy. For instance, there are many ways a household may acquire water: it can be purchased or collected and it may go through a variety pipes, pumps or different containers; the associated methods weren't all apparent from the literature review. The prime objective at the early stage was to learn the language that participants used to describe the assets and capabilities related to their energy access. The interviews were discovering the right terminology; they were testing the questions themselves, with a judgement based on the quality of the answers. This led to a refinement of how questions were phrased and what they were searching for.

For example, one question given to biogas digester households was about "*what benefits*" their system brought to them – they gave answers seemingly rich in opinions and grounded in experience, but their responses were very similar and it soon became clear that they were quoting from the promotion and training given to them by NBP. What they said was not incorrect, but nor was it personal – more likely it was what they thought was the 'right answer' (Desai and Potter 2006, p.150). Thus, the question was refined to ask about particular benefits: "*how much time or money did you save / in what way is it easier to cook with biogas or with wood?*" These questions prompted more informative answers. Where the original question was asking for effects of their biogas use, the refined questions asked for how this impacted upon their lifestyle.

Throughout all the interviews there was consistency in asking about certain energy services: cooking, providing water or any service powered by electricity. According to my analytical framework these were the core elements that underpinned energy access. Though, in this scoping phase I needed to extend many lines of enquiry in order to explore energy access in the field. I identified numerous other energy services such as waste disposal, preservation of food and washing of clothes, but since those conversations were less helpful in understanding the household's energy access I wouldn't talk about them in every interview. Thus avoiding the burden of too much data, similarly to the Rapid Rural Appraisal (Chambers 2008)(Narayanasamy 2009).

In interviews there was a turnover of interview questions. As this phase of fieldwork was to hone the interview technique for the next phase, I needed to test different questions rather than continually use the ones that worked well. If an interview question consistently prompted full and informative answers then I had reason to believe it was a 'good question' but would not necessarily keep it in the interview script. Once I was familiar with answers I was getting, I could move the enquiry along, trial a different question and get some different answers. That process was based on value judgements with reference to the dataset and my evolving understanding of energy access. At the cost of consistency in the script, towards the end of the scoping phase I had a large pool of questions to draw from, so I could tailor each interview to make the most out of the kind of knowledge that the interviewees were presenting.

5.3.3 Summer: Preliminary analysis

The wet season (British summer) put a hold on fieldwork; in Cambodia the rains dictate farming and rural participants were likely busier with their agricultural livelihoods and less available for interview at that time of year. Also, the heat, humidity and heavy rains made it harder to work and less safe to travel. Fieldwork was thus postponed until the end of the monsoon. In the break, an early analysis was made of the data extracted. Outputs were to revise the analytical framework and reformulate the methods of data gathering – leading to design of the first the surveys.

Early analysis encoded the information from the interviews to make it more accessible, data was tabulated with the following column headings and subheadings.

Household details	Biogas	Wood	Water	Electricity	Engines	Farming
Name	Duration of ownership	Time for collection	Method	Battery, or time on grid	Types owned	Hectares or land size
Livelihood	Favoured benefit	Cost	Cost	Uses	Uses	Animals owned
Head of household (m/f)	Specification of digester	Usage	Pumping details	Usage	Costs	How they mill their rice
Income	Maintenance	Charcoal	Boiling	Cost	Fuel	Yield
	Responsibility	Awareness of deforestation	Responsibility	Blackout		
	Discovery		Irrigation	Savings		
	Additional notes			Wanted appliances		

Table 5.3: Codes used for organising analysis of interviews from the spring fieldwork

For each interview, any information that could be associated with the subheadings above was inputted into a spread sheet, with cell values taking the form of numbers, words or symbols. The syntax was complex but compressed and organised the information within transcripts. The spread sheet was neither strictly qualitative nor quantitative but more a catalogue of data in both its qualitative and quantitative forms. From this catalogue, strings of data could be exported or quotes retrieved on any of the subheadings in the table above. By reducing the transcripts to a consistent language, patterns and distributions could be observed in the data and each point within these was linked to statements in interviews.

The greater product of the preliminary analysis is the set of 135+ quotes arranged into 20 themes. These quotes were chosen for the quality of information they convey and the corresponding questions have been collated and evaluated. The quotes themselves go towards forming an answer to the first research question on how people talk about accessing energy; likewise the corresponding interview questions are relevant to the second research question on indicators.

5.3.4 Autumn: Surveys

5.3.4.1 Content

Conducting interviews can retrieve complex information such as nuanced opinions, but it is a resource-intensive process and so can be an inefficient method. One of the research interests that came from SNV was on how to mobilise a large scale impact assessment without having to commit much capital. I trialled a method that used local actors to carry out surveys; they were cheaper and more able to navigate the target villages than an external actor such as myself. So, their surveying would be faster, cheaper and possibly even able to reach farther than my interviews.

During the preliminary analysis, I decided which bits of the data would be more appropriately gathered through a survey rather than a full interview – they were simple questions akin to those from the first and second sections of the layout in 5.3.2.1. Like the interview script, the surveys changed over time, each version is given in the appendix. The survey named the principal assets used in accessing the main forms of energy (according to the new analytical framework) and asked for the respondents' spending or consumption related to those assets, essentially this was to find out the following:

- The person's name, livelihood and address (to locate them for a follow-up interview)
- What kind of electrical connection they have and how much they consume
- How they get their water and how much this costs
- Which cooking fuels they use and whether or not they buy them
- What engines (or vehicles) they have in the household and how much fuel they use

The data from these surveys was naturally more quantitative than that from interviews; it was possible to graph much of this data as shown in chapter 6. In this sense the quantitative and qualitative methods ran in parallel but they were also interlinked by the following sampling method.

Picture 5.1: Giving surveys to the chief of the village

This kind of table is ubiquitous in Khmer homes; it is where most interviews took place.

5.3.4.2 Surveys for interview sampling

Upon return of the completed surveys, they were examined for outliers – responses that were unique or extreme. The aim being to identify a diverse selection of households within all those surveyed. These diverse households were then pursued for further interview (if they ticked the box on the form saying that they were willing). In many cases the interviewee was chosen based upon the high or low consumption that they put down on the form, others were chosen for their livelihood or use of particular assets, one was even chosen for responding with the Thai currency, Baht, rather than in Cambodian Riels.

With this, the databases of my project partners were not needed to acquire interview participants. The process of surveying became the usual means of interview sampling for the autumn fieldwork (it was used to select 29 of the 42 autumnal interviewees). In the other cases, interviews were conducted by opportunity sampling whilst waiting for the surveys responses come back.

In Kandal and Samlout I used a local agent to carry out the surveys (details below); though in Chambok I conducted the surveys with my translator (this was the only location I didn't delegate the surveying). We used a mixture of systematic and referral sampling to hand the surveys to the villagers, door-to-door. Depending upon the livelihood and appearance of the household we would conduct the full interview, the choice driven by the want for a diverse set of households in light of their livelihood or visible clues of their energy access (machinery, electronics or fuels).

Finally, surveys were not used in Battambang. There was no local research agent to whom I could delegate the task and too sparse a population to do it myself.

5.3.4.3 Survey technique

The choice of the local (village) actor to join the research team was guided by the translator at the time. Their recommendation about where to look was verified by several other Khmer informants – the chief is the gatekeeper of the village, he or she knows everyone, can speak for them and adjudicate between them. They are members of the community and are already associated with collecting statistical data on the population (Ledgerwood & Vijghen 2001). Using this kind of actor is part of gaining entry but their influence on the research must be monitored (Bailey 1996), reflections are given in Chapter 10. The chief's position is not particularly well paid; $30-60 per month is relatively low, though this role is only part of their livelihood. Chiefs usually have farm land and other better sources of income as well. They are busy people and theirs is a respected position. The villagers I spoke to explained that the chief tends to know everything that is going on and that it would be inappropriate to hand out surveys in the village without at least the chief's consent.

I first used the surveys in Kandal, in a consultation with a village chief regarding who would be best to hand out these surveys, he volunteered himself. I was somewhat dubious about how fair his representation of the village would be and in trying to make sure than he understood my requirements the language barrier was at this moment felt to be its most problematic. Fortunately, my translator at the time had (master's degree level) experience in quantitative research and surveys, so I could rely upon them to know about good practice for surveying and also to be able to tell if the chief truly understood the instructions he or she was given.

The chiefs were instructed to hand out surveys to 10-15 people in his or her village, we made it clear to them that we wanted many different kinds of household: those from separate locations and with varied wealth, family size and consumption. Each chief was given a pen and told to fill out the form for them if the participant could not do so themselves. I had attempted to make the form as intuitive as possible but I needed to run through an example with some chiefs to show them how to fill it out. A member of the research team suggested a $10 payment, for which the chiefs would carry out the surveys and have them ready in two days' time.

This same method was applied to four villages in Kandal and another four in Samlout. In Samlout the chiefs were slower to complete their task, likely because of the layout of the villages. The commune in Kandal had grown along a very straight main road with a few minor streets running parallel, whereas in Samlout the villages were more sporadically clustered and the road between them weaved with the lay of the land.

By using these surveys, I found that the interviews progressed quicker as I spent less time asking the rudimentary questions – I had more freedom with how to allot the 30 minutes of interview.

5.3.5 Autumn: Interviews

5.3.5.1 Content

For this trip, the interview script was divided into sections based upon particular parts of energy access:

- Opener
- Food/cooking
- Water/irrigation
- Wood
- Light
- Electricity
- Communication and travel
- Asset ownership

Interviews were still semi-structured but less flexibility was permitted – in this phase the project was no longer searching for appropriate questions to ask, rather, asking the questions already found to be appropriate. Within each section, focus was on subjects such as the responsibility within the household for the related energy services, the frequency and cost of access, the location of the point of access (for example, the water tap) and a particular indicator specific to each section: for example, for the section on lighting the indicator was the number of lamps in the household.

After the main sections were complete, a few unscripted questions were asked at the end of the interview. These were more open, reflecting on the content received in that interview and from the village as a whole. A recurring theme here was the choice and confidence participants had in their coping strategies, this to address a core aspect of energy access: resilience.

5.3.5.2 Relationship to surveys

A base function of the interviews as a follow-up to the survey was for confirmation of the data; this is one way in which triangulation of methods yields more reliability. Conversation during interviews could clarify what was meant by survey responses, for instance, where a survey respondent had given their monthly consumption in riels (money) then the interview would check how this would convert to an amount of energy – this may not have been in terms of joules, sometimes I was shown a sack of charcoal and had to make judgements from there. With this kind of checking, a particular survey would be given more depth, and to a limited extent, the other surveys from the area would gain from that too: this might indicated if what that household paid per sack of charcoal was the same rate as others in the village. The validity of making such an inference came through the rest of the interview content: whilst the survey would tell if they purchased charcoal, the follow-up interview would ascertain how this purchase was made, for example, did the trader deliver to any household in the village or were they buying the surplus from their neighbour at a discount.

As the autumn fieldwork progressed, the survey changed. Questions were removed or added in, the appendix covers these changes. The motivation for this often came from what was discovered in interviews. In particular, one example was the survey question that asked for an 'electricity generator' which to my mind is a device for generating electricity. However, the literal translation in Khmer is an 'engine for generating electricity', that is, a combustion engine. So the survey participants who owned solar cells truthfully responded that they didn't have such an engine – however I was trying to find out if they could generate electricity (the capability as opposed to the device). By routinely matching surveys to interviews it was possible to catch discrepancies such as this and edit the surveys accordingly.

5.3.6 Auxiliary data collection:

The methods of interviews and surveys were narrated in chronological order to underline how they fed into one another and the cooperation of the qualitative and quantitative approaches to data gathering. The auxiliary methods given below were employed throughout the whole project and are listed in order of how much they influenced the research – though to reaffirm, data from the methods below did not feed directly into conclusions, but it did do indirectly, via interviews.

5.3.6.1 Conversations with (key) informants

Household interviews were used to develop an understanding of how energy is accessed in the home, yet, there are other facets relevant to energy access and other perspectives on it that could not be obtained from the rural householder. Consequently, many conversations I had with people over the course of fieldwork, outside of the formal household interviews, were relevant to my understanding of energy access, poverty and Cambodia. I refer to these conversations as with informants rather than interviewees, only three are named (by their initial) in the thesis. These weren't recorded and transcribed but were noted down or otherwise just became internalised into my working-theory at the time. With this lack of formality (and no recording) my 'position of power' (Desai and Potter 2006, p.64) was checked and it was easier to talk about sensitive topics such as illegal logging.

From the state side, three interviews were conducted with officials from a government ministry. These were key informants as they prepared me with knowledge about biodigesters and protected forests before I discussed those matters in interviews. One informant (interviewed twice) was the provincial head of the biodigester programme in Kampong Speu (a local arm of NBP) and the other was the head of the Sustainable Forestry Management department of the Forestry Administration.

Other informants were also gatekeepers: members of the NGOs or local businesses whom I asked for support and permission in accessing case studies, and particularly, the village chiefs in some of those case studies. Both types proffered general knowledge about the local area and the history of events to do with energy access there for example, the arrival of the electricity grid and the change in the villagers since then. In one particular case study, Chambok, there were English speaking guides in the commune's ecotourism business. Though much of their information was for tourists it was relevant (and thus informed interviews) in regards to the interaction the locals had with their protected forest (for instance, the materials they could harvest and livelihoods they practised).

The four translators I employed were also informants. They were each present during interviews and they all had a rural farming background similar to the interviewees. As such, they were familiar with most of what was being said and I found that discussing the day's interviews with them was helpful. Partly this was for alignment so that any interpretations I had weren't too erroneous but also they could give their opinion about interviewees and the energy access behaviours they spoke about.

5.3.6.2 Observations and participation

Immersion into the rural environment has always been a central tenet of this project and it led to homestays in the villages. In the spring fieldwork, during every week of interviews, one night would be spent in the home of a Khmer family. A longer homestay (four days) was taken in Chambok in the autumn. The tactics used here were either to take a notebook to a place with a good view of the residence, then attempt to fade from view and write down what could be observed, or, to take active participation in life at home: washing, cooking and collecting wood. Other mundane activities, such as eating, sleeping and going to the toilet, still come under participation and did go into the research process.

In the cities the same was true, enthused by ethnography, I scrutinised every part of daily life for the energy services involved. Although my research is set in villages, the energy behaviours of the city are still relevant, they form a ceiling to rural energy behaviours, demonstrating what it is like to have high energy access in that country. By experiencing what was high energy access, relative to Cambodia, I could better understand what low energy access was like.

In terms of observation, travelling provided ample opportunity to witness many different parts of the country. Watching people go about their daily business often provided food for thought, for instance, seeing how people carry produce to and from their fields would link to my awareness of mechanical energy, then later in interviews I would mention the kind of vehicle I had seen.

5.3.6.3 Notes, photos and documents

> [A]side from getting along in the setting, the fundamental concrete task of the observer is the taking of field notes. If you are not doing so, you might as well not be in the setting – (John and Lyn Lofland (1984:72), cited in (Bailey 1996))

Partly, notes are a memory aid, they tell a story of the research. More significantly, just the routine of taking them altered the way I acted, making me less passive. Over time, writing field notes affected what I interpreted whilst watching people and as I became more attuned to what it meant about their energy access. Also, through writing a blog I invested more time into thinking about my experiences, in turn this influenced the way I thought whilst observing a stimulus as I became more aware of how I would have to recall and describe it at a later date.

Similarly, photos act as a reminder but with very different detail. The routine of taking them made me explore (with permission) the homes of interviewees; a photo often provided a visual link to something we may have discussed in the interview and which may not have been so obvious from the transcript.

There are also many documents recovered from the field, for instance the physical surveys (to be examined for the *way* in which they were filled out), newspapers (for events of the time) and emails with project partners (containing data they had collected).

5.4 Ethics

My proposed research methodology was approved by the University of Sheffield; this permission included the use of the interview technique with supplementary photos. The main stipulations were to ensure informed, voluntary participation in the research, to anonymise the responses of participants, to avoid causing stress on either of our behalves and to ensure fair, non-discriminatory portrayal of their situation.

Good research is mediated by good ethics. I often felt the research was a balancing act, to gather better data yet not to cause detrimental experience in participants. I was taking up their time so had to offer something in return. Also I had some interest in topics which are emotionally laden, so in asking about these I had to act responsibly. Moreover, I had to convince them that their responses would not have negative repercussions and that they would remain anonymous. Beyond this, I needed to take measures to ensure the data was helpful and not misleading so I could make fair conclusions. This section details my interaction with participants and the data regarding these concerns.

5.4.1 Protecting research participants

Fortunately, the people I approached for interviews were all willing to take part. For some this may have been due my research team's apparent status as we may have come across as representatives from NBP, SNV or MJP (the groups who supported me and were active in the area). I also feel that it was because of the good-natured culture in the villages and that people were curious to talk to an outsider. This meant that there was scant coercion for them to participate. Though they may have been under a social obligation I couldn't see.

For appropriate reimbursement, participants were not paid but instead gifted with soap from the local market. To avoid complications I would interview only the adults, usually the male head of household. Interviews were conducted in the communal space by the house which provided little privacy but this is standard procedure for interviews from outsiders (Luco

2002). Where the household was also a business, I would offer to pause the interview if customers arrived so as not to cause disruption. After the interview when participants understood the nature of my study I would ask permission to take photos around the household.

Participants were given permission slips and information sheets about the study as part of university regulations (see appendix). Yet they often either couldn't or weren't interested in reading these so I had my translator brief them on the project. Mainly this was to reassure them about data protection and that the questions were on their energy behaviours and not legal or political issues. Supporting the right political part at the right time has been a dominant factor in the balance of power within villages (Ledgerwood & Vijghen 2001). I wanted to assure them that I wasn't affiliated with any party. Since the focus of questions was on energy, mostly a neutral topic, the interviewees had no qualms about how their data was used. Nevertheless, signatures were obtained to confirm agreement of disclosure. Quotes in this text are anonymised and referenced by their number, the case study location and, if relevant, the gender of the interviewee. For example:

> People can see the experiment of the science, but religion is about mind, is about belief, so I think Buddhism and the science can go together no problem – Interview 99, male, Samlout

Though energy is fairly neutral, the semi-structured interviews would sometimes veer towards topics that I realised might place discomfort on participants. In particular, the mortality associated with low energy access is a driver for the study but I refrained from asking about this and used other research methods to get that information. For example, I knew that the health problems caused by indoor air pollution is a common issue for people who burn wood but I did not want to bring up death or illness in the family; instead of talking about it I observed and participated in cooking to find out what I needed to know. Similarly, political or legal issues were avoided for the most part – they weren't the main focus of the research and I felt talking about them would have deterred comfortable and honest interviews. With this precaution, it is hard to appreciate how the villagers feel that problems of corruption or history of civil war affects their access to energy, though interesting, these issues were not pertinent enough to my project to warrant asking about them.

5.4.2 Data quality: verification of experiences in and ideas from the field

Much of this chapter has been devoted to documenting, in detail, the research process as far as data gathering. This transparency of procedure gives it a form of reliability (Flick 2009, p.387). It is clear from where, indeed whom, the data comes. Here a final step is taken in affirming that the information acquired through this procedure can be used to make findings which can be accepted under a reasonable degree of certainty.

The use of a qualitative approach was to convey what the rural energy user was saying – whilst it has been argued that the less remote, qualitative investigation is better at "*capturing the individual's point of view*" (Denzin and Lincon 1994, p.16) what comes out of this process is not their words but my interpretation. Though this is an indirect conveyance of the research participants account, that is inevitable – and unproblematic to the extent that the conclusions have utility for others (Herbert 2009, p.560).

It is equivalently arguable that the quantitative approach has the advantage in that the empirical data produced is less impressionistic so is more reliable (Denzin and Lincon 1994, p.16). However, the extent of this depends on what is the focus of study. The point of me using case studies and talking to villagers was to gain some appreciation of just how reliable listening to their account is in comparison to otherwise extracting numbers from the village. It was exactly the utility of their responses that was in question. Through dialogue, it is possible to perceive the way in which someone is speaking or possibly, through context, to be aware of what is left unsaid. Beyond that, tone, expression and body language are integral parts of communication and incorporating them does not weaken the reliability of interpretation. Moreover, they are also biases about which to exercise caution.

This is why I consider it important that the researcher accepts themselves as existing within qualitative research, so that their interpretations, and influence on the methods, become differentiated from the empirical evidence. Then, it is possible to record and represent these nuances of face-to-face conversation but keep aware that the translation and recollection is highly organic and be critical of this. In practice, I was an instrument within my interviews, one that could detect emotional response – I had to consider these interpretations to conduct respectful interviews, equally, they became meaningful data in later analysis.

5.5 Structure of the analysis and discussion

Chapter 6: Data overview: basic results from the fieldwork are given in the next chapter. Superficially this may be considered to be the quantitative data; it gives an overview so that the reader can get some impression of how energy is being accessed. The chapter explores the transition from raw to numerical data, commenting on the implications of this quantification. Findings here are on what kind of information participants are most willing and able to express in surveys and interviews. Particularly, one effect is to redesign the analytical framework for what forms of energy to study. Throughout the chapter, different ways to represent the data are given to demonstrate how it can be analysed and what inferences can be made (such as averages and distributions). This discussion of information about energy access behaviours gives part of the answer to the first and second research questions.

Chapter 7: Detailed description of how energy is accessed: this chapter expands and unpacks the content of the data overview, in doing so it fleshes out the answer to the first two research questions. The description of energy access here is given with specific reference to four aspects of energy access which act as cross cutting themes for analysis, these are: performance, convenience, appropriateness and resilience. The overview that was given in Chapter 6 is augmented with a more thorough explanation of the physical assets and devices used in energy access, in terms of those four aspects. This more thorough explanation names and identifies the devices that were grouped into categories in the previous chapter, thus providing a more nuanced understanding of assets and capabilities related to energy access. In doing so, the discussion reframes energy access in a broader sense which has implications for how it can be studied through an RRA.

Chapter 8: Design of the appraisal: this chapter explains the architecture of the two tools in the appraisal and how a researcher would go about using them. The first embodies the quantitative approach as seen in the data overview (Chapter 6). It is a streamlined tool that compresses easily obtainable but relevant data into an indicator on the quality of energy access in a given area, assigning priority between each form of energy. The tool is designed to draw its data from surveys, so it is resource-light. It advances upon contemporary measures by using a crafted scoring mechanism informed by the rural villagers it represents. The other tool is fashioned similarly (through participation) and from this it is based upon the important aspects of energy access: performance, convenience, appropriateness and resilience. It uses interview data to give a much broader, non-numerical, description of energy access so that the reader has more information upon which to make an opinion.

Chapter 9: Demonstration of the appraisal: whilst the previous chapter explains the mechanisms for the appraisal, this chapter applies it to the final case study, Samlout, so that the appraisal can be seen in action. The content of this chapter reads more like a stand-alone report on the energy access of Samlout. By moving from a theoretical design of an appraisal tool to an actual demonstration of how it works, this chapter provides substantive discussion of energy. Conclusions from this chapter answer the final research question on the implications that can be drawn from an energy-access-themed RRA.

Chapter 10: Conclusions: the arguments in the thesis are drawn together in this final chapter. It recaps the main points and illustrates how these have answered the research questions and satisfied the aims of the project. The findings of the research – on the nature of energy access and the appraisal tool – are then generalised for what they imply about indicators, poverty and development.

6 Quantitative overview

6.0 Introduction

This chapter applies the quantitative approach, giving an at-a-glance overview of the empirical evidence and a basic indication of energy access. Data is initially presented in a highly reduced form then in more detail throughout. The first section deals with how quantitative analysis can be applied to interviews, findings here prompt a revision to the analytical framework – this orchestrates analysis of surveys in the second section. Overall, analysis tends to focus on patterns in aggregated data rather than on specific, individual households. An output is to calculate averages and distributions; this chapter will consider these for their meaning with respect to the data from which they are deduced – essentially, asking what they can say about energy access. Thus this chapter expresses quantitative description of energy access and also methodological criticism of that approach.

Throughout, this chapter will demonstrate how data can be manipulated. Initially this provides an overview of the data. Subsequent sections then perform other analyses. At first, following information from verbal account to graphical representation, thus making the reduction process transparent. A crucial point is that in the extraction of data, some information is lost and that information can be significant. This then has implications about how the data should be gathered. The second section (autumn fieldwork) employs larger datasets; through these it is possible to observe patterns and model underlying behaviours. Examples in this chapter both lay down content that will be used for conclusions about how energy is accessed and also outline the role of a quantitative approach in these assertions.

		Case study (number of households reporting each supply type)						Fieldwork trip (% of households with modern access)		
Energy	Supply	K. Speu	Takeo	Kandal	Chambok	B.Bang	Samlout	Spring	Autumn	Total
Electricity	Grid	15	30	45	0	3	9	66%	45%	53%
	Off grid	23	0	0	34	2	33			
Cooking fuel	Modern	20	22	3	0	0	5	62%	5.8%	24%
	Traditional	18	8	45	37	5	42			

Table 6.1: Access to electricity and cooking fuels in the case studies

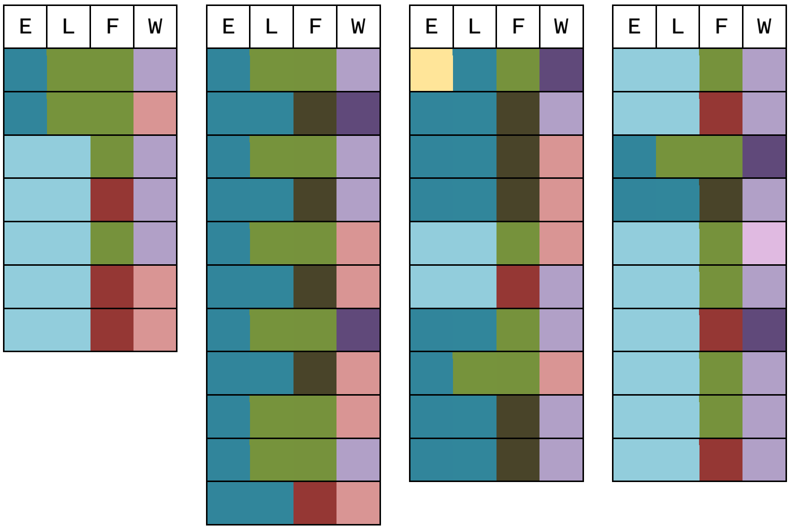
This table extracts the supply-based indicators from the fieldwork data. The proportional rates of access to modern energies are given in the right section of the table, these are mostly higher than the Cambodian averages (31% for electricity and 11% for fuels, see page 130). This is to be expected; the spring fieldwork was skewed towards biodigesters, also, these areas are the less remote and easier to study locations, especially the Kandal villages which are close to the capital.

6.1 Spring fieldwork (Interviews)

6.1.1 Conspectus

The tables below give a highly condensed form of the interview data from the spring fieldwork. Each block represents a village (one week's data collection). Each row relates to a household and each column shows a component of energy access. These components draw from an early analytical framework that has since been revised but organises this early data into the following: electricity (E), lighting (L), cooking fuel (F) and water (W).

6.1.1.1 Kampong Speu



6.1.1.2 Takeo

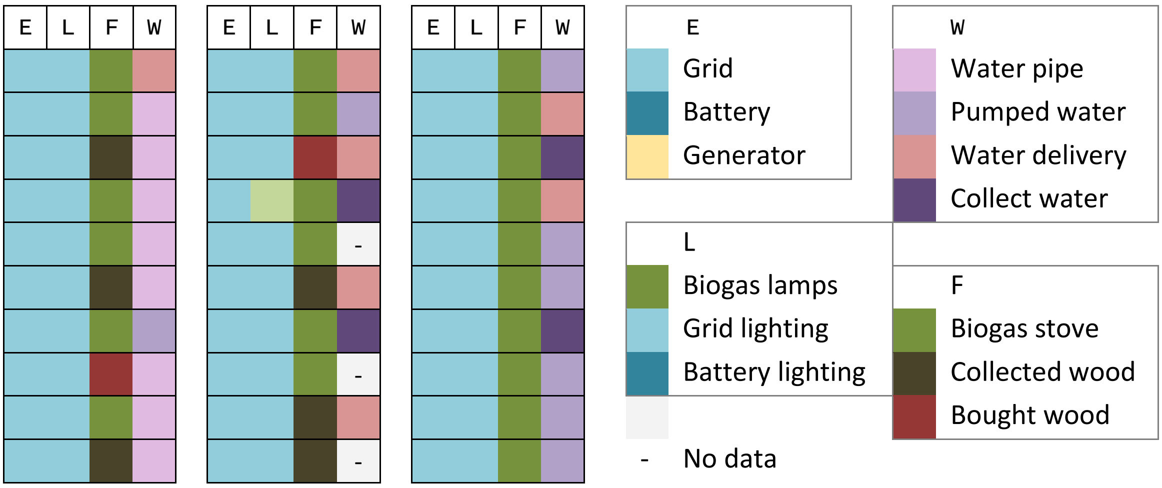


Table 6.2a & 6.2b: Energy access in Kampong Speu and Takeo (heavily simplified)

The four categories (columns) relate to the initial analytical framework that was taken into the field; notice that there is a correlation between the lighting (L) and electrical access (E) – where it is available, the grid is always used for lighting with only one exception. Similarly, where the grid is unavailable, biogas (F) correlates with lighting in all but 2/12 cases. Immediately this yields a result that batteries appear to be the least favoured means of lighting. So, this condensed data was useful early on in refining the analytical framework by merging the category of lighting into electricity as the former is not very helpful on its own.

Several other findings can be taken from the conspectus, demonstrating the utility of such a reduction. For those people questioned:

- There is only a single household with an electrical generator making it a rare asset
- Only one village (in Kampong Speu) had zero electrical grid connections implying that the infrastructure is far-reaching
- There is a grid connection for every household in Takeo – within these villages access is fairer
- Almost every water pipe connection is in one village in Takeo, so where available, it is preferable
- Biogas lighting and water pumping are more common in Kampong Speu, possibly meaning those methods are linked
- There are fewer cases of the household buying water where there is a water pipe in the village, possibly related to the nature of the resources

These findings are tentative but useful; they yield little certainty but are a sound basis for further investigation. Moreover, they are useful in differentiating between the household-village-province scales. In particular, for water access, the village is an appropriate unit – whereas for electrical access there is unequal access within villages, so the household is a better unit.

The limitations of the data within this study are caused by the skew towards biogas fuel households. The data set is not representational; most of the households in the villages do not have biogas digesters. This was stated in the methodology and will be reflected upon in Chapter 10.

Overall a basic observation might be that Takeo has ‘better’ energy access than Kampong Speu: there is a greater availability of electricity and water through infrastructure – but before such an assertion of ‘better’ is made, it is necessary to pry deeper into the data to see what the above classifications are doing and indeed obscuring. The following subsections will focus less upon location and instead upon each component of the data. The validity of ‘better’ will be interrogated and more apt terminology will be defined. In doing so, this section will walk the reader through how the quantitative data was extracted from interviews.

6.1.2 Village economy

Before studying the data on energy access in the villages, the data on their livelihoods and income is given. This is mainly to allow relative understanding of the rest of the content to do with prices or lifestyles.

Primary sector (farming)	Rice	Animal	Vegetable	Peanut	Taro	Mushroom	Palm juice
	59	46	16	4	2	2	3
Secondary sector	Garment factory	Knitting	Construction	Miller	Rice alcohol	Welder	
	21	16	9	4	3	3	
Tertiary sector (services)	Retail	Teacher	School director	Village chief	Commune committee member	Wedding ceremony materials	Driver
	8	6	2	3	2	2	2

Table 6.3: Reported livelihoods from the 68 households in Kampong Speu and Takeo, by economic sector

The numbers represent how many households answered that they had at least one member with the associated livelihood. Notice that the considerable majority of villagers are rice farmers and that most keep animals, these livelihoods are well-paired as the animals can be used in agricultural labour (for manure and as draught animals) they can also be fed on agricultural by-products (rice hay). Conversely, some of the secondary sector and tertiary sector jobs exist separately from farming due to the labour requirement – a garment factory worker does not have the time to tend a field. There are exceptions, as being a village chief or commune committee member is more of a role, they have free time for other activities (for example, farming); also, construction workers, knitters and welders are employed inconsistently so they may have multiple jobs depending on the season or state of their business. The point is that there is a range of different livelihoods which can be associated with varying degrees of labour input and monetary output; though, most rural people are farmers, receiving low income and having high labour requirements in the wet season.

For similar motivations in giving context, household income was recorded in 38 interviews: in this first half of fieldwork households had average annual earnings of $2050 per year. The cost of energy can take up a significant proportion of this, with wood accounting for around $120 and electricity costing something on the order of $47 to $100 (yearly) – how these figures are produced is given in 6.1.3 & 6.1.4. However, this is only a very basic estimation of energy poverty in informal, agrarian societies where many people in the villages collect fuel freely and rely on their rice cultivation (for food and barter) instead of financial transactions. Though important, price is not the only factor in energy access, as will be shown.

6.1.3 Fuel choices and fuel stacking

In the overview, cooking fuels were represented by one of three types: biogas and bought or collected wood. However, households often mix these types but that could not be seen in the prior dataset which gave only the primary fuel. To see what information was lost, the table on the next page shows more on this ‘stacking’ of fuels by categorising them according to the share of wood or biogas in the fuel mix. Entire use of one fuel relates to mixing a few times per year, mainly is to mix at least once a month and mostly, at least once per week.

Forty two biogas households — **Twenty six wood household** — **Twenty one households stack their fuels**

Entirely biogas
Twenty seven households use only biogas
Twenty seven

Mainly biogas	
Stack with	Method
Wood	Buy
Wood	Buy
Wood	Collect
Wood	Collect
Wood	Collect
Wood	Collect
Six	

Mostly biogas	
Stack with	Method
Elec	Buy
Wood	Collect
Wood	Collect
Wood	Collect
Wood	Collect
Wood	I-20
Wood	I-30
Wood	I-53
Wood	I-67
Nine	

Mostly wood	
Stack with	Method
Elec+gas	Buy
Elec	Buy
Gas	Buy
Gas	Collect
Gas	Collect
Biogas	I-47
Six	

Entirely wood (twenty)	
Seven use bought wood only	Twelve households use collected wood only
Seven	I-37
	Thirteen

Table 6.4: Fuel stacking of households in the spring fieldwork

Households that stack fuels are shown in the middle, with single fuel households to the sides. Special cases are numbered “ I-x ”, referencing the interview number – these are discussed below.

Of the 68 interviews, 47 reported to use only a single source of fuel (either biogas or wood), the remaining 21 engaged in some form of stacking (including natural gas or electricity). As these villages in the spring fieldwork received a lot of promotion from the biogas programme, biogas households are over represented, and possibly, so is staking. However, the table does give generalizable information about the transition behaviours in adopting a new energy source. Stacking is more common with this new fuel, biogas, than with wood households (36% versus 23%); interviews indicate that this is because of the limited biogas supplies, especially when it is also used for lighting. Also, buying wood is less common for those stacking it with biogas: from interviews, this can be linked to biogas households having more time to spare or being more thriftily minded. Finally, it can be seen that electricity and natural gas are rarely used for cooking, though with so few reported cases it is hard to say much about them. Regardless of the skew of the sample, stacking is common enough to be an important issue in these studies.

The yearly/monthly/weekly periods for mixing fuels are chosen such that there is a fairly even spread of stacking in the table, it is to illustrate that not indicating stacking misrepresents a significant number of households. The rationale for stacking fuels is better supported by the qualitative analysis in Chapter 7. The point made here is that it is meaningful to break down the three categories of 'biogas', 'bought wood' and 'collected wood' into at least five meta-categories of stacking.

By not representing stacking, the earlier conspectus tables misrepresented the energy access of around a third of the households. Even at this greater level of detail there are behaviours which are hard to represent, such as the I-x households. For any discrete classification of household behaviours in a large enough dataset there is almost inevitably a borderline case which is ambiguous. Although these more complicated behaviours are in the minority, they imply that it may be impossible to construct a robust system of categorisation.

Consider those I-x households who gave responses that were difficult to classify. Interviewees 20 and 30 would use wood to augment their biogas but neither could say if they bought it or collected it more often – they lay between data categories, forcing a choice upon the analyst. For other interviewees, the act of classifying them and reducing their responses would lose out on vital information:

> He don't want to buy any energy besides wood to cook because there are energy available, for example in the vegetable land they grow cashew tree, they can cut this for wood – Interview 53, male, Kampong Speu

Similarly, interviewee 37 explained that they cultivated trees by their house – technically they collect this wood but it is a crucially different behaviour than those who collect wood from a forest which can mean travelling up a mountain or a distance of many miles. Classifying behaviours inevitably leads to obscuring details.

Two other interviewees both owned a biogas system but due to a lack of manure each were reliant upon wood as a fuel. 67 did this due to labour shortage from temporary illness and 47 because he shared his biogas supply with his son's household. As 67 is only temporarily stacking it is difficult to classify them, at the time of study they were using wood as well as their neighbour's manure to feed their own digester but this is not the norm, just a snapshot. Household 47 are also hard to classify, their behaviours are entwined with those of their relatives so their fuel behaviour only make sense at the inter-household level.

This is evidence that even the five categories of stacking are not enough to capture, fairly, all the data. Behaviours relating to fuel are complex; just from information on fuel type it is difficult to say who has 'better' energy access so further analysis is needed. Classification alone can be misleading – a biogas user relying on their neighbour's animal manure may find it harder to access fuel than a wood user with a plentiful supply of trees in their garden.

Discussion now shifts to the process of quantification. Considering just the wood consuming households, values for the cost of buying or time taken in collection are tabulated below. A bigger aggregate is drawn upon later in the chapter using survey data, the point of the table here is not to achieve statistical significance but to show how the data is extracted from interviews.

Table 6.5 (next page) refers to buying or collecting wood in terms of the time and monetary cost. The left column of raw data gives the time/financial expense as stated by the respondent, the next column then quantifies the information as single, normalised value and the right column gives a likely reason for this size.

The quantification makes the data easier to read. The information represented is the kind of figure (cost of living or time burden) used in the literature review to express the difficulties of living with low energy access.

Buy wood		
Price (raw data)	Price ($ per month)	Notes
$7.5 trailer every 4 months	1.875	Old price
$75 truck, lasts 2-3 years	2.5	Wholesale
$7.5 per $meter^3$, one $meter^3$ per 2-3 month	3	Bulk buy
$30 trailer every 3 months	10	Bulk buy
$0.375 per day	11.25	Frequent
$25 trailer every 2 months	12.5	Large family
100 bunches per month, $0.125 per bunch	12.5	Small units
$0.50 per day	15	Frequent
$2.5 per bag, one bag every 3 to 4 day	21.43	Wealthy household
Average	**$10**	

Collect wood		
Labour (raw data)	Labour (hours per month)	Notes
Yearly, 4-5 hour	0.375 (low outlier)	Power tiller
4-5 hours every 2 months	2.25	Power tiller
2-3 hours, 3 or 4 times per month	8.75	Power tiller
15-30 min per day	11.25	By hand, daily
4 hours, 3 times per month	12	Animal trail
2-3 hours, 5 to 6 times per month	13.75	Cafe owner
2 to 3 times per month, 4-10am	15	Wood scarcity
3 hours, 3 or 4 time per week	45.62 (high outlier)	Distillery livelihood
Average	13.6	
Average (omitting outliers)	**10.5 hours**	

Table 6.5: Quantification of wood acquisition

The table quantifies verbal explanations for wood acquisition (buying or collecting). This allows for easier comparison of data values so they can be ordered by size, averaged and otherwise manipulated. There is variation in both sides, but more so for labour reflecting the nature of resource collection. Top and bottom outliers for labour are a notable distance from the rest of the group.

As an output of this process, the per person cost of, or labour associated with wood can be estimated. On average each person contributes $1.82 to wood purchase or 2 hours 17 minutes into wood collection, per month. Immediately this gives some idea of the cost of living and the value of wood-fuel. The spending on fuel versus total household income can be used to indicate energy poverty. The time spent collecting wood is harder to use because it is difficult to say how this may otherwise be spent, though some benchmark could be set, say 25% above the average, which would class two of the non-outlier households in the table to be in energy poverty. Though arbitrary, such a benchmark could be used to identify problematic cases or set targets for initiatives.

The distribution has at least as much meaning as the average, here it is supported by the column of notes. An obvious influencing factor is the size of the household; per unit per capita, larger households pay slightly less for wood or take more time collecting it (see correlations in appendix). However, household size is not the main factor. The variation in cost/labour is better linked to the frequency of purchase (bulk purchasers pay less per month) or the tools used in collection (power tillers save on labour). Thus, frequency plays a bigger part later study; this is given in the revision of the analytical framework.

Also, notice that each item in the first column (raw data) uses its own time period and that this is highly correlated to the values in the second column, yet this time period is lost in the transition. Methodologically, this has an implication for the process of data gathering: in the autumn fieldwork interviews would focus on the frequency of wood acquisition and the volume that could be stored.

Whilst the reduced data has a purpose – for instance, it can be used to estimate the financial/time savings of adopting biogas – it is the need for an underlying explanation of *why* the values are what they are which is ultimately motivates the more in-depth study of the next chapter. Indeed, both qualitative and quantitative information is needed here, to locate who might be in energy poverty and to identify what factors are influencing this.

6.1.4 Electricity

In contrast to the previous subsection, here there are no additional categories to break down electricity consumption into, though the particular consumption figures were easier to obtain and so that is the additional layer of detail given here. In the table below, there are several values relating to consumption though not all participants could give each of these. So, part of the quantification process here is to calculate those missing values.

Battery			**Grid**							
Kampong Speu			Kampong Speu				Takeo			
Cost per charge ($)	Charges per week	Cost per week	Years connected	kWh per month	Tariff ($/kWh)	Monthly bill ($)	Years connected	kWh per month	Tariff ($/kWh)	Monthly bill ($)
0.5	**0.33**	0.165	**-**	**20**	**0.18**	3.6	5	**25**	0.35	**8.75**
0.535	**0.5**	*0.27*	2	**41**	0.24	**10**	9	**10**	*0.28*	*2.8*
0.535	**0.5**	*0.27*	**-**	**27**	**0.2**	**5**	-	*15.18*	*0.28*	**4.25**
0.625	**1**	0.625	2	*14.67*	*0.27*	**4**	1	*8.93*	*0.28*	**2.5**
0.625	**1**	0.625	2	**37.5**	0.375	**17.5**	8	**12.5**	0.2	**2.5**
0.5	**1**	0.5	2	**100**	0.175	**17.5**	8	29.17	**0.3**	**8.75**
0.535	**1.45**	*0.78*	**-**	27.78	**0.18**	**5**	4	*15.83*	*0.3*	**4.75**
0.375	**7** (outlier)	2.625	**-**	**20**	**0.3**	6	2	*33.33*	*0.3*	**10**
0.5	**1**	0.5	2	**42**	**0.18**	7.56	1	33.33	**0.3**	**10**
0.62	**1.4**	0.87	2	*13.54*	*0.24*	**3.25**	4	8.33	**0.3**	**2.5**
0.535	**2**	*1.07*	0.6	*10.42*	*0.24*	**2.5**	1.4	29.17	**0.3**	**8.75**
0.535	**2.33**	*1.25*	3	*62.5*	*0.24*	**15**	5	**20**	*0.325*	*6.5*
0.535	2.15	**1.15**	3	*52.08*	*0.24*	**12.5**	2	**10**	*0.325*	*3.25*
			1	*31.25*	*0.24*	**7.5**	3.5	**17.5**	**0.4**	**7.5**
Average	1.78	0.88					4	**50**	**0.3**	15
Average (\outlier)	1.85	0.91					4	*17.31*	*0.325*	**5.625**
Average (monthly)	8.03	3.96	Average	35.70	0.24	8.35	Average	20.97	0.30	6.46

Table 6.6: Costs of electricity from batteries and the grid

The left section gives data on battery usage, normalised to a week, the columns on the right relate to grid electricity, monthly. Numbers in bold represent values taken from interviews, the plain text values are calculated from these. With an idea of the for the tariff village, the remaining values in italics are calculated. For battery households, calculations are in weeks not months, using the constant of 4.345 weeks in a month.

The battery households on the left generally pay less per month but there is a noticeable outlier who charges their battery seven times per week and thus pays a substantial amount more than their peers and a quarter of the grid users. Grid households, on average, pay more per month than battery households for several reasons, these reasons are considered in later chapters but mainly it is because it is much easier for them to consume the electricity, that is, the cable's supply is not as limited as the battery's charge.

Batteries are effectively the minimum level of electricity, they became popularised in Cambodia sometime in the eighties. Households said that they need to replace their battery every two or three years (although one high consumer put it at just six months). Batteries cost $40-50 but villagers can earn $12.5 for recycling their old cell – this equates to an extra $0.76-2.08 on their overall monthly costs depending on how well they maintain their battery and if they can recycle it.

Cambodia's electricity sector is fragmented, it has numerous providers, so though the grid has higher penetration in Takeo and has been there for longer, the unit price in Kampong Speu is lower – this difference is met with proportionally higher demand. The average tariff is one fifth lower in Kampong Speu and consumption is 70% higher, though this drops to 41% when the top and bottom outliers are removed from the calculations. The outliers, detailed below, are influential so care must be taken in dealing with them. Nonetheless, electricity consumption is sensitive to the tariff. With this, a remark from section 6.1.1 can be disputed: Kampong Speu now has 'better' energy access than Takeo in terms of lower costs and higher consumption.

Of the grid-households, the top outlier has a consumption of 100 kWh per month; they have livelihoods in agriculture and textiles, so they use mechanical devices like pumps and also sewing machines and an iron which uses much electricity to create heat. By contrast, the low outlier just uses a cell phone, lighting and TV – the interviewee owned a DVD player but didn't know how to use it and she said she was waiting for the price to fall before investing in an electric cooker or fridge. Solely based on consumption data it seems that the former household has the 'better' electrical access. Yet, they use it for their livelihoods, so the effect that it achieves may only be income generation which the latter household accesses through other means. Essentially, more is not necessarily better, it only indirectly relates to capabilities and even less directly to welfare. It depends on what assets the household has – this motivates the analysis below. In-depth study of their use is the remit of Chapter 7.

Total number of electrical devices owned in total sample											
Light	TV	Cell	Fan	DVD/CD player	Water pump	Speaker	Power tools	Stove	Sewing machine	Desk phone	Radio
60	48	30	21	15	14	9	4	3	3	3	3

Average number of devices owned per household					
With battery	Grid for 1 year	Grid for 2 years	Grid for 3 years	Grid for 4 years	Grid for 5+ years
1.52	3.57	4.67	5.67	4.14	3.67

Table 6.7: Reported ownership of electrical devices

This table gives an overview of ownership of electrical appliances in all households. Immediately it reinforces the popularity of lighting and TV. It should be noted that devices such as cell phones and radios were often observed but left unreported unless asked for specifically. Nevertheless, it is either not true to say that a user accumulates more assets the longer they are connected to the grid, or, it can be inferred that users' perceptions of what counts as electrical assets changes of time. More information is needed on the household with respect to their asset ownership.

The following table attempts to present the data in such a way that different kinds of electricity user can be identified. It shows ownership of electrical appliances for those households who own at least four, thus it omits those with low-demand – these don't add anything interesting. The groups below can be considered in two ways: by the rarity of assets or the number the household owns (red and blue dividing lines).

- **Rarity**: Assets to the left of the red line are relatively common, notably, lighting and TV are all but universal; cell phones and fans are more common below the thickest blue line but DVDs and pumps are quite evenly spread. Assets to the right of the red line seem to pertain more to luxuries and specific livelihoods (power tools and speakers) than basic essentials (lighting), though stoves – which relate to a basic energy service – are the exception to this.

- **Number**: four asset households usually own lights and TVs, then either a DVD player or a pump plus one other asset – more data would clarify if there really is an either/or pattern. For greater-than-four asset households, phones and fans become standard and speakers are common, also the rarest assets become visible. The highest-ownership households tend to have everything that isn't fairly rare (that is, owned by fewer than five households).

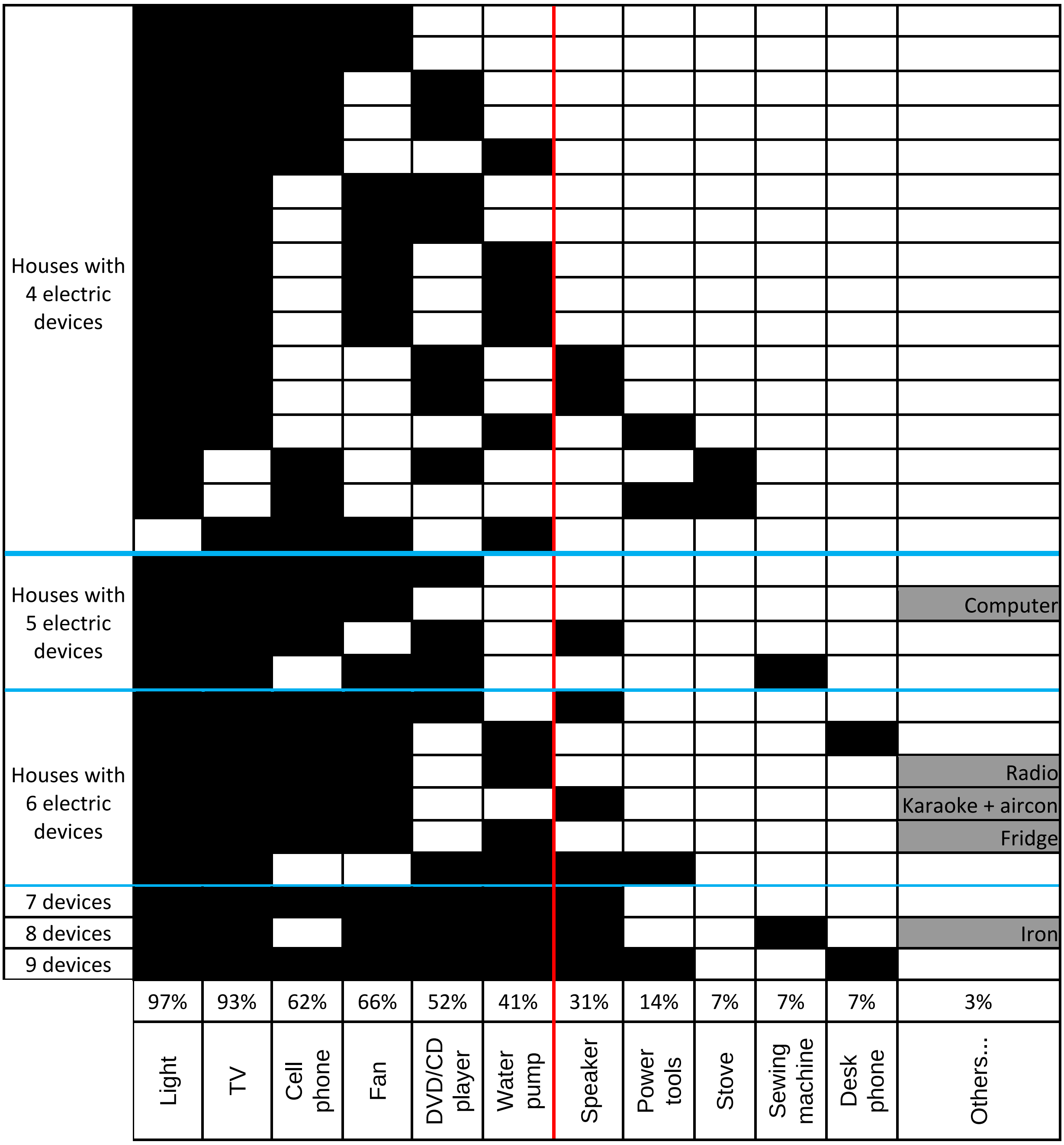


Table 6.8: Ownership of electric devices in medium-to-high consumption grid households

Each row represents a household owning at least 4 electrical assets. A rough pattern of distribution can be seen from the black blocks (indicating that that devices is owned by the household in that row). The red dividing line relates to devices in their rarity, the blue to households in how many devices they own.

The point of this table is that with it, it is fairer to make inferences about people's energy access than based on their consumption alone. Assets can be an indication of the capabilities that people have; nearly everyone has a TV and at least one person has a computer, thus it can be inferred that nearly everyone is capable of receiving information broadcast on TV and feasibly, they have the potential to use IT if they follow that early adopter. Assets can be appreciated for their rarity and vitally, this can be cross-referenced to the nature of the household in terms of what other assets they own. However, this indicator is limited because it cannot convey the way in which these assets are used and the actual capabilities realised by users, this is explored more thoroughly in the next chapter.

6.1.5 Water

The water supply of households can be divided into four principal methods: 1) a pipe connected to some infrastructure, 2) a delivery from someone outside of the household, 3) by the household themselves pumping from a nearby stream or pond using fuel/electric motors, or 4) manual collection.

Piped water (monthly)		
Usage (m^3)	Unit price ($\$/m^3$)	Bill ($)
10	0.5	**5**
4.5	**0.3**	1.35
10	0.5	**5**
11.76	*0.425*	**5**
17.65	*0.425*	**7.5**
11	**0.4**	4.4
Average: 10.82	Average: 0.425	Average: 4.71

Table 6.9: Details of piped water

Each row represents a household with a water pipe connection; the columns show different methods I found of recording their water consumption.

Similarly to the previous tables, the values taken straight from interviews are in bold and the interpolated values are in plain text, and those with assumptions in italics. As there are not many households in the 'pipe' sample it is difficult to find trends in the data, though through tariffs and bills the information is easy to quantify. For these piped households, water is cheaper per unit, though that does not mean they pay less overall (as with electrical infrastructure).

Water delivery (no specific time scale)		
Raw data	Cost per time	Notes
$0.375 for 20 litre container	0.375	Drinking only
$0.5 for 30 litre container	0.5	Drinking only
Four jars, each cost $0.625	0.625	Can't afford pump
$0.75 per tank, buy weekly	0.75	Domestic uses
$1-1.25	1.125	From pagoda
$2.5 per container	2.5	Neighbour's service
$3.75 for five jars	3.75	Domestic uses
$4.5 month for 4m^3	4.5	Monthly
By truck, $6.25 for 4 months	6.25	Too old to collect
$6.25 per trailer every 10-15 day	6.25	Cattle husbandry
1 truck is 6 jar (6*500l), $6.25/week	6.25	Large family + animals
5 days, 1 truck	*6.25*	Pig husbandry

Table 6.10: Quantification of verbal explanations for the cost of delivered water

Fewer than half of these households gave the frequency with which they would purchase water deliveries but a pattern can be established from the amount that they pay per time. The price per litre is fairly consistent though varies with quality. The cheaper deliveries are the smaller ones, to households that only use water for drinking or other domestic duties such as washing; bigger and more expensive deliveries go to households that need water in their livelihoods for supporting animals. However, there are low demand households that buy infrequently and in bulk – the extent to which they can buy in bulk depends on their storage. Description of the water containers, large ceramic ‘jars’, is given in chapter 7. Since not every household gave exact quantities it is hard to say how much water costs per litre, large deliveries are between $1.1 and $2.1 per meter cubed, though higher quality drinking water costs nearly ten times as much – the key indicator here is the desired quality of the water.

Water pumping (monthly)			
Energy	Frequency	Quantity	Hours
10 kWh	10	-	-
30 kWh	30	-	-
-	3.5	30 jars	-
-	13	-	13
15 kWh	10	-	10
1 kWh	-	-	3
8.5 kWh	8.5	-	-
2 kWh	-	4 jars	-
-	1	-	-
-	12	-	3.5
-	12	-	-
1 litre	1	6 jars	0.5
-	3	-	-
-	8	10 jars	-
2 litre	1	-	3
-	-	21 jars	30
2 litre	-	6-7 jars	-
1.5 litre	-	-	2
Percent reported			
55.56%	72.22%	33.33%	44.44%

Table 6.11: User reports for quantification of pumping water

Unlike in table 6.9 the information given cannot be used to infer that which is not given, hence the blank cells. The litres in the left column refers to fuel, jars in the quantity column refers to 500 litre water containers. As the bottom row shows, the number users give is usually in terms of frequency.

This table gives the extracted data from villagers' accounts of how they pump their water. Values are normalised to the month and this marks significant differences between the households. The outliers here are again influenced by their livelihoods for instance, animal husbandry, cement mixing or rice alcohol production all consume a lot. However, since villagers live at varying distances from water sources, it is impossible to interpolate the energy consumption as the pumps are outputting different quantities of work. The quantity of water needed (which relates to livelihood) is still a significant factor but doesn't represent all the important information regarding the task of pumping water.

One finding that can be taken from the table is that, similarly to wood, the frequency is useful data because participants think in these terms (high percentage reported). This does not express the energy involved but it does give an indication of the scale of this chore for the household.

A difficulty in comparing the above data is partly that the product is different in each case, that is, the water quality, but also that there are very different forms of responses. For piped and delivered water, interviewees more readily give details on the cost – though for delivery they have their own measurement of quantity (jars, tanks or containers). For pumped water, interviewees found it more difficult to calculate costs but were quite able to say how regularly they pump.

In terms of analysing the data, the method itself (pipe, pump, delivery) is quite indicative of the users' energy access. Also, more so than with cooking fuel or electricity, the quality of water and the water supply come across as being significant: potable water is more valuable and a distant stream requires more energy to be pumped to the household. These findings fed into the methods of data extraction in the next section on autumn fieldwork.

As a final point on extracting data from interviews, the person with whom the interview is conducted can make a difference. Many household tasks are gendered or otherwise given to one member of the household; there are divisions of labour and the knowledge of these tasks is not entirely shared. Particularly, it is the men who tend to operate the machines such as pumps so they can be the more reliable source of data on the household supply, though perhaps not on the household demand if that too belongs to a gendered role.

6.1.6 Engines

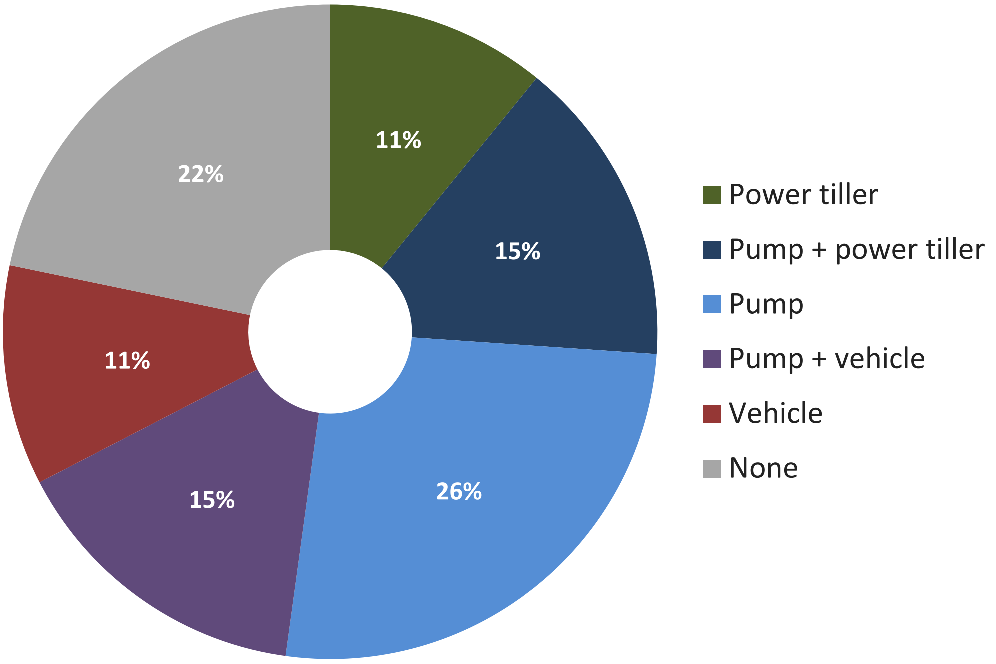


Figure 6.1: Classification of households by ownership of engines in Kampong Speu and Takeo

The total number of households represented by the chart is 46.

This chart gives the ownership of engines throughout the villages, as with electrical assets, it gives an indirect indication of the capabilities of villagers. More directly, it shows which engines are rarer/more common, however there is remarkable symmetry in the data in that the groups are of similar sizes.

The chart indicates that over half of those asked about engines professed to own at least a pump, a quarter said they owned at least a power tiller, and another quarter at least a vehicle. Interestingly, there is no overlap between the power tiller and vehicle owners, possibly this is because these engines have a substitution effect, both in practice (one can use a power tiller as a vehicle) or in interview responses (people may not consider a vehicle to be an engine in the same sense as a power tiller, so would only report the latter). My estimation is that it is more towards the latter reason: care must be taken in the language used of these studies to ensure the participants understand what is being asked.

It should be noted that not all households with a pump use it for their domestic supply of water (as examined earlier), some use them for irrigation. Likewise, the actual ownership of engines does not match the usage of these engines as sharing is a common practice in the villages, this could also account for the lack of overlap between power tillers and vehicles. More on sharing is given in Chapter 7.

There are other engines in the villages which were left out of the classifications above. There were six rice mills, a threshing machine, a few sewing machines, a flour mixer and an electrical generator. Although I did not speak to them directly, some interviewees explained that other villagers own machines used for cutting in carpentry – I expect that more such specialised machines would turn up the longer one looked.

6.1.7 Additional data

A final element of quantitative data from the spring fieldwork is in the biodigester users' response to the question on the advantages of that asset. Initially, this was intended to provide qualitative and descriptive data, however, in interviews the response was usually along the lines of the benefits advertised in NBP's promotions – thus producing roughly categorical data. Although some of the categories are difficult to distinguish, for example, the preference to use gas may refer to its controllability as a cooking energy or its shorter cooking time. Nevertheless, the fact that the data came back in a more quantitative form than was intended is useful as it makes it clear which of these principal, advertised benefits are most esteemed by the user.

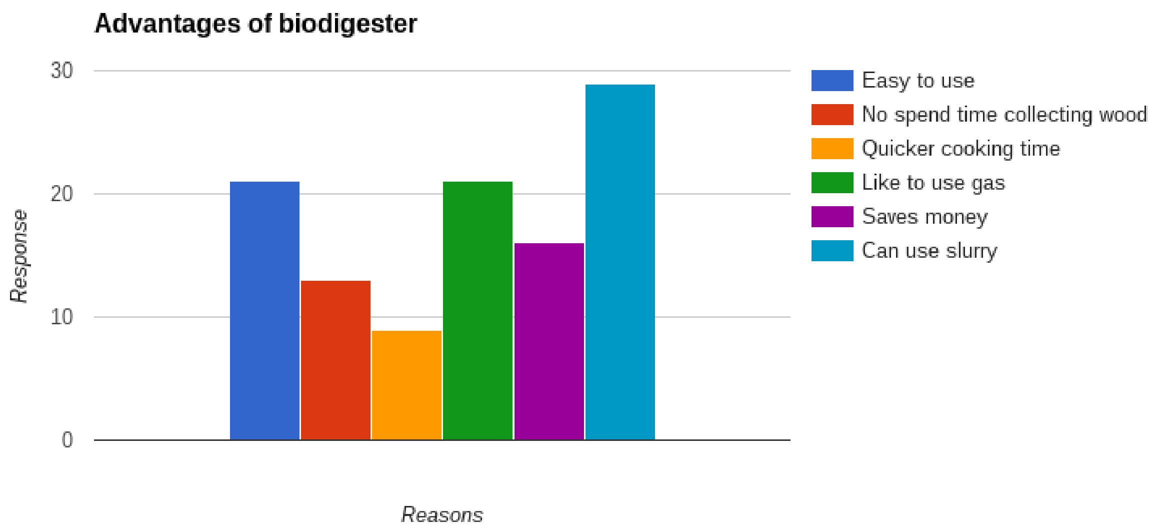


Figure 6.2: Users' favoured benefits of biogas digesters

Almost every household asked could report the majority of these advantages; instead of plotting them all, this graph represents the users' selection of their favourite of these advantages (some named more than one). Most responded that it provided them with a free bioslurry fertiliser. The two reasons of time saving (from wood collection and cooking) total up to 22, which rates overall time saving to be a similarly appreciated advantage as the other reasons. If these two reasons of time saving are collated, then the money saving is the least favoured advantage. Conversely, if the cost and time saved in acquiring wood are collated then these savings are equally valued as slurry. It is difficult to ascertain the inter-subjective agreement on what is the best advantage of the biodigester because the households have different backgrounds and different reasons for adopting the digester. The data on opinions can be counted as in this graph but that does not satisfy the core aims of this project in gaining a more nuanced understanding of these opinions on energy behaviours. In particular, it is these opinions which are revisited in later chapters.

However, this graph demonstrates practical applications of the quantitative approach for an actor, such as SNV, who are promoting biodigesters. Seemingly bioslurry is where they can gain most leverage in promotion. Also, this graph shows that data on opinions is not definitively qualitative. Finally, it relates to energy access in terms of how users feel about that particular cooking fuel and the ramifications of its use.

6.2 Revising the analytical framework

The initial evaluation of the data from the Spring led to the redesign of the first analytical framework given on page 143. This new framework still embodies concepts from the literature review but is tempered with experiences and observations from the field; specifically, in what data to gather. Fieldwork in the spring was exploratory, from that, several focal points were identified to hasten the process of data collection and ensure that the data collected was useful. The new focus redefines time and quantities to align with the way that rural people think and talk about energy access.

This revision to the analytical framework also merges the category of lighting into that for electricity, since lighting didn't allow for much analysis on its own. Mechanical energy is now split into water access and access to engines: water is not a fit proxy for all of mechanical energy since water access is so dependent on water sources, also, engines such as the power tiller have broad reaching influence on the way energy is accessed and as such they deserve their place in the framework. The section on cooking fuels remains fairly similar. The cross-cutting reflects the nature of the data that was obtainable in, and useable from, the spring fieldwork, with these changes, the assessment of energy access became more suited to the research participants and both more effective and efficient at extracting data.

Analytical framework (II):

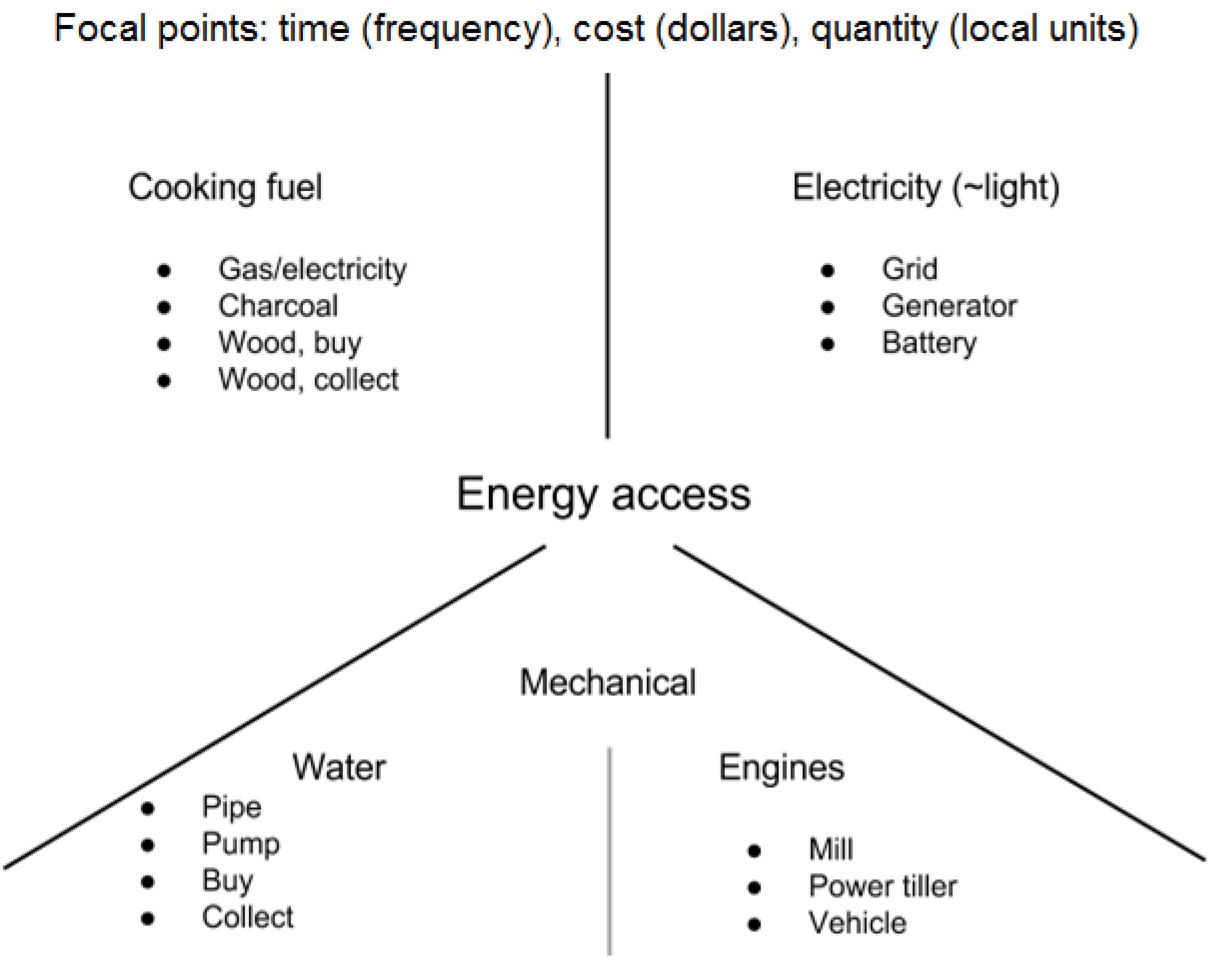


Figure 6.3: Revised analytical framework

This is informed by the preliminary analysis of spring fieldwork, so is no longer purely based on the literature. The assets listed in each section were those observed in the fieldwork.

6.3 Autumn fieldwork (Surveys)

6.3.1 Conspectus

The following tables differ from those in the previous conspectus due to the revision of the analytical framework. There is a noticeable lack of biodigesters in these tables which is due to the different method of sampling that did not draw upon NBP's database. The column for mechanical energy (M) shows the ownership of a vehicle (usually a lightweight motorcycle), power tiller or a rice mill with the latter taking priority. Unless stated otherwise, the tables draw from surveys – this method was only introduced in this period of fieldwork. Surveys were in one sense less effective than interviews: there are many blank (unanswered) spaces in the tables; however they were more efficient, these tables are larger.

6.3.1.1 Kandal

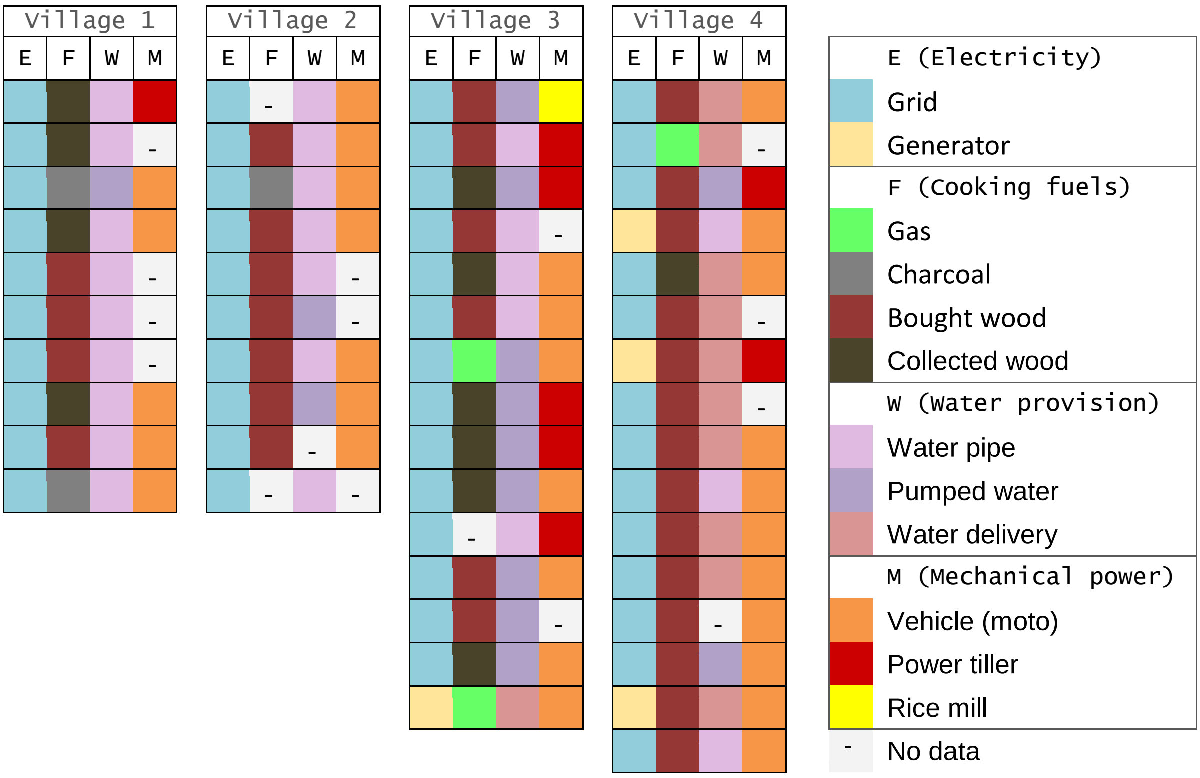


Table 6.12: Energy access in Kandal (revised framework), ordered by village 1 to 4

Kandal seems to have good infrastructure in that there are many households connected to the electricity grid and water pipe. However, it is the high quality roads to the village and its proximity to the capital which set this area apart from the other case. Notably, roads in the villages make the delivery of water or wood easier, so these businesses serve many households. Whilst the electricity grid is pervasive (similar to Takeo), there are several generators present. The transition from water pipes, through pumps, to delivery can be seen in the progression from villages 1 to 4; the first villages are closer to the centre of the region and are better served by infrastructure. However, cooking fuels do not follow the same progressive pattern, collection is more common in villages 1 and 3 – unfortunately there are too few gas/charcoal users in the data set to establish a pattern.

6.3.1.2 Chambok

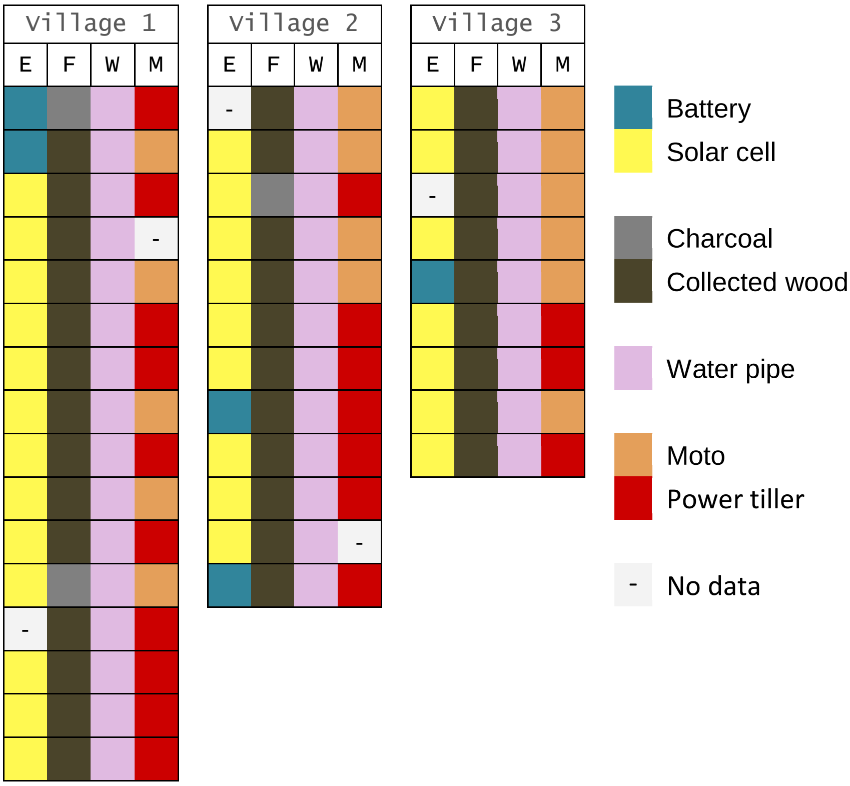


Table 6.13: Energy access in Chambok (revised framework), ordered by village

The results from Chambok stand out in the data set, notably there is a lower level of deviation in categories E, F and W. Partly this is due to intervention in the area: the electrical access here is as a result of NGO activity promoting solar cells, the UNDP installed a water pipe which everyone uses and the villages themselves are located within a sustainably managed forest so few of them need to buy wood.

There are a handful of households that use charcoal for cooking, but the rest forage their wood – it is possible to buy wood but being situated in a forest, most residents of Chambok choose to get their own. Perhaps because of this foraging, the ownership of power tillers is relatively high; people need the mechanical power of a tiller to traverse the rough terrain of the forest. Also, the high ownership of vehicles can be accounted for due to the remoteness of the location, only the very small village markets are in walking distance.

Apart from the polarisation of their methods, another notable finding about Chambok's energy access is that solar home systems are common – elsewhere in the country decentralised generation is rare. In this remote location it would be difficult or impossible for villagers to make use infrastructure such as the electricity grid, so with an NGO helping to finance them, solar cells became very popular in Chambok. Likewise other locations I studied didn't have a nearby waterfall like the one which enables the piped water in Chambok. It is the geography and ecotourism which make this case unique. Particularly, it is an interesting place to conduct impact assessments of intervention – pertinent to Cambodia with its high concentration of NGOs and indeed relevant to other locations seeking to practice ecotourism.

6.3.1.3 Battambang

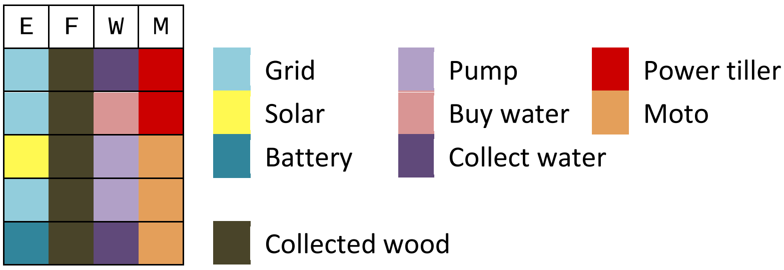


Table 6.14: Energy access in peri-urban Battambang (revised framework, based on interview data)

This small data set is taken from interviews as opposed to surveys as with the rest of the data in this overview of the autumn fieldwork. Surveys were not conducted in Battambang as no local research agent was available. Though the interviews provide a rich set of data, when they are condensed it is quite apparent how much faster surveys are in collecting basic information. With just five cases it is hard to generalise about this Battambang region, though this data still has implications. There is a mixture of behaviours except for fuel which is all wood collection. This shows that water deliveries and the electricity grid can reach at least some parts of this area. Also of note is the solar cell in use, this is unique outside of Chambok so it is clear that that technology isn't confined to one region of the country, just that the NGO in Chambok was more active. That all five cases collect wood does not reveal much about the fuel market in the area; interviews confirmed that it is expensive and that households would take it from trees on their rice farms.

6.3.1.4 Samlout

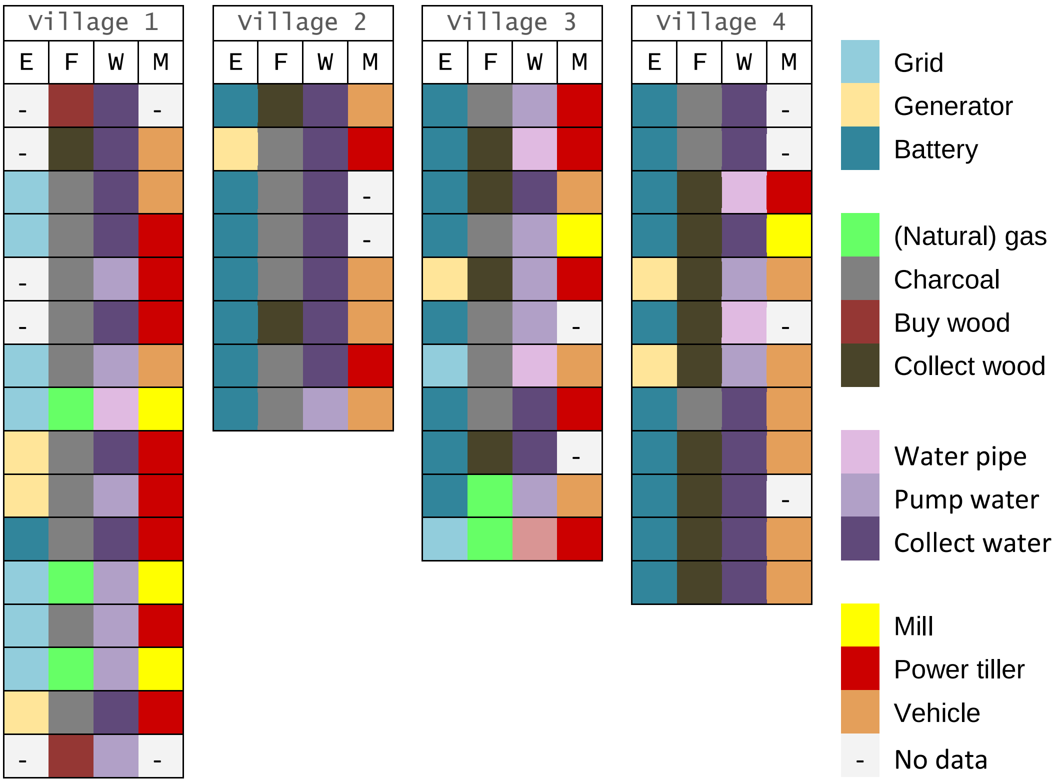


Table 6.15: Energy access in Samlout (revised framework), ordered by village

A further and fuller analysis of the Samlout data is given in Chapter 9 but the conspectus is shown here for a complete overview. The grid is uncommon except in village 1, it is in the process of being extended. Also the purchase of water deliveries is rare – there are many water wells dug in Samlout so villagers probably don't need to pay for the delivery service, indeed there are more reports of manual collection of water than seen in other locations.

Like Kampong Speu there are many battery households but conversely there are many more electrical generators. This could be due to a greater number of wealthy households or the poorer users' assessment of grid tariffs (mains electricity was more expensive here). There is also a high level of charcoal use in Samlout, probably due to the plentiful forests and good local knowledge of its production. Also, due to its remoteness and hilly terrain there is a higher presence of powerful mechanical devices than in the other locations, but due to the moderately big markets within the villages themselves there is less need for vehicular transport to the provincial town or such like.

Subsection format

Similarly to the previous section on the spring fieldwork, the following subsections go in to a finer level of detail than in the conspectus tables. However, this time the data used is more quantitative as it is taken from surveys; there is data from interviews to lend support but it does not feed directly into the graphs drawn below. As the matter of extracting data has already been covered, discussion is more based around how to represent that data and what it can imply. The subsection titles are the same; it follows the divisions of the analytical framework given in 6.2.

Survey data is less rich but more plentiful, its evaluation is less specific but also less prone to perturbation by a few extreme cases. Significantly, this data can be better used for pattern recognition. The overall style of analysis is to plot distributions, allowing for study of the commonly practised energy access behaviours in a given area. This kind of specific regional analysis can be used in the initial scoping phase of planning intervention or to monitor the outputs as a form of impact assessment.

6.3.2 Cooking fuel

The following graph on the cost of wood is taken from households in Kandal as that region contained the most wood buyers – whereas wood collection is better studied in Chambok for the same reason. Findings can be generalised to other similar areas, where it is common to buy or collect wood.

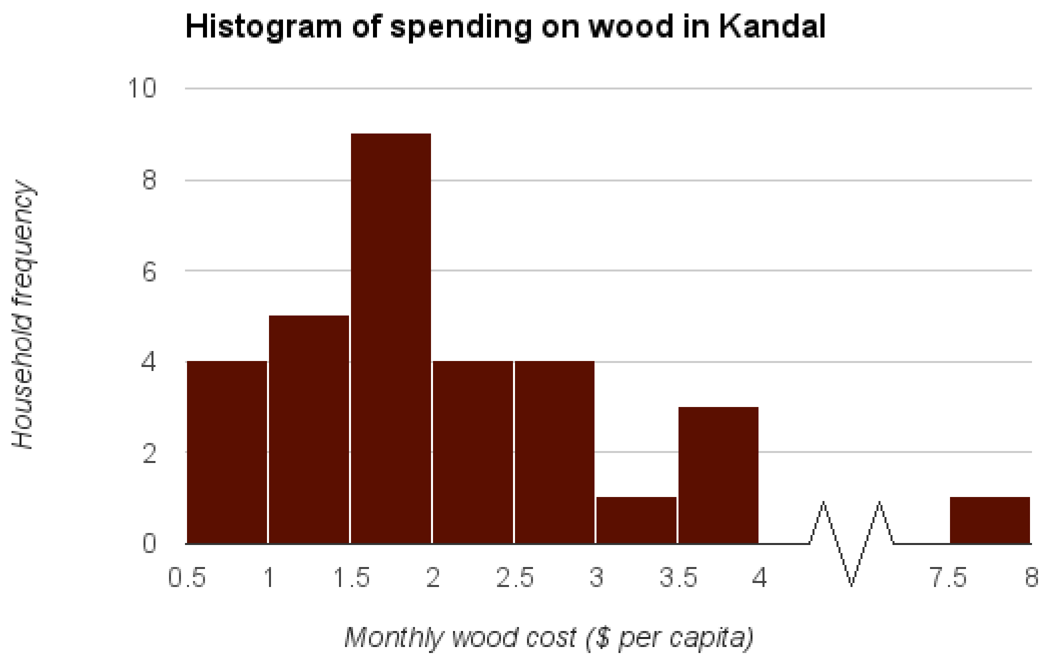


Figure 6.4: Wood consumption from surveys in Kandal

The histogram is used to collate responses and describe distributions. Values are given per capita for comparison with previous data.

Similar to the estimate in 6.1.2, the average household per capita contribution to wood is $2.01 per month (or $1.90 without the high outlier). With this graph it is easier to see the distribution. There is a clear modal average between $1.5 and $2. Some respondents were also able to give a figure in m^3 since they bought in these units; a calculation using that conversion factor puts the average wood consumption at $0.28m^3$ per person per month. These results indicate the magnitude of energy which people are accessing for cooking fuels and the investment into them. Though this has uses, like in gauging the potential savings of using a biodigester for fuel, it doesn't really convey much about the way in which villagers access that energy, for instance stove efficiency or fuel density.

With surveys alone it is hard to know how this fuel is being used. Accordingly, the following table has more detailed examination. It looks at the task of collecting wood more closely; this is information that can still be acquired through surveys.

Wood collection in Chambok					Total monthly labour divided by household size
Household size	**Trips per month**	**Time (hours)**	**Gatherers**	**Total labour hours per month**	
5	1	1	w	1	0.2
5	0.3	3	w + h	1.8	0.36
4	1	2	w/h	2	0.5
5	4	30 min	h + w	4	0.8
5	1	2	s + d	4	0.8
3	3	1.5	w/d	4.5	1.5
4	5	30 min	w + s	5	1.25
5	3	2	w/h	6	1.2
4	5	30 - 60 min	w + d	7.5	1.88
3	10	1	w	10	3.33
8	10	30 min	w + d	10	1.25
6	5	1	w + s	10	1.67
5	1	4	3 (h + w +k?)	12	2.4
4	3	3	h + w	18	4.5
5	10	1	w + d	20	4
6	4	2-4	h + w/k	24	4
3	6	2	w + s	24	8
6	Daily	30 min	w + d	30	5
5	5	7am-2pm	h	35 (collect for others)	7
5	10	2	h + s	40 (collect without cart)	8

Table 6.16: Time investment for gathering wood for households in Chambok, ordered by total labour

The column of gatherers is coded: h = husband, w = wife, d = daughter, s = son, k = children. Frequency of collection is particularly significant; the highest labour values come when this coincides with another high multiplier.

This information is in a table to make the calculations visible. It gives the frequency of collection per month, the time taken and number of gatherers; the product of these three inputs gives the overall labour invested into collecting wood per month. This is then used to give the labour per person per month, which averages to 2 hours and 53 minutes (about 25% more than the previous estimate, though that didn’t account for multiple gatherers, however, there were abundant forests in this particular case study).

The data shows that a trip to gather wood is more often than not a task divided between two members of the household, usually with the wife of the family as one of these members but around half the time with a child to help. An assertion that fits in with other observations is that collection of wood without a power tiller is female gendered.

In line with the second analytical framework, this enquiry is attempting to understand the user's access to cooking fuels by the time which they invest into that energy. The per capita average above is somewhat misleading because not all household members invest that time; taking the product of the time, trips and gatherers is at best an estimation of the labour involved. For now it is taken that the range of results is wide, amounting to an entire working day per month for many households.

Of the data given in the above table, the two columns for labour (per month and per person per month) are most sensitive to the input data of how many times wood is collected per month; conversely, the actual number of people in the household has the weakest influence on these calculations for labour (this measured by correlation strength). This supports the previous finding that the best way to indicate the task is through the frequency of collection – essentially, the frequency describes if it is more likely to be a highly time consuming chore or not.

6.3.3 Electricity

In terms of electricity, the surveys only asked about the type of connection and consumption in the household. It is feasible to have asked for a list of electrical devices, similar to that in 6.1.4, but that information was of low priority – in terms of quantitative data, a figure for consumption was sought both because it is well-known by the villagers and for what it says about electricity behaviours. Kandal has enough metered grid connections for sense to be made of a distribution of consumption; elsewhere grids are unavailable or expensive so that data is patchy and anomalous – thus Kandal is presented below, representing those villages where grid access is common or an expectancy of a general electricity user.

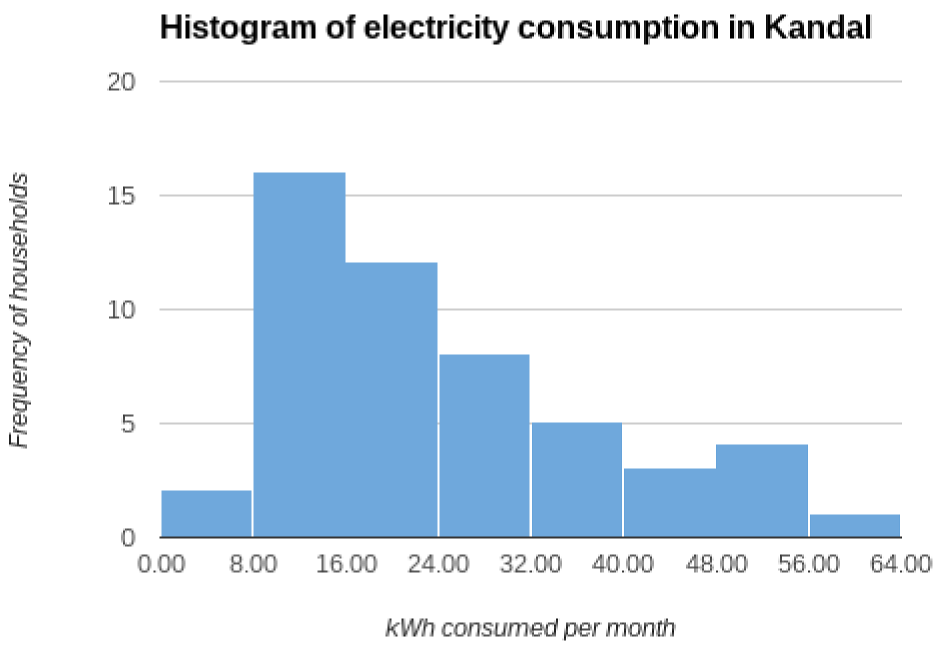


Figure 6.5: Electricity consumption from the survey data in Kandal

Values are given per household as it is that unit which is the basis of this branch of quantitative analysis.

Around a quarter of surveys gave their monthly bill rather than their consumption – though with a value for the unit price taken from the local research agent it is easy to combine the data. Unlike cooking fuel, electricity consumption is not normalised per person since devices may or may not be used by the family simultaneously, I noticed that the kids will watch TV in the day but everyone will at night.

From the histogram, it is evident that there is a modal average in quite a low consumption group and that with higher consumption the size of the group decays fairly consistently. As opposed to wood consumption, it is easier to make assumptions about what appliances the household is using and thus what capabilities they have. Households that consume less than 8 kWh per month will probably be limited to lighting, TV and charging mobile phones: 8 kWh per month is enough to run a 20 watt bulb and an 80 watt TV for around 2 hours 40 minutes a night. The more populous consumption brackets above this will likely be lighting several rooms or using a fan throughout the night to sleep comfortably. Beyond 30 kWh, it is possible that the household is using an electric stove, a water pump or speakers. Energy services that use heat or a lot of motion are more demanding than those which are just light.

In the above, the ownership of electrical devices (data which is difficult to obtain) is inferred based on consumption (which is easier to obtain). Here consumption is being used as an indicator for energy access. However, returning to the theory of the literature review (Ilskog 2008), this indicator is neither *comprehensive* nor *fair*. Higher consumption can come from longer, multiple or more intense uses of electricity – it does not necessarily relate to more capabilities, and especially, those groups who use inefficient devices are misrepresented.

6.3.4 Water

Again, Kandal is used in the following graph since that data is more easily obtainable from metered supplies, as with electricity, it represents areas with the associated infrastructure such as Takeo (spring fieldwork). In addition to those with water pipes, data from those who purchase water deliveries are included in the graph because their data is commensurable.

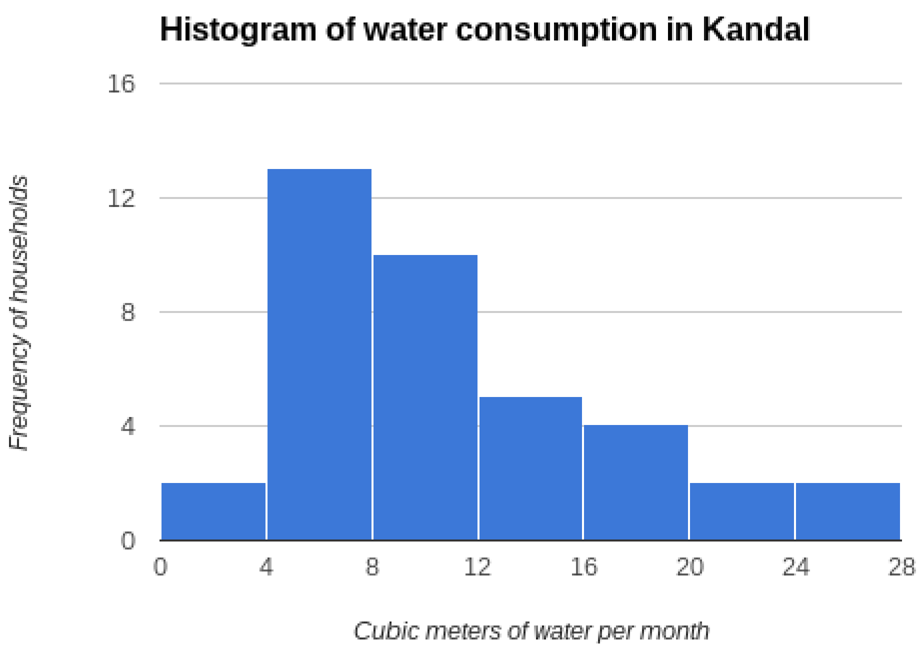


Figure 6.6: Water consumption from the survey data in Kandal

Again, the unit is the household; for water especially, factors that lead to high consumption (livelihood) tend not to be of a person but related to the whole household.

Those who get water through a pipe or from a truck are both internally varied groups; they have different distributions but a similar range. Proportionally, there are more water-delivery households than water-pipe households in the modal consumption bracket [4-8), this indicates that like electricity, greater consumption is associated with piped access.

This histogram for water consumption has a striking resemblance to that for electricity – a tapered distribution with its centre to the left. Again, the particular levels of demand can be used to make certain associations based on the supporting interview data: the lowest consumption bracket likely buys water only for drinking and washing, whereas the higher brackets may relate to livelihoods such as animal husbandry or vegetable cultivation. It is feasible that wealthier users are more liberal with their water consumption but as opposed to electricity, high-demand uses are from livelihoods and not luxuries.

As intimated above, having water supplied by a pipe does engender a higher consumption than through other means – it is a less limited and more convenient supply. This concurs with data from the spring fieldwork, though unfortunately, the key indicator from that section, water quality, wasn't attained through surveys – it can only be estimated from the price.

Pipe	Pipe and pump		Pump	Pump and delivered		Delivered
2.03	6.75	1.13	1.69	-	3.13	2.50
2.50	6.75	10.13	3.75	-	3.75	3.13
3.38	3.75	22.50	9.00	6.25	6.25	3.75
3.38	4.73	33.75	11.25	22.50	3.13	5.00
3.75	9.38	33.75	11.25	16.25	10.50	6.25
3.75	1.88	101.25	22.50	33.75	12.50	Average
5.50	Average		22.50	Average		4.13
6.25	5.54	33.75	22.50	19.69	6.54	
6.75	Sum		22.50	Sum		
6.75	39.29		33.75	26.23		
8.78			67.50			
8.78			Average			
10.00			20.74			
10.13						
10.13						
10.75						
11.00						
12.83						
13.50						
Average						
7.36						

Pipe, pump and delivered			Sum
0.13	101.25	18.75	120.13

Table 6.17: The stacking of water supplies and cost of each method in dollars

As with wood collection, stacking is not rare: 13 out of 48 households do so. In total there are six combinations of stacking – the only household that buys water through the pipe *and* from delivery also pumps it. It is clear that more money is spent on pumping water, though since the cost of that energy service cannot be translated into its effect (volume of water pumped) the inference is limited. High pumping costs, in particular the outliers, are most likely related to some form of irrigation – within this kind of data it is important to maintain these separate categories so as to distinguish domestic and agricultural demand.

6.3.5 Engines

For the following graphs Chambok and Samlout are better candidates than Kandal. In these locations vehicle and power tiller use was prolific enough to produce a distribution. They represent the more rural areas with fewer roads and more hills; this requires additional output of their own mechanical energy, as opposed the households in Kandal who could make use of roadside deliveries (thus using the traders' mechanical energy).

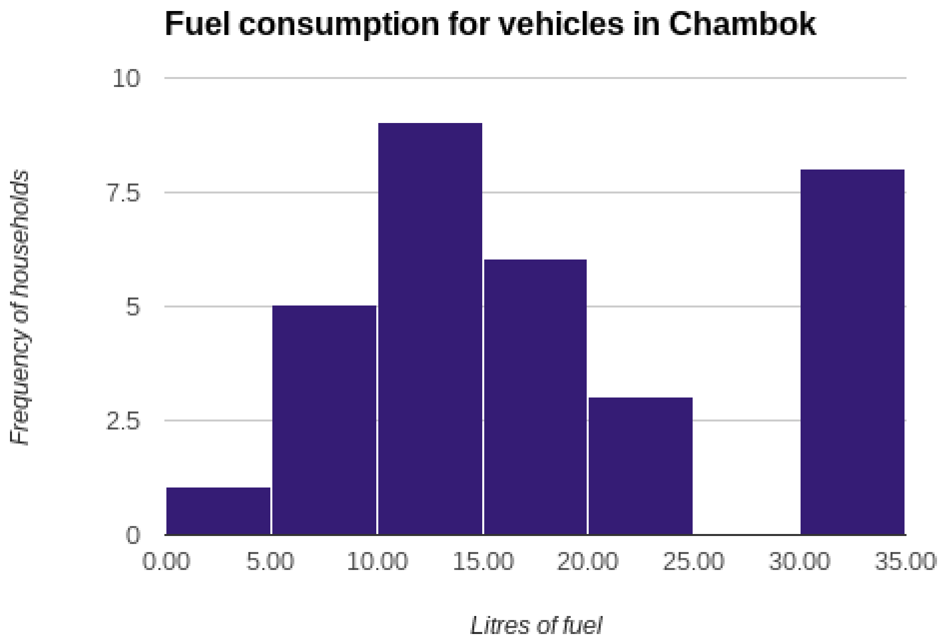


Figure 6.7: Vehicular fuel consumption based on survey data in Chambok

Unlike previous consumption data, vehicular fuel consumption is more centrally distributed except for the significant outlier of the high consumption group. High outliers exist in the other categories, those were small in number, yet here there are many. There are numerous explanations: the long journey to the nearest town (Chambok is isolated), the use of a vehicle as part of a specific livelihood (such as a travelling trader), sharing the vehicle with others or simply enjoying travelling enough to spend much more on fuel. As opposed to electrical consumption, it is harder associate certain activities with high or low brackets of fuel consumption – it can safely be assumed that they are using their vehicle more or less but the journeys they make or the associated capabilities aren't safe assumptions. This limits the utility of the data: for instance, those in the below average consumption brackets can't be inferred to be in energy poverty, interviews confirm that some people simply don't have the demand for fuel. Even five litres is enough for several hours' driving in small vehicles. However, the data can at least be used to gauge the fuel supply going into the village, the villagers' average consumption and to identify the high outlier group (30-35 litres per month).

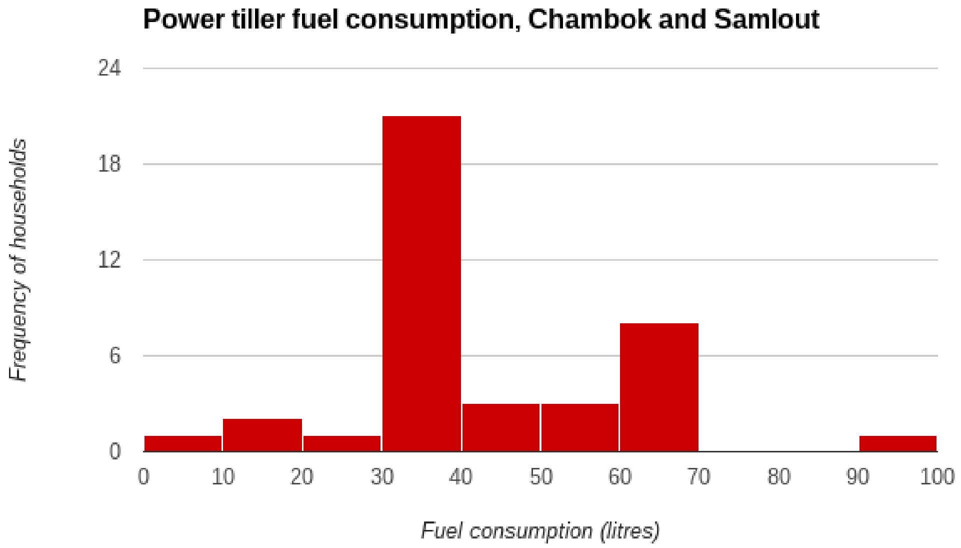


Figure 6.8: Power tiller fuel consumption based on survey data in Chambok and Samlout

Fuel consumption for power tillers has some similarities to the previous graph: the modal average lies in the centre and outliers exist at high consumption – though this distribution is dominated by the modal average. Here, high usage is from the following: managing a large farm, driving the power tiller a long distance / up a mountain, sharing the power tiller or use of it for another task such as generating electricity. Notably the modal average here is prominent, possibly offering a more reliable expectation of fuel demand or some benchmark of mechanical energy needed per month. A benchmark can be set less precariously here than with vehicular fuel because it is safer to assume that the fuel consumed in power tillers relates more directly to mechanical energy services used in domestic tasks, agriculture or some of income generation. As a final point, it is worth noting that the graphs imply that fuel consumption from power tillers is much greater than from vehicles, this is partly because the vehicles in question are usually the lightweight and low demand motorbikes.

In summary, these distributions can be used to gauge quantities pertinent to planning development initiatives, such as the introduction of biofuels. Alternatively, the values can be taken in their totality to estimate how much fuel is consumed in these villages, perhaps to calculate carbon emissions. It is this kind of baseline consumption method that was used in planning the Free Basic Electricity package in South Africa which was deemed successful (Marquard et al. 2007).

6.3.6 Additional analysis

Since Kandal offered consumption data for electricity and water from infrastructure, the two can be correlated in a meaningful way. In the graph below, the size of each circle represents the number of people in the household and the colour indicates to which village the household belongs. The two strings of data for water and electricity consumption only correlate with a coefficient of 0.21 – this weak correlation could be accidental but it may imply that good access to water and electricity are not tightly related *or* that the relation doesn't directly concern the quantities of consumption (for instance, household wealth).

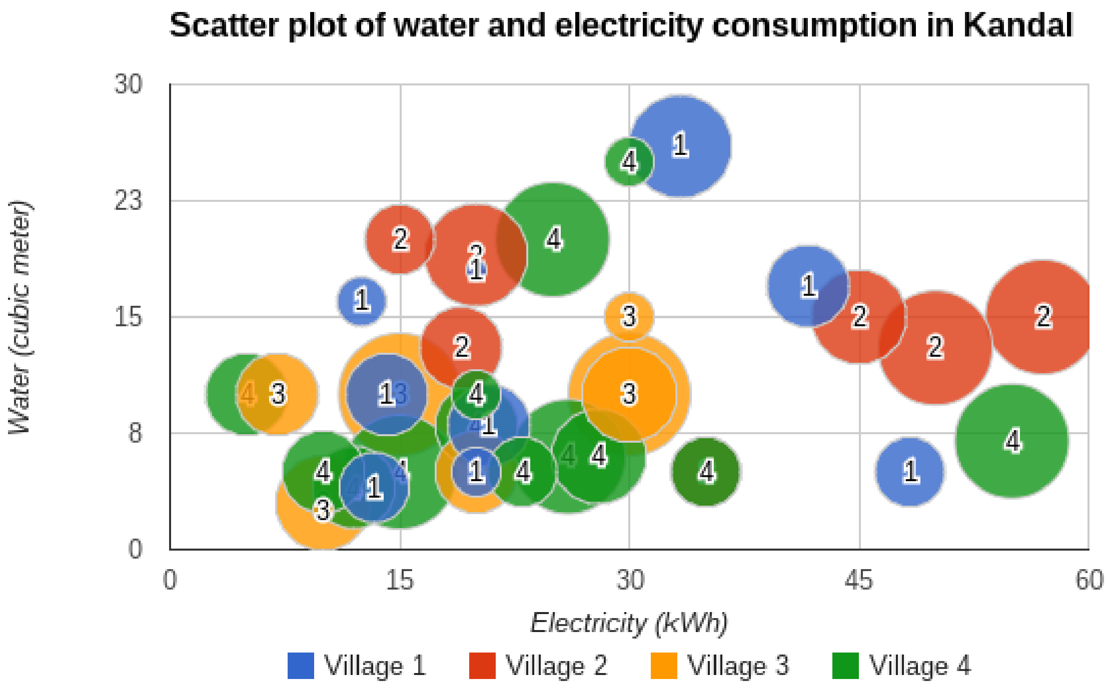


Figure 6.9: Water versus electricity consumption from the survey data in Kandal

Another explanation is in the emergent pattern that the centre of the region (the lower village numbers) fares better than the periphery (as fitting in with Chambers (1983) explanations of deprivation). With their better infrastructure, this centre region is *able* to use more electricity/water but this doesn't mean that all the people can, want or need to do so, so the correlation is only weak. A crucial point to take from this graph is that the conventional binary measures, a 'yes/no connection', would classify all the above as having access to both electricity and water yet these numbers imply very different behaviours and capabilities. This opens up the role of interviews in the study, as given in the next chapter.

6.4 Conclusions

Throughout this chapter an overview of the quantitative approach to fieldwork has been expressed. The conspectus tables gave superficial depiction of the six case studies, the subsections explored this further with quantitative methods and that was supported by explanations drawn from interviews. Beyond the overview of how energy is accessed, this chapter has given the argument for what it suitable data to extract regarding rural energy access and how such data can be analysed.

At first glance a sense of energy access can be derived from the number of villagers who are connected to infrastructure: with their grids and pipes it seems more likely that people living in Takeo or Kandal can consume greater quantities of electricity or water and thus it is more feasible that they have capabilities which alleviate poverty. Equally, the lack of infrastructure in Kampong Speu and Samlout means that many villagers have to pump or collect their own water. This is linked to higher costs and labour (but it depends on the available water sources). Conversely, the use of batteries for electricity tends to have the effect of spending less money on electricity yet users still own lights, cell phones and sometimes a TV or radio. Despite the potential benefits of high consumption through infrastructure, it is not so obvious what constitutes 'better' energy access or if it is more a question of sufficiency. People in Chambok use solar cells to generate their own electricity, this provides a level of power somewhere between the grid and a battery but analysis of what this means requires more data than a survey. The function the surveys did provide was a platform for analysing each form of energy via the averages and distributions of consumption behaviours, mostly these were left-leaning distributions, often with outliers at the high end. These consumption behaviours are generalisable to other similar settings: Kandal with grids and water pipes, Samlout and Chambok both being very rural – and Chambok in particular makes a good case of a well-forested area reliant on wood collection.

At the outset of each section, conspectus tables displayed the primary methods that villagers have for accessing energy. Those single tables were unpacked in the following subsections. In studying those data in more depth – especially cooking fuels – it became apparent that the methods of accessing energy cannot fairly be divided into discrete classes of one or another. Though unpacking this depth is informative it does not necessarily make that information easier to understand or use. The conspectus tables are more spatially aware but at the cost of detail about energy access; the first section went over these missing details by studying the process of quantification. All this is the basis for an answer to the first two research questions: how people access energy and how the quantitative approach can interpret this. That initial analysis also prompted the revision of the analytical framework (6.2) and guided the design of the surveys for autumn.

Early analysis was to find what ‘good data’ looks like. For the quantitative approach, this was driven by value judgements of what interview questions were effective and efficient in extracting data that could be tabulated or otherwise manipulated to give a helpful representation of the energy users’ behaviours. For methods of accessing energy, such as manual collection, this analysis determined that it is the frequency of that chore which is most helpful in understanding the behaviour. In terms of the forms of energy themselves, the revised analytical framework posits that lighting can be encompassed by electricity and that mechanical energy has significance both in water access and engines for other uses. Quantifying how much mechanical energy is accessed can be achieved only in terms of fuel (usually diesel or petrol) as villagers have no way to measure pushing/pulling forces they effect as part of their agriculture or otherwise. As an indicator this can be used to set benchmarks but, again, further analysis in needed to understand how fuel consumption relates to capabilities. Similarly, the rest of the graphed data throughout 6.3 has its own function in describing users' demand or possibly in monitoring the impact of initiatives have upon consumption of various energies; however, auxiliary (and often qualitative) data is needed to form an understanding of the associated capabilities.

Study in this chapter has challenged the use of the quantitative approach in indicators by demonstrating what that approach achieves and obscures. There is a relationship between consumption and capabilities, this is most apparent with electricity though less so with water or cooking fuels and least of all, engine fuel. This leads to the conclusion that energy access may be better studied through more dimensions than just quantities of consumption – as a corollary, because access to energy is multidimensional it is improper to generalise using terminology of better or worse energy access. Consider that though Kandal seems to have the best infrastructure, this is only a proxy indicator for how they access energy and there are many other aspects in effect – in what ways energy access in Kandal is better, or at least less problematic, than say, Chambok, cannot be ascertained without fuller evaluation of those other aspects of energy access. Moreover, for people within Kandal (who are nearly all connected to grid and pipe infrastructure) there are ways of differentiating their energy access, this has been done in along the dimension of quantity – but again, this is not entirely indicative of the capabilities or expanded freedoms as was understood from the literature review to constitute development.

This chapter has served to outline the energy behaviours of the case studied and open up discussion to define important aspects of energy access beyond just quantity. The next chapter will identify a set of aspects that underpin energy access and use these to explore, more thoroughly, those energy access behaviours that are so relevant to poverty.

7 The qualitative approach

7.0 Introduction: the important factors and aspects of energy access

The previous chapter gave data on consumption and readily-measurable quantities to do with energy access. The conclusions were that a quantitative approach could gauge the scale of an energy access themed initiative. This chapter is a departure from that approach; it seeks to add depth to those numbers by providing a much more detailed description of energy access attained through the qualitative approach. Whilst some parts of energy access can be isolated and measured, others must be studied more holistically, that will come out in this chapter. The content here lies within the same analytical framework though it is acquired from a much broader perspective. For instance, the subject of cooking energy is discussed, again, regarding stacking different fuels, but it is now linked to the source and sustainability of those fuels. The purpose of this chapter is to show that there is enough meaningful, qualitative content on energy access that to use only quantitative indicators can be misleading as they do not do justice to the concept. Using both makes a stronger, more illuminating tool. The implications from this chapter, and the previous combined, will set up a style of rural data gathering that is more helpful in planning development initiatives. Effectively, the quantitative approach answering the 'what' of energy access and the following qualitative approach answering the 'why'.

This project is not ethnographic but some of that style of research was attempted through the rural appraisal of energy access. Discussion here is based upon interviews, but observations and other experiences from the field are woven in for support and enrichment. This chapter describes various assets that are used in the access of energy, already these have been counted in the quantitative approach. It is the study of how people use these assets that distinguishes this chapter. The tactic here is to study energy access with people at the centre, making use of their subjective experiences and accounts. In this vein, the energy access behaviours are neither measured nor given a score; rather, a language is built up around them that can convey the salient information about the core aspects of energy access. Ultimately, this is then used to refine the analytical framework (given at the end of the chapter). These core aspects are the qualities that this approach focuses on; they constitute the many dimensions of energy access that have been referenced throughout the thesis. In effect, the qualitative approach here brings out the complexity of energy access.

The structure here accords to the previous chapter: cooking fuel, electricity, water, mechanical energy and some additional analysis. Each section has two or three components. Initial content analyses the main methods of access, for example with cooking fuel that is the use of wood, charcoal, [bio] gas or electric stoves. These first subsections reveal what users say about methods and their effects. Other subsection(s) refer to associated content that is not part of the method, for example, fuel choices. This secondary content was only partially visible in the previous, quantitative, chapter – discussion here highlights its significance, so that the next chapter can construct an appropriate tool for overall appraisal.

This appraisal will hinge upon the four core aspects of energy access. These aspects emerged as the initial concept of energy access, taken from the literature, review was tempered by experiences in the field. Their selection was such that they cut across all behaviours related to energy access, so a robust evaluation can be made of each method and the related assets. The aspects cover paramount concerns and provide a platform for identifying strengths or problematic issues in the way energy is accessed.

The key aspects of energy access, in their relation to the literature, are:

- *Appropriateness.* Mentioned frequently in Chapter 3 when describing energy access technologies in how they match the users' needs and technical skills.
- *Performance.* Linking to Practical Action (2012) terminology, 'adequacy' and 'quality'. This term also captures the number of energy services which can be performed.

- *Convenience.* Used by the IEA (2012) and the World Bank & IEA (2014). It relates to drudgery (labour and time burden).
- *Resilience*. Discussed extensively in Chapters 2 and 3 in relation to health and climate change.

7.1.1 The four aspects of energy access

In addition to describing energy access, a point of this chapter is to make the language of these four aspects familiar. The list above identifies their roots in the literature: these tables reframe the terms for use in this thesis.

Appropriateness
- Affordability by poor villagers
- Compatibility with traditional behaviours
- Suitability to local environment
- Fitting technological sophistication
- Participant satisfaction

Performance
- Variety of energy services that can be accessed
- Extent to which services meet basic needs
- Effectiveness and efficiency
- Power and empowerment

Convenience
- Time taken to access energy services
- Timeliness of access
- Distance from power source to the point of use
- Effort involved on behalf of the user
- Regularity of maintenance or upkeep

Resilience
- Safety, risks and health concerns
- Environmental damage
- Seasonal weaknesses
- Fragility of the energy system
- Resistance to accidents or externals shocks

Figure 7.1: The four aspects of energy access used in this thesis

The bullet points here do not precisely define the aspects but set them up to be explored throughout this chapter

7.1 Cooking fuel

This section is divided into three parts: the first describes the fuels which villagers use for cooking, the second explores the sources of some of these fuels (wood and charcoal) and the third part analyses why villagers might use one fuel or another. So, whilst the first subsection deals with categorisation (fuel type), the latter subsections are more concerned with finding the finer, descriptive, details to form a more complete understanding. This begins the argument of why the qualitative approach should be employed.

7.1.1 Fuel and stove types

This subsection focuses on the different fuels burned, stoves used and the effects of that method.

> He use the stone stove, in Cambodia they call it the Lao stove … [it burns] only wood or charcoal – Interview 19, Takeo

Picture 7.1: A traditional Lao stove

The stove has a protected combustion chamber but no chimney. Here a dirty pot is used directly above the flame to prevent the cleaner pot from becoming soiled.

For cooking with solid fuels, villagers would normally use the 'Lao' stove. This is an improved cook-stove, which has a protected combustion chamber but unfortunately no chimney to divert smoke. The Lao stove is typically used for performing energy services like cooking a family meal or boiling a kettle of water, though a larger stove is needed for some special purposes:

> She use the fire wood for cooking, but sometimes with the large pot because they need a lot of energy – Interview 1, Kampong Speu

Unlike the Lao stove, the large types are not commercially produced and will generally be built by the household to suit their need. Examples I saw include basic three-stone fires used to heat big pans of water, a large improved cook-stove used to boil palm juice and a combustion chamber set into a kitchen surface used to cook rice paper (pictured below). Additionally, boilers are used in the production of rice wine. Though these are not stoves they nevertheless represent another way thermal energy can be accessed in the villages.

Picture 7.2: Larger stoves for specific purposes

Left: The stove burns wood to boil a large pan of palm juice. Right: the system steadily feeds rice husks into an oven made of bricks. Both are custom made to suit the tasks in that livelihood.

The fuels used in traditional household stoves all across rural Cambodia are usually some form of biomass, either wood or charcoal for conventional cooking but sometimes sawdust or rice husks if a different kind of fire is needed. Sawdust and rice husks yield a smouldering flame and gentler heat; which is not well-suited to cook at meal times because it requires constant addition of fuel and doesn't reach the desired temperature. However, it performs well for the rice paper maker pictured above; additionally the rice flour which makes the paper is bought alongside the rice husks which cook them – fuel choices are linked to wider systems. For cooking meals, a few sticks of wood or charcoal perform better; also the latter emits less smoke and, depending on its quality, can reach a higher temperature. For all kinds of biomass, the quality is variable:

> Recently the charcoal is not as good if compare to the charcoal before. It is not hard enough, it is soft, not as good for cooking – Interview 31, Takeo

This variation can be partly attributed to moisture content, people remark on the difference in the wet season. However the more subtle factors affecting fuel quality are harder to understand without a deep knowledge of cooking practices: the rate it burns, the length of flame and the aroma of the smoke were all mentioned in interview conversations. This is an area where the villagers' knowledge becomes too sophisticated, so it is really only their simplified estimation of the fuel quality which can inform a broad energy-wide analysis. This does not contradict the aim for depth in this project, but rather, is its limit.

> The quality of charcoal is better than wood, can save money. Wood easy to burn but just for a short time, charcoal we can use for a long time – Interview 71, Kandal

> Charcoal, we cook for small pot. The wood is for the big pots, cook rice or soup – Interview 83, Chambok

The performance of wood and charcoal differs. Though charcoal may perform some tasks better, wood is still used in others. A finding that emerged from these conversations is that there are different types of fire used for different purposes, not just in cooking but in livelihoods. In the attempt to promote new fuels, such as biogas, one must maintain awareness of all kinds of thermal energy access, such as larger stoves or ovens, as these relate to many varied capabilities and basic needs.

Below study narrows to just one strand of access to cooking fuels: the mealtime cooking process. As someone must be there to attend the stove they are at severe risk, as emphasised in interviews: "*of course a problem with the smoke*" (interview 9). Health, classed within the aspect of resilience, is a main driver for study into energy access and that issue directs the discussion here.

More modern cooking fuels emit less pollution. In that sense, the user is more resilient as they are healthier. Electric and [bio] gas stoves are the examples that were observed in fieldwork. Since these stoves are smokeless, they alter the way in which kitchen spaces are defined. Lao stoves are usually placed in semi-outdoor structures but modern stoves can be put indoors as they won't cake the interior in soot. This marks a significant change in the way the energy is accessed as spaces adapt around the different technology. A trend with biogas stoves is to build indoor kitchens with raised counters and multiple heat sources: "*there are two stoves, the rice cooking stove and soup stove, easy to use*" (interview 14). This is a more convenient way to cook and there are wider repercussions on what meals are possible.

In terms of the energy, stoves that use modern fuels have the benefit that they can generate heat immediately. I was told "*they use the electric pot in case they need to hurry*" (interview 4), and that gas is even quicker and better suited to cooking soups. For both, the thermal energy is available instantly and controllable via switches. A mechanic explained that he valued this as he could cook easily even with dirty hands. Families of factory workers said that they had switched to gas cookers because it allowed them to make a meal quickly before the morning shift started. There is quite possibly an interaction here between modern fuels and modern livelihoods, though any given household may have reasons for using modern fuels:

> She said the gas more better than wood but sometimes we cannot afford the price of canned gas … she just use gas sometimes, for example someone in the household got sick she have to cook on time – Interview 52, Kampong Speu

Essentially, the speed and controllability of [bio] gas cooking gives the user more freedom in their lifestyle. A downside is that for natural gas, the cans are empty after just a few meals; conversely, the electricity cable doesn't run out. However, it is even more expensive and some users are wary of shocks from those cookers. In terms of supply, biogas cookers deserve special mention; functionally, they perform the same as any other gas cooker, though the quantity of fuel available is determined by the operation of the biodigester. This is usually advantageous since it means that households practising animal husbandry are self-sufficient in a clean fuel. It is hard to untangle discussion on biogas stoves from that of the digester as a system; they are given more attention in the next chapter. Here it suffices to say that they have the most esteem of many rural cooks:

> She think the biodigester can improve their livelihood because no expenditure with the digester … the digester very easy to use for cooking, no smoking, and the time used for controlling the cooking can used to do something else ... also if we use the wood, have to care about drying the wood – Interview 36, language clarified, Takeo

7.1.2 Fuel sources and woodlands

Forests are a source of fuel but improper management and deforestation can lead to fuel insecurity. Land and policy are important factors in energy access. Sustainability of fuel sources relates to the aspects of convenience and resilience. The availability of trees nearby can make the task of collecting wood easier and quicker (convenience), yet harvesting too heavily risks shortening the future of that supply (resilience).

Much of Cambodia's forest areas are exploited through 'slash and burn' land concessions of big business (Scheidel & Work 2016), although the encroachment of small scale farmers is also a factor in jeopardising the forests sustainability. A village chief explained "*If the people have a small piece of land they try to cut down the tree to extend their land*" (interview 90); needs for food and income are more immediate. Close to the capital, Kandal has mostly been depleted of woodland from the charcoal industry. A villager said *"no wood to cut, [we] have to buy"* (interview 78); they used to sell to the city but now they too import from surrounding provinces. A village chief in Kandal told me that it is harder to prevent people harvesting the few remaining trees without proper policy in place.

In the Chambok and Samlout regions Community Protected Forest policies were active. These allow rural villagers to take stewardship of their forests in an effort to sustain them. An agreement is made between the people and state: the former are given the responsibility to manage the forests, the latter are prevented from selling the natural resources through economic land concessions or otherwise. The locals can draw from wood supplies in the forest but only with sustainable behaviours – villagers would attest: *"I collect only the dead wood"* (interview 102). With such protective practices, energy supplies can be maintained.

However, even in areas with a CPF, many households still produce charcoal or are unable to account for the origins of their wood. It is unclear the extent to which they respect agreements about what to harvest:

> The forest protected by the government but some households break the law, there are limits to the staff in the district department, not enough to protect the forests – Interview (anonymised)

Though policy acts for the wider benefit, people still have their needs and wants; community protection requires agreement and collective action – though in practice this is not easy to achieve. A chief explained that villagers understood why they must protect the trees, "*but they have no choice*" (interview 90). In Kampong Speu the depletion of nearby sources has forced collection to move further afield:

> Is difficult to access to the forest, he and his wife go by the animal trail, have to spend from 7 till nearly 12, [when the trailer] is full come back … he think the forest will not be destroyed, where he cut the next plant will grow again – Interview 20, Takeo

This villager knew that the woodland nearby was too heavily harvested yet was convinced that his new (less convenient) supply would sustain itself. Similarly, another villager bought wood wholesale from the mountain and sold it on to villagers; she reported no knowledge of deforestation and it is hard to say whether or not it was responsibly managed. On the whole, the participation of villagers in forest management was stronger in Chambok, where the woodlands were more than a fuel source, but part of many (non-timber) livelihoods and also central to the identity of the village in its ecotourism.

Picture 7.3: A logging business

This stockpile of wood was imported from the mountains; the villager would cut it down to smaller pieces and sell it on. Since the source is so removed from the village and the study is just a snapshot, it is difficult to ascertain much about its sustainability.

7.1.3 Stacking and fuel choices

> Me: If she couldn't use wood from the rice farm, would she use charcoal?
>
> Them: She would have to buy charcoal, sometimes if there is not charcoal they use the electricity pot
>
> Me: What is the difference between cooking with wood and electricity?
>
> Them: Wood is faster than electricity for cooking the rice, sometimes when the wood is wet and they have no choice, they use electricity – Interview 85, Battambang

The interviewee quoted above describes her fuel choice; principally it is availability which influences this. Normally she would collect wood from the rice farm, which is convenient because she is travelling there anyway. Since this is free and going there is part of her livelihood routine, it is her preferred method. Consequently, it is difficult to measure how long she spends collecting wood in a meaningful way. Also, she has the expensive option to use electricity with a bespoke rice-cooker, which makes very good rice but is slower than a stove. Effectively, this expands the performance of her energy access as she can cook when wood is unavailable, though, she has the capability of using other fuels when she chooses and can afford to do so. That her preferred method is to use wood does not take away this capability, though it does imply that she is still breathing in a lot of smoke.

Another interviewee gave a little more detail on the difference between fuels:

> Them: ...charcoal is not too smoky and no flame
> Me: Is the food better?
> Them: Same same, depends on how you cook – Interview 88, Battambang

Though many people said that wood cooked tastier food, this interviewee disagreed; the dissonance is partly because it is such a subjective issue but also due to the slow adaptation of cuisine away from traditional wood-fire cooking

The reasons for use of non-wood fuels are numerous: personal preferences in taste, lack of time, or because the user is wealthy and prefers modern cooking stoves rather than the traditional style and the connotations they bring. In any case, they are adopting the fuel which is most well-suited to their lifestyle or the local conditions. Households have other options for obtaining cooked food: buying or being given it ready-made. Their method and fuel choice can change on a daily basis; this may be because they are forced or because they make a choice:

> Me: In one week how many times will she cook with wood?
>
> Them: Not regular, if she free she will use wood, if she busy with sewing she will use only gas – Interview 42, Kampong Speu

Here the fuel choice reacts according to the villager's livelihood – she switches between classifications of being a busy gas-user and a thrifty wood-user. Other interviewees say they switch fuels for more social reasons, like when they have many guests for a party:

> Me: Can you ask them if they ever have to use wood to cook?

Them: She just use wood sometimes, especially with the large pot when, for example New Year's ceremony, lots of relatives come to her home so she have to use the large pot and biogas is not sufficient – Interview 30, Takeo

Picture 7.4: A household's stoves

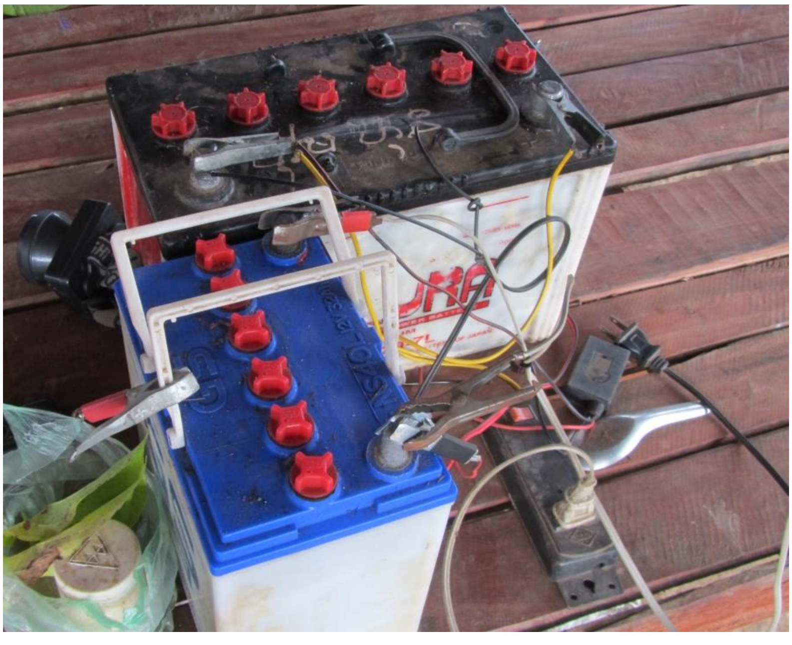
This household has a mix of stoves in their kitchen area, a gas cooker on the table and many traditional 'Lao' stoves on the floor. The smaller kettle is on the gas ring, probably for quickly boiling tea. A larger three-stone fire is in the background; this heats a big pan of water, it burns logs not sticks and is kept afar because of the smoke.

Different fuels have their niches, there is no best fuel. Rather, a better access to energy would be to have the choice of many, allowing users to select the advantages they desire (akin to Sen's idea of development as expanded freedoms). The problem is that villagers can't necessarily make the most rational decision if they underappreciate the health cost of crude fuels or the safety of cleaner fuels, for example, the danger of using 'dirty' biogas or receiving shocks from electric stoves – despite the damage that wood smoke always does. The point is that different cooking energies need to be available and intervention to promote modern energies should not rest on singular factors such as time or cost (quantitative indicators of energy access) but upon, for instance, the different performances they can allow or the way in which they can fit into villagers' current lifestyles (qualitative aspects of energy access).

7.2 Electricity

These subsections go over the supply, demand and effect of electricity. Assets in the second subsection are the common appliances which are owned by the majority of grid users (see 6.1.4). The third subsection then goes deeper into how electricity affects people's lifestyles.

7.2.1 Batteries, generators and grids



Picture 7.5: Batteries that households use for electricity.

The blue battery is hooked up to a light bulb, the black one to the plugs, these then charge phones or other low power devices.

In all case studies, the minimum standard of electricity supply in a household was a 12 volt lead acid battery, like those used in cars. Smaller batteries from lighter vehicles were also used as portable power sources. The few households without even these would share light and electrical devices with their neighbours. Though the de facto definition of electrical access (yes/no connection to the electricity grid) doesn't class batteries as electrification, batteries do enable access to lighting, TVs and mobile phones. Whilst low-power, these services are very much significant:

> She is not interesting with the electricity link because recently is enough for her with battery and biodigester – Interview 14, Kampong Speu

The type of high-powered energy services that a battery cannot supply are not needed in every household, especially those with adequate fuel and water supplies. Batteries are easy to use and portable, they can provide lighting anywhere in the home, on farmland, in street-stalls or even for night fishing. Though the low-powered energy services aren't marketed themselves, they can make a big difference to a business. A retailer I interviewed used her small lights and a radio to attract people to her home to play cards and buy drinks. Electrical energy services were part of the service she offered, making her shop more attractive to customers:

> When I get the battery I am more comfortable with my business. When I use the candle and it is getting windy the candle can blow off but with battery light it is no problem … obviously when I use the battery my business is getting better, is getting better to run – Interview 104, Samlout

For the small businesses or the poorer households I saw, the battery is in a sense, quite suitable. Many cannot afford the high-power electrical appliances like refrigerators or washing machines; also, the level of supply from the grid can outstrip their needs:

> I think if we compare between the battery and the electricity cable, when I use battery is better … when we have the electricity cable we always use more! When we have a battery so we don't use it often – Interview 108, Samlout

Consuming more and more electricity does not necessarily improve welfare and the limited nature of the battery makes it easy to consume electricity conservatively.

Unfortunately, recharging batteries is difficult, they are heavy, cumbersome and yet fragile; that they can break reduces the resilience of this electricity supply. As only a few households have the generators to charge batteries they are kilometres apart making it an inconvenient way to access energy. Charging batteries using fossil fuel powered generators involves careful decision-making; the process is not cost effective without the right number of batteries, so the charger either has to wait or perform a suboptimal charge. Waiting means that customers must cope without electricity (sometimes overnight) and a suboptimal charge reduces the battery life and increases running costs. This lessens the reliability of coping mechanisms which need batteries since the power source may be unavailable or short-lived.

To charge batteries, or otherwise provide off-grid power, villagers use generators. These usually run on liquid fuels but solar technology is also in evidence. Fuel generators, or power tillers with dynamo attachments, are enough for high-power appliances, which allows the performance of many more electrical energy services than just a battery:

> Electricity is not arrived here yet, is only over there [points up the road towards the village] and is expensive … he can use the generator every evening, but sometimes if not important he don't use it, unless some people come to sing karaoke … this is a business, before he did not think it was a business, he use for his own family, then some people come to sing and he just make it a business – Interview 93, Samlout

This retailer owned a generator. He used it to expand his small cafe business into hospitality by powering bigger lights and a karaoke music system. In selling these services, the retailer offers the surrounding villagers greater access to energy. Additionally, this power source can be used during grid blackouts, and since it is transportable, it can provide energy anywhere – for example, I saw villagers use them to power audio equipment in ceremonies and builders using them to make welding repairs on-location. Again, this furthers the capabilities of villagers even if they don't own the generator – relating to the aspect of performance.

Though generators eliminate the need to recharge batteries it is incorrect to say they give a more convenient supply – that is mitigated by the physical difficulty in using the equipment:

> Me: Is it difficult to start the semi-tractor and make the dynamo work?
>
> Them: We use the man-power, the lady we don't have any power to start the machine, sometimes when the men get out of the house we have to stay and use the candle at night – Interview 103, Samlout

So the generator can be problematic as it provides unequal access to electricity within the household. Although this interviewee did not express any irritation with this inequity, the point can be generalised that fossil fuel generators are harder to use than batteries and thus not appropriate for everyone. Notably, generators are expensive – a mechanic put the cost at $500 for his 4 kW machine. He explained that running it was the cheaper alternative if grid prices are above $0.37/kWh. Yet, the initial outlay is beyond many families so this cost makes them inappropriate for many users.

The solar generators I saw in Chambok were cheaper; they paid an NGO in instalments ($7 per month for four years). PV cells are paired with a battery to mitigate the intermittent sunlight. At around 100 watts the output of the system is less than a fuel generator but is far more convenience as it produces electricity passively, so the user doesn't need to carry their battery or operate machinery. Interviews revealed problems with the systems: storms can cause damage and due to their sophistication, maintenance must be called in. A point to draw on here is the user's feelings towards system: they do not need to worry about draining their battery or the loud noise of an engine-based generator, but they do have to take care of the equipment. An unreliable supply of energy can cause anxiety; however subjective, this feeling affects the way that people access energy. Conversely, a renewable and unmetered supply of electricity is a comfort.

The electricity grid also provides the assurance of energy at all times but with the bonus of greater capacity. However, it is another bill to pay and some users are wary of the dangers of electric shocks. In the cases studied, blackouts were said to be a monthly occurrence, so energy is not truly available at all times, but its supply is far more consistent than is the case with batteries or generators. Moreover, this kind of supply means that many more capabilities are enabled. Low-power devices can be run throughout the night: fans for comfort and lights for safety or in ‘emergency times’ – people value these small changes to

Picture 7.6: The difference when using electricity in textiles.

Left: the spools are connected to an electric motor, this uses the grid. Right: the spools are rotated with a hand crank which is more laborious and slower.

the way they can access energy. High-power devices like cookers and water pumps also become feasible, allowing users to replace other less clean energy sources. Also devices like refrigerators and computers can be used, bringing entirely new energy services into homes.

> I want to buy one fridge … because I am too lazy to go to the market every day ... one more thing I want to buy is a washing machine: that can make my life easier because now I am old and I don't have the power to wash by hand – Interview 101, Samlout

> The village have two households who use electricity for their livelihood: welding machine and also they use motors for building furniture ... the electricity for cutting motor, electric drill and painting, spraying pen – Interview 60, Takeo

Interviewee 101 (above) talks about grid electricity making her domestic life easier, but unfortunately those devices are expensive. Interviewee 60 explains uses of grid electricity in business – with these improved livelihoods expensive devices are more attainable. Unlike the energy services of the battery, it is feasible to market those from the grid. Though it can create inequity between those who can and cannot afford it, the extension of the grid marks a change in lifestyle: status, convenience and modernisation.

7.2.2 Basic electrical appliances

Light bulbs are often the first electrical asset to be bought. Underlined in my field notes is "light is time": it is very hard to do anything in the dark and artificial lighting opens up the evening:

> They use the light for eating dinner and sometimes they have guests and they discuss with them, sometimes the children want to discuss with them too – Interview 13, Kampong Speu

Dinner can be eaten after sunset and social activities can continue later. If people aren't forced to eat early they can work more in the day, one villager said they use this extra time "*to take care of vegetable production and the animals*" (interview 45), another explained "*he has to transport equipment to another household at night so he has to use the lighting*" – (interview 33). The literature on access to lighting tends focuses particular benefits like children studying at night (Solar Aid 2014). This is a narrow scope, as is naming any specific action that occurs at night. Lighting supports the performance of almost *any* activities in the home, business or anywhere. It is a necessary enabling factor.

In fieldwork, I mostly observed electric lighting but there are preferences for other types. Biogas lighting is softer on the eye and attracts fewer insects than electric bulbs, making it more appropriate for activities like eating dinner. However, fuel lamps can blow out and are more likely to break (fire risk) so they are less suited to working environments.

After lighting, the most apparent effect of electricity is to power communication devices like radio or TV for news and entertainment:

> When we get bored we find entertainment in the TV, if we don't have TV then we don't have something to make entertainment – Interview 66, Takeo

The TVs I saw were a mix of box-shaped cathode ray tubes and modern liquid crystal displays. The former type is less efficient whereas the modern screens gives a sharp colour picture and have built-in optical drives. Here, newer technology has better performance: more energy services yet with lower energy demands. However, the actual benefit of the energy service is relative to the user. Notwidthstanding, the smaller modern TVs can run on battery power, which makes them more appropriate in conditions without the infrastructure.

Picture 7.7: A low-power LCD TV

These LCDs are small screens so demand little power but can't display to a big group. They were observed even in the more remote locations.

Villagers reported mainly watching local news, sport or films on disc, though the older generation are more inclined to the radio. These media are large carriers of information into rural areas but perform differently in terms of what information can be accessed. Significantly, there is little choice in the radio; one informant explained that the few channels are all controlled by the state. The reliability of the information received is crucial: weather reports effect farmers' decisions in agriculture and news influences people's political stance.

I simply could not validate how accurate the local news is within Cambodia but I found that villagers do not believe in all the content (something around 70% is trustworthy according to one village chief). That aside, the element of choice determines the function of the energy service:

> Honestly, from my experience of living in this village for a long time, the people in this village they don't get a good education, they don't like the politics or social activity, normally they like watching the fighting, the boxing or the music. I think because of their education they are not interested in politics very much, but for me I like [the news] – Interview 100, Samlout

This villager talks about how the same device, a TV, can be used for different purposes to suit different personal preferences. The needs satisfied can range from entertainment to political participation but crucially, much of this satisfaction is up to the user. Communication devices such as TVs, radios or mobile phones, are associated with many functions, needs and capabilities – however, realising these is all down to the people involved.

Mobile phones are an entirely different form of communication with different effects. Many businesses I spoke to relied on them to contact suppliers or customers, and since telecommunications can bridge distances, they mean a lot for families:

> I live alone, my two daughters work in the garment factories in Phnom Penh … this phone is used for contacting my daughters … [they] send me the money I use for my health[care] – Interview 102, Samlout

The phone call is a core part of interpersonal relationships and in this case is integral to a coping strategy relying on remittances. Communication is a capability that supports many others and also reduces one of Chambers' (1983) deprivations of poverty: isolation.

The final, basic electrical appliance considered here is the fan; I saw clever applications for these in repelling insects, blowing away smoke and oxygenating stoves but for the most part they offer a simple degree of comfort:

> …can make our life more happy, with a fan can sleep through the night with convenient time – Interview 58, Kampong Speu

7.2.3 Electrical energy: infrastructure and digital lifestyles

Grid electricity is highly enabling but it is not a straightforward upgrade from the battery – this subsection examines more about what electricity means to users. Battery households explain many wants for the grid – at least a quarter would use it for a better TV:

> Me: How would [grid electricity] change her lifestyle?
>
> Them: Can change her lifestyle through entertainment of TV, can make them more happy ... main important thing is the fan and TV, the fridge they hesitate to use because require more energy – Interview 46, Kampong Speu

Due to the expense of running devices such as a fridge or water pump, many users would principally be using electricity for entertainment, so the kind of devices that the grid would power are not very different from those connectable to battery. A more noticeable advantage of the grid, which compares to a ubiquitous complaint from battery users, is to eliminate the effort of charging the battery itself. The limited nature of the battery, both in terms of the volts it can output or watts it can sustain, seems to be less of an issue versus the labour of carrying batteries to be charged – this is another form of drudgery.

In Chambok, solar cells were an effective remedy to this – in the short term people saved time and effort, and in the long term they made financial savings too. For such a remote location, connection to a national grid would be prohibitively expensive. It is more cost-efficient to power energy services through other means than the grid, for example using piped water in place of pumping, having a sustainably managed forest for cooking energy and using efficient devices like LCD TVs to make the most of the limited electricity supply.

Whilst some battery households seem content with their electrical access (apart from having to carry the battery to be recharged), the reports of several say that the sheer presence of grid electricity when it is introduced that changes people's attitude:

> She said she have to connect with electricity and spend a lot of money because if all other households do then they are all bright in the night - so she have to connect with electricity too because if she don't it is only her home that is black out in the night – Interview 21, Takeo

One household put it more frankly saying that it is envy of other households' colour TV that would force them to connect. Another bought a DVD player but had no knowledge of how to use it. These modern assets are symbols of status (Winther 2008). Consequently, the introduction of the grid to these villages affects more than just those who can afford it. When the sun goes down people gather and discuss beneath the electric lights of those who have them, and up until quite late the noise from TVs breaks the night-time silence. This marks out the grid-electrified households as they can consume electricity longer and more freely. The most evident effect of transitioning to the grid is not to enable new energy services but to improve the performance of battery-powered services. The 'grid-only' services, like pumped water, are momentous but as they are less visible, they are not such a pull factor for people to connect to the grid.

In terms of cost, people usually pay less per month if they use a battery. The grid can allow for savings, by substituting kerosene lighting, or it can allow for additional income generation, through services such as welding or in textiles (as in interview 43 below) – but for the vast majority of my interviewees, the grid electricity did not lead to financial gain.

> [Electricity] can be used with a lot of materials, especially with the cooker, TV and fan. She said that she don't know how electricity can improve their income but she just know it can improve their lives; about their income it cannot improve to [earn] more, very difficult – Interview 19, Takeo

Grid electricity can be used to enhance rural livelihoods but more often than not it is just used to improve the users' lifestyle. The majority of grid-households were in accordance with this interviewee: the grid is not putting any extra money in their pockets but they appreciate it for the convenience and feeling of modernisation. Grid-powered livelihoods exist in Cambodia, but as villagers are mostly (and traditionally) farmers, they are less effected.

In terms of planning development initiatives, the pertinent questions are not what the grid enables but how people will transition to those behaviours. An immediate effect is in upgrading the way battery-devices are used or replacing other more expensive energies:

> Can use the electrical pumping motor, the price of electricity per kWh only 720 riel, cheaper than if we use the diesel pumping engine ... also use electrical motor with sewing machine, can improve the activity of our sewing – Interview 43, Kampong Speu

These effects of the grid are appropriate in the sense that they relate to behaviours with which villagers are already familiar. Yet, energy services like computing are unfamiliar to the villagers so only appear very slowly. I only heard of one business using a computer to organise rice wholesaling, another interviewee expressed that with grid she would buy one so that her children could learn to use it and be more employable in the future. Schools and hospitals may also have a computer but rarely so. Apart from these few cases there is little to no demand for those services in the villages so whilst the grid may enable the capabilities of ICT, they will only slowly come into evidence.

The interesting point is that though these capabilities are hardly seen, the preconditions for them are already in place: the common 12 volt battery offers sufficient power for a laptop and the mobile internet network covers many rural areas. I often asked villagers where they learned their skills, usually I was told they "*learn from fathers and grandfathers*" (interview 91), but a minority mentioned Google and YouTube (informants C & S on how they learned to use computers and interviewee 94 on how he improved his trade as a mechanic). This is a major inroad for information into villages and it marks a departure from traditional methods of learning. Significantly, it is within close reach of the rural population; they could feasibly adopt a more digital lifestyle even without grid infrastructure.

7.3 Water

Again, the first subsection here goes over the methods by which energy is accessed for this service of providing water. The other subsection brings to light the other important issues that are related to that energy service: quality, mentioned in chapter 6, but also the water's source.

7.3.1 Storing and transporting water

Though the method of transporting water varies, villagers everywhere will tend to store it in ceramic water 'jars' (pictured below). These typically contain 500 litres, but there are half- and double-sized versions. They are clay, so producible in villages, but more commonly high-quality units are made and delivered by specialists – one interviewee put the unit price at $25. The guttering of a house's roofs will feed the rainwater into the jar stores, so in the rainy season this provides villagers with all the water they need. Maintained carefully, a jar can hold nearly enough to provide a person with drinking water for the whole year. Notably, it is from the jar that villagers get at their water, so it is necessary to keep these in mind when considering their water behaviours as a whole.

The most basic method of transporting water is to carry it manually, one interviewee said that this took her three hours per day, every day; such behaviour was rarely observed in fieldwork as most villagers could access enough energy to relieve that kind of drudgery. As with wood collection, a tactic is to merge the task into another daily routine:

Picture 7.8: Water jars for household storage.

These jars hold half a cubic meter, the lids prevent algae growth or evaporation. In the background a toilet outhouse is visible – this has its own store of water. Notice also the small blue and orange buckets; these are used instead of taps.

> Preseth: Before we had the well we carried water from the pond is about 200 metres from here ... in that time we had only one jar so we don't spend much time to carry the water, when anyone go to take the bath and come back, they carry – Interview 107, Samlout

Though the task is merged, it nevertheless required them to carry water a fair distance. With a well dug adjacent to the household, this interviewee's family still collect it by hand but it is now feasible to store more through a separate task of collection. Further away, another villager would use her moto for the 400 metre journey to the well, with that she could ferry a set of twenty 30 litre containers. She would use the containers to fill a jar, then refill the containers to maximise her storage and the interval before having to carry out the task of collecting water again. These are all behaviours of manual collection (from the well or the pond) but they differ: the proximity of the water source and the amount that can be stored affects how energy is accessed to transport it.

In Samlout, many hand-pumped wells were drilled to give convenient access for the households. In villages without such close-by wells, people would rely more heavily on fossil fuel powered pumps to transport the water from distant sources. I observed power tillers being used for pumping but the standard was a 4-inch diameter, bespoke pump – with long, flexible piping this is used to reach streams or canals further from the home. Electric pumps are available but are less common despite being lighter and easier to use. The problem is that they need more power than a battery can output but it is not always possible to connect them to the grid where the pump is needed[3]. Close to the household and its power outlets, electric pumps were employed effectively for uses like making cement for construction or irrigating residential vegetable plots, quietly, from a pond near the house.

[3] A length of cable could surely resolve this issue, though that was not observed in fieldwork.

Picture 7.9: A fossil fuel pump

The fossil fuel pump is large and noisy, yet it commonplace due to its portability and the lack of affordable electricity supplies.

Picture 7.10: An electric pump

The electric pump does not pump water as fast but it is easier to run on continuous operation.

Though pumps are a common asset for a household to use, a given household is as likely to borrow their neighbour's as they are to own one themselves. Pumps are not fixed to the household and there is a market in renting them out to other villagers. During one interview I observed the business of water pumping: the seller arrived with a gasoline pump transported by a power tiller, connected the pump via a hose to a stream that ran at the bottom of the hill, and thus filled up all the water jars around the household at a cost of 3000 riels per jar ($1.5/m^3$). As opposed to delivering the energy service of pumping water, the business may deliver the water itself on the back of a truck. This may be higher-quality water and reach areas further away than can be pumped – although that range could not be ascertained in the study. It was noted that the service of direct water delivery did not occur in the dry hilly region of Samlout.

Broadly, the consensus was that villagers would prefer to access their water through piped infrastructure. Pipes do not require any energy expenditure on behalf of the villager; the mechanical power to move the water is accessed by simply turning the tap and it is paid for in a monthly bill. Moreover, the quality of the water can yield further benefits to convenience:

> Before the pipe, he used well water, is more clean now and more safer. Can save time: no need to filter, sometimes no need to boil. About the well water, have to use filter, even though the water is in the ground, there is still some virus – Interview 53, Kampong Speu

Unfortunately, the infrastructure to provide these pipes is not pervasive. Close to the capital, the Kandal region had good coverage but the same is not true elsewhere. Pipes are a rarity and much desired for their convenience and health benefits. However, villagers are content without them if their current supply is adequate already, for instance, those living adjacent to streams. In terms of development planning, these people have other priorities – this ties awareness of the layout of water sources into the household's energy access.

Similarly to cooking-fuels, the household will stack their methods for acquiring water. Though the water pipe is better in most respects, villagers will still make use of rainwater for drinking or pump surface water for irrigation. In order to understand water access, its uses need to be differentiated and the related factors identified:

> She pump water for irrigation and taking a shower but she have to buy clean water for drinking – Interview 18, Kampong Speu
>
> In dry season she has to buy water every week, in the wet season she can use the rainy water – Interview 41, Kampong Speu

Another interviewee explained that he would buy water not because he was forced by the seasons or quality, but merely because he was sometimes too tired to pump it himself – physical human energy is part of access. Stacking is complex; again, with a choice of methods the user can select the better means of accessing energy with respect to their situation. Discovering what affects this choice is the key to understanding how the user accesses energy to transport water.

As mentioned above, the water's source and storage govern what the user must do to get it to their household. The assets they have, such as a pump, can indicate their capability to acquire that water, and the actions they do influence how much water they need: making rice wine demands a lot. Furthermore, the weather and time of year have an effect, as does the infrastructure, namely, pipes and roads. These factors all influence how much energy the user accesses for their water supply, so whilst the method itself (collecting, pumping, buying or piping) can indicate the essentials of how they access mechanical energy for water, there is more to consider when evaluating if that energy access is problematic or not.

7.3.2 Water source and quality

Interviews can provide details on the water source, though not always a figure for how far away it is – this makes it difficult to compute the energy used in transport, yet, as has been argued, this energy value is not the critical part of energy access. Instead consider the water quality. Villagers present knowledge on how clean the water is and what steps they take to purify it but although, people are familiar with some impurities in their water source such as calcium carbonates, it is difficult to measure contamination with minerals such as arsenic without chemically testing the water itself. Whilst not always verifiable, conversations about water quality can still signify issues that affect people's welfare:

> [The mining company] use a bomb to break the stone and after that the chemical flow in the raining water ... very difficult for this village because the chemical drip out in the air and move from the mountain to the village and affect their health – Interview 68, Takeo

People's knowledge is reinforced by what works for them: in the case above they found that boiled surface water was better than polluted rainwater. In another case a trader explained that he used ice to sterilise his well water. Whilst this is technically incorrect it would stall bacterial growth and yield cleaner water than otherwise. The behaviours people exhibit can be used to identify possible health risks, but also their appreciation (that is, their particular local knowledge) of the water quality must be considered in order to understand those behaviours.

Domestic water filters have been circulated in many rural regions; these devices perform well in a technical sense. They work passively and are highly effective at ridding water of most contaminants but their uptake is inhibited:

> Me: Can she tell me how to use the filter?
>
> Preseth: In the evening we take the water to pour inside, in the morning we can use the water but we can get only a little that drop down, drip by drip
>
> …
>
> Me: How many people can get drinking water from one system?
>
> Preseth: Normally we drink boiled water, the filtered water is for cooking or other things, but sometimes we don't have boil water and we drink filter water
>
> Me: Is there any difference between the boiled and filtered water?
>
> Preseth: Boil water is better than the filter water, if you ask about the taste is similar, but normally *I believe in boiled water more than filter water*
> – Interview 108 (emphasis added), Samlout

Practically, it can be hard to use these filters as they don't fit in with the way that people want to access their water, that is, they want large amounts stored in jars, not to wait for a small amount to come through the filter. Although as the interviewee says, it is more about what she believes in; in a context where diarrheal diseases can be fatal it is understandable that people stick to methods they trust. Overall, the operation of the filter is inappropriate for the desires of the user. Equally, some households use bottled water for drinking because of its certified quality. Though is expensive per unit, it is easy to consume: no boiling, no waiting for filters and no chance of mineral impurities; this matches how users want to access water, thus is an appropriate way for them to access the mechanical energy of transporting water.

Though the user's opinions are significant in how they choose to behave, it is the availability of water sources that determines much of their behaviour. Within fieldwork several distinct classes of water source were identified: rain, pond, stream/river, canal, reservoir/lake and groundwater, or just a mains pipe that delivered it. Each of these has specific advantages and as such people will rely upon more than one. Again, stacking is a matter of selecting what benefits match the user's needs.

Chambok was fortunate that the nearby but upstream river was tens of vertical metres above the villages; this gave the residents an effective and efficient means of water access by piping it with a natural system of pressure. Using pipes and gravity to access natural mechanical energy saved the villagers considerable effort.

Picture 7.11: Pipes transporting water to the households in Chambok.

> The people before they have connection to the waterfall, they have to go to the lake, is so far from here and to buy is much money but now we have water supply in the house so the water is easy – Interview 81, Chambok

Similarly in Kandal the water infrastructure gave residents ample, clean water for domestic uses like washing and cleaning. In Kandal this infrastructure comprised both pipes and good quality roads, allowing water to be delivered easily by truck. Here villagers stacked their methods as they still had to draw upon other sources for irrigation, such as pumping from rivers.

Artificial water sources such as canals and reservoirs sources are designed to have greater availability throughout the year. In this sense they can provide a convenient access to water but also a resilient one, since they can offer some more protection in times of drought:

> When we have the climate change it is very difficult for me, I don't have any technique to change to improve. I only want to get a pond because when there is no rain I can use the water in the pond – Interview 105, Samlout

Though they can be more reliable, ponds and canals are more likely to be of lower quality, affecting the domestic tasks users can perform with the water: it is not potable, attracts mosquitos and can't be used for cleaning as effectively. However, it is fair for irrigation, as evidenced when comparing rice yields from land near to and far from canals: with good conditions four tonnes per hectare per season is possible, in poorer conditions this can fall to just a half tonne. One interviewee in Battambang explained how Chinese donations had built canals in the area but she was not "lucky enough" to have them close to her fields – one household may enjoy well-irrigated rice paddies whilst their neighbour may have to rely on the rains:

> Their farm is only waiting for the rain water, she will find somehow to survive, but a few years has gone without getting much crops from the rice – Interview 85, Battambang

> We really need the canals because we need more water but the water is not just for the crop. You know we use the medicine to kill the grass and insects, the poison. The source of water is very far from my farmland so it is difficult to carry the water – Interview 109, Samlout

For many tasks, in farming livelihoods especially, the quality of water can be lower; this affirms the need to differentiate the demands and uses of water in assessments of how it is accessed. For each of these tasks, a particular water source may be more appropriate and it is the user's account which can describe this. For instance, buying pumped water is a fraction of the cost of bottled water, but it is down to the user if they want to drink it and if they will purify it first.

Picture 7.12: Storing water in a pond

This water is suitable for animals to drink from, or to feed crops but needs cleaning for human consumption. Also, mosquito larvae grow in such bodies of standing water – posing a risk if it is adjacent to the household.

7.4 Mechanical energy

This section considers the mechanical energy that is evident besides that which is used to transport water. Mainly, this is comes from engines such as the power tiller or vehicles, though as the second subsection explains, it also relates to human power and how this is can be mitigated by weakness or multiplied by tools. This links to the earlier mention of manual carrying versus machine pumping, and whilst the latter can be indicated by an asset, it is less obvious how to represent physical strength and labour.

7.4.1 Engines and machines

Picture 7.13: A power tiller

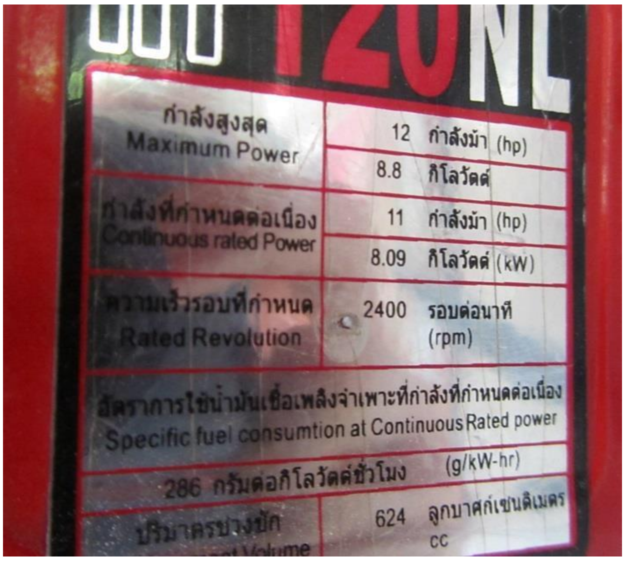
The power tiller engine here is attached to two large wheels, the handlebar controls and an A-frame extending out of shot which connects to a trailer. These are also known as semi-tractors or iron buffalo.

The power tiller is a two-wheeled tractor. There are many designs but its function is the same, to provide mechanical power. The basic operation I observed was in the transport and haulage of heavy items. Interviews explained that it is primarily for tasks in agriculture, although a few households used their power tiller as an electrical generator.

These modular engines have a high penetration into the Cambodian market and are fast becoming a cornerstone of small scale, rural agriculture (Saruth et al. 2014). One farmer reported that they can be worked for twice as many hours per day as an animal plough – they are faster, stronger and less likely to break a leg. Another interviewee explained that plots of land smaller than a hectare can be tilled with animal power and hand tools; only a third of my farmer-interviewees were in this small-holder group. The majority of farmers, who have more land or practise more intense farming (double-cropping), are more appropriately served by mechanised labour. For some tasks a full tractor is necessary, according to an interviewee who prepared land for planting trees. However, full tractors are rare due to their cost, whereas the smaller and cheaper power tillers were almost ubiquitous. Even on highways they could be seen tugging materials, produce and indeed people.

> [With power tiller] can do everything on time. Before could only work 4 hour per day, recently can work for 8 hours – Interview 54, Kampong Speu

In terms of energy access, the mechanical power delivered by these engines multiplies the output of a person's labour. However, it is heavy machinery and needs some degree of strength and skill to operate; practicality excludes older or infirm users and convention seems to exclude women using them as well.



Picture 7.14: Power tiller specifications

The tiller is rated at 11 horsepower. Villagers were not familiar with this kind

For haulage, trailers can be attached to power tillers, allowing villagers to invest in fuel and save on labour: "*sometimes he transport [wood] by power tiller, sometimes by shoulder*" (interview 25). As mentioned, a strategy for collecting resources is to merge frequent collection with another chore, such as gathering wood from the rice farm. Yet with a power tiller, resources can be fetched from a wider range and a stockpile produced from one trip. This is vital for livelihoods like boiling palm juice or manufacturing charcoal. Additionally, it simplifies gathering cooking fuel for feasts at large social gatherings or preparing a dry wood store before the rainy season starts – this is significant in terms of the household's resilience. The power tiller appeals to all aspects of energy access: in terms of performance and convenience it is enables and enhances many capabilities with reduced drudgery and effort on behalf of the user.

Another attachment for the power tiller is a generator, which complements the mechanical energy services of the engine. Power tillers work at 8-12 horsepower which can be transformed to around 8 kilowatts, easily enough for rural households (lights, TV and feasibly an electric stove). This completes the range of energy forms in the home. It also gives decentralised energy access, only requiring fuel, maintenance and spare parts – widely available in Cambodia. Akin to biodigesters, this relates to the appropriateness of the device.

Unfortunately, power tillers are expensive – at $3000 this initial cost is beyond many households. For households without, it is not unusual to borrow or rent power tillers from households who have one. This may be to till their fields on a seasonal basis or to collect wood from the forest every month. The incidence of this was difficult to quantify in interviews – respondents would say if they used a power tiller but sometimes neglect to say if they owned it, though when specifically asked they gave details on the interaction:

> Me: Does anyone in the village share a power tiller for free?
> Them: No, no household share [group laughter]. They don't just rent the power tiller, the other household will come and take care of the land for her because she cannot control it
> – Interview 70, language clarified, Kandal

Though it evoked laughter here, others did share without cost, though in this village the standard behaviour was to rent rather than lend. Depending on the relationship, this renting transaction includes delivery of the device and/or labour to use the power tiller. The cost varies, from fixed rates per job, per hour, fuel only or entirely for free. Though it avoids investment, borrowing assets is an inconvenience; interviewees expressed anxiety about breaking the equipment, but where the transaction is within an extended family network, this stress is less apparent. Significantly, a household can have regular and adequate access to a power tiller and its services without actually owning it themselves – this has consequences for how mechanical energy access is measured and understood. As power tillers are so often shared this project came to consider them through their usage and not just ownership.

Picture 7.15: Several modes of transport within the village

The moto (top left) was nigh on ubiquitous in villagers' homes, it is used for all sorts of journeys. Bicycles (right) are cheaper – in this photo the cyclist is selling palm juice, the bike is part of his livelihood. The truck (bottom left) is used to carry the awnings and frames used in village parties, another livelihood.

The next most significant means of accessing mechanical energy is from vehicles. Throughout my fieldwork the vehicles I most often saw on the road were small motorcycles known as a motos (scooters). When asked about vehicles, most households reported to have at least one of these, typically with a 2-stroke engine smaller than 100cc. They make up the bulk of traffic within cities and in the villages they are almost the only vehicles. The exceptions in my study were three cars, three trucks and a dumper truck – mostly for use in livelihoods. Around a tenth of households, mostly elderly interviewees, responded that they would hire moto transport (motodop). Motodops may be informal and without cost, for example one interviewee said she would just walk until someone passed by and gave her a lift.

I saw bicycles used in the villages, mostly for children going to school, but in at least one case for transporting rice – this farmer didn't know how to drive and her bicycle was her vehicle and means of haulage. Bicycles can be very empowering (Macy 2011). Another interviewee explained that her daughters learned to ride a moto when they were 13 or 14 years old. There did not appear to be a strong gendered aspect to driving. Albeit it was more common for the males of the household to own the motos, I observed many instances of women driving alone or with men as their passengers.

Motos are nimble and can traverse the broken pathways in villages so they are suited to rural locations. There is also much anecdotal evidence of the number of passengers on a single moto – my observed count reached five, but I did hear of seven. With a cab attachment, the moto becomes a tuktuk, a cab which comfortably seat six; one interviewee used his to transport factory workers. I made a single observation of a moto with a trailer attachment carrying at least twenty people in the worker convoy to the garment factories, though the standard carrier is the larger truck with standing room for at least eighty.

With attachments the moto is versatile, it can be backbone of an enterprise in carrying produce and assets – mostly I observed this in the cities with food stalls but they also operate in the villages. Essentially, the moto is well-incorporated into traditional behaviours, it can be used affordably when fetching wood or water and this makes it appropriate for the villagers.

Picture 7.16: Various ways a moto can be used as part of a business

The motos in these photos are all part of livelihoods, used to transport goods (left), as part of a mobile food stall (middle) or for this knife sharpener to visit restaurants (right).

As mentioned, in a few cases cars are used in livelihoods. I interviewed a builder who used power tools in construction and to carry these around required a pickup truck. Another interviewee made a livelihood renting out the equipment for ceremonies, this included speakers, a kitchen, tables and canopy, transporting these needed a light-duty truck.

There is a set of livelihoods based around delivering supplies to households from the roadside, which evidently require vehicles. I watched a delivery of water to a host-household when I stayed in a village at a time when the water pipes were broken – this is an example of resilience as the trucks provided a much-needed backup.

Picture 7.17: A ox-cart carrying passengers along an uphill trail

Apart from the power tillers already discussed, the remaining vehicle to consider is the cart, drawn by ox or cow. These are for ploughing more so than personal transport but they are used to haul heavy items such as water drums, crops or logs. Similarly to the power tiller, these carts are frequently shared between households; six of fifteen reported this in my final survey in Chambok. With Chambok's beautiful scenery and ecotourism, the ox-cart was to transport visitors up the mountain – a motorised vehicle may have been quicker but would not be compatible with the image they were selling to tourists.

This subsection has listed machine assets and vehicles, and related them to capabilities. Such an account is part of building a comprehensive tool for assessing energy access. The following subsection is more concerned with the user of those machines and what access to mechanical energy means to them.

7.4.2 Labour and personal power

Without infrastructure or machinery, the mechanical energy a person is able to access is limited by the tools they can use but also the nature of the person themselves. Labour can be conceived in hour long units, but that does not represent the personal power which has much more to do with the effort which can be expended:

> Me: What are the rules or laws about the wood you can collect?
>
> Them: Actually I collect only the dead wood, the small one not the big one, because I have no power
>
> Me: What about chopping the wood, how do you make the logs smaller?
>
> Them: I hire the people to cut but I will make it smaller by myself when I have the energy – Interview 102, Samlout

This interviewee is an elderly lady, who talks about the 'power' she has, referring to her physical, bodily strength. The labour she hires has very different physical power, they are fitter and better equipped, but quantitatively, these hours are equivalent to the ones that she would expend even though she can effect less change.

Picture 7.18: A hatchet and a chainsaw – for cutting wood

Usually villagers chop wood with hand tools but professionals are more likely to use power tools.

Personal power can be multiplied by tools and machines, or even draft animals. It is very much a determinant of energy access but measures of personal power aren't included in energy access indicators – not even through statistics on malnutrition or disability. The physical power of a person is a 'foreground' issue, at the centre of energy access's importance but often not mentioned specifically to be part of mechanical energy. Personal power is affected by issues of health (as above), gender (from interview 103, page 215, where it takes man-power to start the electrical generator) and age (from interview 101, page 216, who wanted a washing machine because she was too old to do it herself); this even has an effect on identity and the decisions people make about how to access energy:

> Me: Is she interested in connecting to the electricity cable?
>
> Them: She wants to but she is unsure about the money
>
> Me: How does she think it might benefit her?
>
> Them: She cannot imagine in the future get anything that improve her life, she only have this job that can give her profit to live, *she doesn't have the power to do anything else to live* – Interview 92, emphasis added, Samlout

This interviewee ran a noodle shop and was very poor. Through the interview it came across that she didn't think she had a choice about her lifestyle, that is to say, she felt powerless and in turn this affected her decisions about how to access energy. Ostensibly, the feeling of powerlessness is a self-perception, but as Chambers (1983) explains, physical weakness reinforces this. In deference to her age and frailty, interviewee 92 would receive food-gifts from her neighbours, she would pay to have her water pumped, buy charcoal as it doesn't need chopping and travel by motodop instead of having her own vehicle – and because she couldn't use machines she had to make her noodles by hand. Her personal power thus has an effect on all of the ways in which she accesses energy. Accordingly, people's personal power relates to all of the ways in which they access energy, and by consequence, also the choices they make about their energy behaviours in the future.

7.5 Other factors within energy access

There is literature on the following topics but not in relation to energy. Yet, these issues make good observational indicators of rural energy access. Particularly, the quality of bridges is an indicator employed in the next chapters. Though I did not find a way to make use of the others in the final assessment tool, they were a helpful guide in data gathering.

7.5.1 Roads and bridges

A good road network is the route to farmland, markets, hospitals, schools and the urban centres. Energy is needed to build roads and their quality is a direct determinant of how mechanical energy is accessed. In turn, this can link to almost every other form of energy, for instance wood delivered by a truck, accessibility of spare parts to repair machines and the road even influences where electrical power lines can be built.

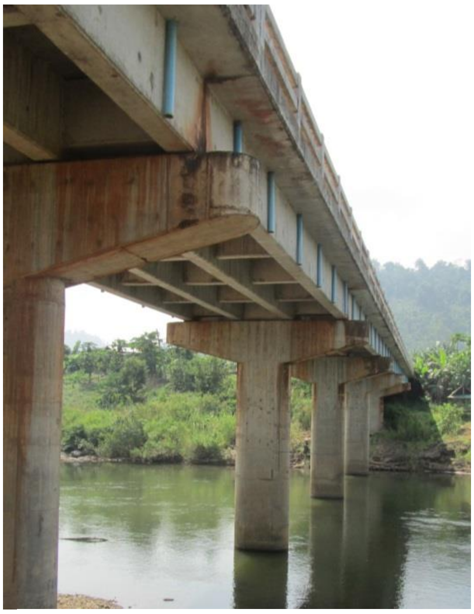
Just as much as the vehicles used, the type of road or path affects the journeys that can be made or what can be transported. In Samlout, the farmers would talk about how the road quality affected their livelihood:

> I hire the tractor from a villager who lives near my farmland, you see the way <points to dirt path> when it is raining I cannot use my moto or semi-tractor, I hire that tractor to help me – Interview 109, Samlout

Picture 7.19: A tractor

This vehicle is larger than the power tillers discussed earlier, such machines are necessary for jobs that require more power or traction over steep or muddy terrain.

The poor quality of the road network in the rains weakens the farmers' resilience, but this is countered where and when these large machines are available for hire.By contrast, villages in the Kandal case study have a much higher-quality road running through them. This connects the commune to many different markets: farmers can main-crop sesame as the road makes it easier to sell to middlemen, also the households can easily buy water or wood with deliveries running down that main road almost daily. The villages in Kampong Speu or Takeo that were closer to the main highways also benefitted, it was much easier for people living near the highways to work in the garment factories. Furthermore these factories need electricity, so they encourage grid extension in the area. Remote places like Chambok have much poorer roads, so deliveries cannot be made and the wider economy is less accessible. The roads and their quality have many consequences; in maintaining awareness of this across several fieldwork locations I found that an effective way to assess the roads was by the proxy of bridges. Partly, the state of a bridge was indicative of the road quality but also bridges tend to be the weak link in the transport network, so ultimately they determine what transport is safely possible.



Picture 7.22: High quality bridges

These are very high quality bridges along bigger roads in the country – they would serve as indicators of the road quality *to* the villages but not *within* them. They exemplify what makes a good bridge: structural integrity, berth, drainage and the resources piped alongside them.


Picture 7.20: Medium quality bridges

These are high quality bridges. Though, the left one is a foot bridge; motos may cross but cars and trucks would not do so easily. The bridge on the right is seems stronger, notice also the black water pipe that runs along it and the electricity wires above.


Picture 7.21: Lower quality bridges

These two crossings are of poorer quality, they impose difficulties and dangers to vehicles trying to cross. These road junctures are indicative of the poorer transport network in those locations.

7.5.2 Materials used in and around the home

This item follows from the above; it is a more subtle appreciation of energy access to consider the energy accessed in refined materials. Rural studies in Cambodia already look to materials in household construction to identify social class (Lean et al. 2008), and this subsection reframes that classification to energy access. The presence of refined materials implies that they can be either produced locally or imported from somewhere that can. However they acquire these materials, a person is indirectly accessing the energy that goes into refining them. Materials make an observational indicator for what technology is present in the villages or can be accessed via markets. Consequently, a lack of materials such as pyrolysed charcoal or fired bricks means that the area could benefit from programs introducing the skills to produce them or nurturing the market that would import them.

To expand: materials such as wooden stakes or bamboo do not need much refining, whereas smooth wooden boards or woven baskets are materials that do take a lot of time and effort to make. They may not embody more chemical energy but the refining itself is an energy service, so by importing it to their household, a person is bypassing the need to do it themselves. Energy is also required to carve stone pillars, bake clay, mix cement and weld metal. These materials can all be worked within the village and the inclusion of them in building construction reveals the presence of local artisans and state of their energy access. One of the rarer materials seen within villages is glass; this was present only in a few of the wealthiest homes, it signifies the feasibility of the energy service air conditioning.

Picture 7.24: Wood and rattan structures

These builders are weaving the basic style of roofing, rattan (left); this is time consuming but cheap and better than corrugated iron at keeping a low temperature in the shade. The wooden shack (right) is old and unpainted though it is well-constructed, providing shelter to the weather and insects or wild animals.

Picture 7.23: Non-wood construction materials: plaster and metal

The modern-style house (left) is being built to replace a traditional wooden one, this newer build uses bricks and ceramics throughout, it has no open walled space beneath the house – any kitchen inside will use modern, smokeless fuels; it is even possible to use air-conditioning here. Having energy access to work with different materials changes the space in peoples' homes and thus the way they access energy. By contrast the slum (right) is all cheap corrugated iron on floating wooden rafts, again, indicative of (low) wealth but also of the way in which materials can be manipulated.

Picture 7.25: Differing qualities of the same housing style

The house on the left is almost entirely wood, including the main pillars and the added structures to the side. The house on the right uses concrete in the pillars, steps and the ground level building; iron is used in the railings, slate on the roof and glass in the windows – it even has a plastic water butt. These materials add to the quality of shelter that the house provides: for instance thermal control and safety. Ostensibly they are indicators of a wealthier household, but they also imply that there is a welder in the vicinity and builders with high energy access.

7.5.3 Community energy

As mentioned, the focus on energy access in the home is limiting. Already some examples have been given of how a person's energy access is affected by the community, such as businesses which rent out their energy-assets or use them to encourage custom. Food outlets epitomise much of this: they have lights, fans and TV, all electrical energy services; they sell hot food and cold drinks, so they use stoves and refrigerators; and they must provide water to have a clean premises and washed dishes. Like the bridges and materials, such businesses in a village are an indicator of the energy access possible in the area.

To understand energy access in the village, it is important to understand how livelihoods interact with one another. In particular, the miller makes a good example:

> One litre of diesel can mill four bag of rice … can get profit because with his own mill can mill his own rice and sell to the market, also buy the rice from another household and sell to the market – Interview 62

The milling of rice is itself a mechanical energy service; it uses an engine which saves the farmer the effort of threshing their grain manually. The by-products of milling are rice flour and husks, the former can be used in pig feed and the latter as a fuel (and as mentioned earlier, they are both used in making rice paper). Seeing how these livelihoods connect gives a more complete understanding of the energy being accessed in the villages, both directly and indirectly. Energy behaviours, even at the household level, do not exist in isolation as they are all part of a dynamic system. Awareness of this system, of community energy access, is integral to study of energy access at smaller or larger scales.

With this wider scope, energy access can be observed to extend through the job market. In the literature, Practical Action (2012) talk about income generation as an energy service. Though that can be through cottage industries, around a third of interviewed households had at least one member with a job outside of the home. Mainly these would be garment factory workers but people also worked as teachers, as labourers for construction companies, or as extra hands on big farms. In these jobs, the workers are accessing energy and being paid for it – there is energy access within their employment to be aware of, but also those workers can then access energy indirectly by paying for services elsewhere. However, the indirect energy access that comes through financial transactions must be considered in the context of the labour invested – looking at the bigger picture this obligation of time can reduce capabilities overall.

> Yes of course she think they can improve the livelihood of the villager … before availability of garment factory the villager they have a lot of free time, they just sit in the house without getting the benefit, without getting income. But recently they aren't free any more they have to work a lot – Interview 58, language clarified, Kampong Speu

Picture 7.26: A garment factory

The garment factories are beneficial for Cambodia's exports and they bring a relatively good wage into the villages. They even support the electrical infrastructure. However the working conditions are poor and the wage is insufficient in the city.

7.6 Conclusions

Throughout this chapter energy behaviours have been described in a more qualitative manner than in the previous chapter's numerical approach. Whilst that chapter was more effective at pinpointing where behaviours exist and for whom they are a primary strategy, the behaviours themselves were covered in more detail here. Through this representation, the narrative that villagers gave in interviews was told, with their quotes for support rather than just the numbers they mentioned. This data is no more accurate but it does have a different zone in which it is informative. Recall that this research is seeking to differentiate the qualitative and quantitative approaches to assessing rural energy access. An underlying theme has been to demonstrate the information which can't be quantified and to contend that communicating this plays a significant role in understanding energy access. This forms the argument that energy access can be a greater theory of understanding human behaviour than the way it is currently used in the literature, that is, in its relation to capabilities and choice, dependent on physical assets and a person's condition.

Particularly, discussion has begun to exemplify how the aspects of performance, convenience, appropriateness and resilience can be used to pick out the salient points of energy access relating to assets and people's capabilities. For instance, the electricity grid and power tillers allow users good access to the related energy services. Advantages of water pipes and biodigesters are that they give convenient access to energy, moreover, using biodigesters can be deemed appropriate because it is symbiotic with agricultural livelihoods. Also, the aspect of resilience can be seen in some of these behaviours: in sustainable management of woodlands, independent electricity generation or careful selection of clean, healthy water sources.

Equally, the four aspects can be used in sophisticated discussion of the weaknesses in energy access such as the low performance of battery electricity, sufficient only for essentials such as lighting or charging mobile phones; the inconvenience of wood collection that may be mitigated through a farming livelihood; the inappropriateness of water filters because they do not match the way that people want to use them; or that the resilience of coping strategies is compromised if a household relies on the health and strength of a single person.

Evidently, this chapter has not given an exhaustive list of all the assets in the home and their interrogation through the four aspects. Focus has been limited to the basic functions which are jeopardised by situations of poverty – lacking the above assets can lead to severe deprivations. This chapter has grounded some of the classifications from the previous chapter in people's vocal accounts; part of the objective was to make the reality of those people's energy access more comprehensible. Simultaneously this has shown complexity in energy access that deserves more than numerical representation.

With cooking energies the point was argued that there is complexity in the user's choice about which fuel to use and that stacking is caused by that choice varying with the person's current situation. So too with water; the sources, and user's feelings about them, determine how that user accesses energy to transport and clean the water. For mechanical energy as a whole, access is not just a product of physical assets but also affected by the nature of the person who would use (or borrow) those assets. Finally, for electrical energy the capabilities realised by the people in question link to their knowledge and skills, but also their tastes, desires and opinions.

With the terminology and explanations from this chapter, the reader should be able to understand the design of the appraisal tool in the next chapter and appreciate its mechanisms. An implication to take is that with the broader-scoped and finer-grained analysis given here, energy access is taken not simply as a score which a household achieves, but rather, a function of the nature of the people involved and the physical assets which they can use. From this perspective, much more depth can be added to the numerical representation from Chapter 6. Combining the two will produce a much more comprehensive, fair and rigorous method than either of them alone. The next chapter uses this combination in the design of a tool, one that pays heed to the kind of complexities expressed in this chapter. Particularly, the tool retains focus on the human, user, element of energy access yet also is aware of the broader, more peripheral, factors that relate to capabilities and poverty but through indirect, as well as direct, energy access.

7.6.1 Revised map of energy landscape:

Element of energy access	**Electricity**	**Cooking fuels**	**Mechanical power** (including water)	
Focal points within that element	• *Appliances* • *Lights* • *Cost* • *Consumption*	• *Availability* • *Sustainability* • *Storage* • *Smoke*	• *Vehicles and roads* • *Water supply* • *Engines* • *Fuel*	
Cross cutting issues over all elements	Performance	Convenience	Appropriateness	Resilience

Table 7.1: A summary of the important issues to consider within energy access – the three forms of energy and the four aspects of them.

This map of the energy landscape (revised from the map given in 4.3 and analytical framework in 6.2) reframes the perspective for studying energy access; it was designed in light of the findings given so far. Whereas the previous map tracked energy from its source to its uses, this one takes just a slice of that, the forms of energy as they are used, and matches them with aspects which relate energy use to the user. Specifically, this is a rubric for studying energy access in a rural setting, through its structure: key elements of the phenomenon, focal points for analysis and cross-cutting issues which tie the phenomenon to people's experience; can well be used in other similar studies.

In this revised map, for each of the three categories (electricity, cooking fuels and mechanical energy), a set of focal points is identified. Notice that consumption only occurs in the electrical category: units in kWhs are informative and consistent across different locations. Other units are useable (litres of water, sacks of charcoal) but that data is not as helpful as the points listed in the table. The focal points for each category begin the guideline for how to study energy access in a rural location. The significant addition to this framework is the inclusion of the four cross-cutting aspects underpinning energy access. As was shown throughout this chapter, these aspects can be used to frame meaningful discussion.

8 Tool Building

This chapter describes the creation of a pair of tools for the assessment of energy access. It combines the data and approaches of Chapters 6 and 7. One tool is intended to be deployed rapidly to build a wide dataset using surveys and local actors as research agents. This is the API (Access Priority Index) – it indicates which areas are in need of what development. The other tool is intended to be more in-depth with a focus on interviews and interpretive analysis (Qualitative Access Tool). The former tool identifies the scale and severity of problems, the latter provides the necessary information to plan sensible ways to resolve those problems.

This chapter is closely tied to the next. The design of the two tools is given here, Chapter 9 then applies them to the final case study, Samlout. The two tools are separate but interdependent; the best way to see this is by demonstrating their application. In the design of the two tools, discussion begins by recalling the strengths of the quantitative and qualitative approaches, to be used accordingly. Thus enabling this chapter to conclude that each approach has utility when planning or evaluating energy access development initiatives.

8.1 Motivation for the tools

The thesis so far has expanded upon the concept of energy access from the early conclusions drawn at the end of the literature review. This expansion has brought out the breadth and complexity of energy access. The intention now is to select the most useful information upon which to base the indicator tools; this selection will be guided by the revised analytical framework (6.2) and map of the energy landscape (7.8.1). Before the tool construction begins, it is helpful to recall the original intentions of the project to align those aims with the design process. This is to ask: what are the tools for?

From the outset, the project has sought to find ways of alleviating poverty. This has been conceived of as expanding people's capabilities and it is the concept of energy access which has been used to frame those capabilities. The idea is that development in energy access enables capabilities and these in turn mitigate poverty. Thus, the function of the indicator tools is to facilitate the process of planning, monitoring or evaluating developments in energy access.

In Chapter 6, the information presented was on the process and results of quantifying energy access behaviours; this suggested what kind and what scale of energy the research participants were accessing. Chapter 7 then used a qualitative approach to find the implications and interconnections of those different kinds of access; that is, if they were problematic, the related factors and what capabilities were enabled. So, combining this information, the two tools (which embody the respective approaches) can achieve their function by locating what is likely to be problematic energy access then pursuing the details about this to reach a greater level of certainty and understanding.

To give an example, one purpose of the first tool is to locate the uses of crude fuel as they are associated with mortality from respiratory disease. The second tool assesses how those crude fuels are actually used: how the smoke ventilates from the kitchen and also the conditions which affect the user's fuel choices. Thus, a planner using these tools could identify where a clean cooking fuel intervention would have the most impact, and feasibly reapply the tools after the intervention to monitor/evaluate that intervention over time.

The quantitative tool is not a measure of energy access. Instead of indicating 'better' and 'worse' conditions of energy access the tool will score the locations on 'priority'. This does not make inferences about the quality of access in the area – that is left to the qualitative tool – instead it is an indication of how likely there are to be problematic issues of energy poverty in that location. Whilst the API makes village-to-village comparisons, the qualitative tool gives its entire focus to the state of energy access within a specific location. This tool will use the four aspects of energy access as its indicators. Unlike the indicandum of priority, these aspects are not given a score – rather, a description which addresses the most salient points that need to be known in understanding the energy access of that given location.

8.2 The quantitative tool

This section goes over the construction of the Access-Priority Index (API): it gives detail on the purpose it serves, the data it uses, how the data is manipulated and what the end results mean. Part of the novelty of this tool is in the mechanism for combining varied indicators; it is a fairly complex computation, demonstrating useful techniques that can be applied elsewhere. The diagram on the next page outlines how the API is constructed; the revised analytical framework is used as a basis, from this nine indicators are selected, these are assigned values with reference to the core aspects of energy access, then they are combined through a specific calculation. The end product is a set of three sub-indices (forming one index) which can be compared easily.

8.2.1 Design overview

Unsurprisingly, this rapid appraisal tool narrows its focus to the main elements of energy access: electricity, cooking fuels and mechanical energy. These elements were defined in the analytical framework presented in the last chapter. The picture overleaf details how indicators emerge from the framework and are consolidated. Those important forms of energy cover many capabilities relating to basic needs; also they align with much of the literature on energy access indicators (for example, the UNDP's measures (Legros et al. 2009)). The decision to limit the number of elements to three (for instance, neither including lighting as separate to electricity nor differentiating mechanical energy into transport, pumping and lifting) is to avoid overlap between the elements and retain simplicity in comparisons – this tool needs to be easy to use. As the indicandum is priority and not energy access, this simplification is not contrary to the project ethic. The aim of the API is to signify which component(s) is/are in most dire need of attention through development initiatives or otherwise. Ultimately, the index will give a numerical representation for the three separate components, stratified by location, such that it is clear what needs attention.

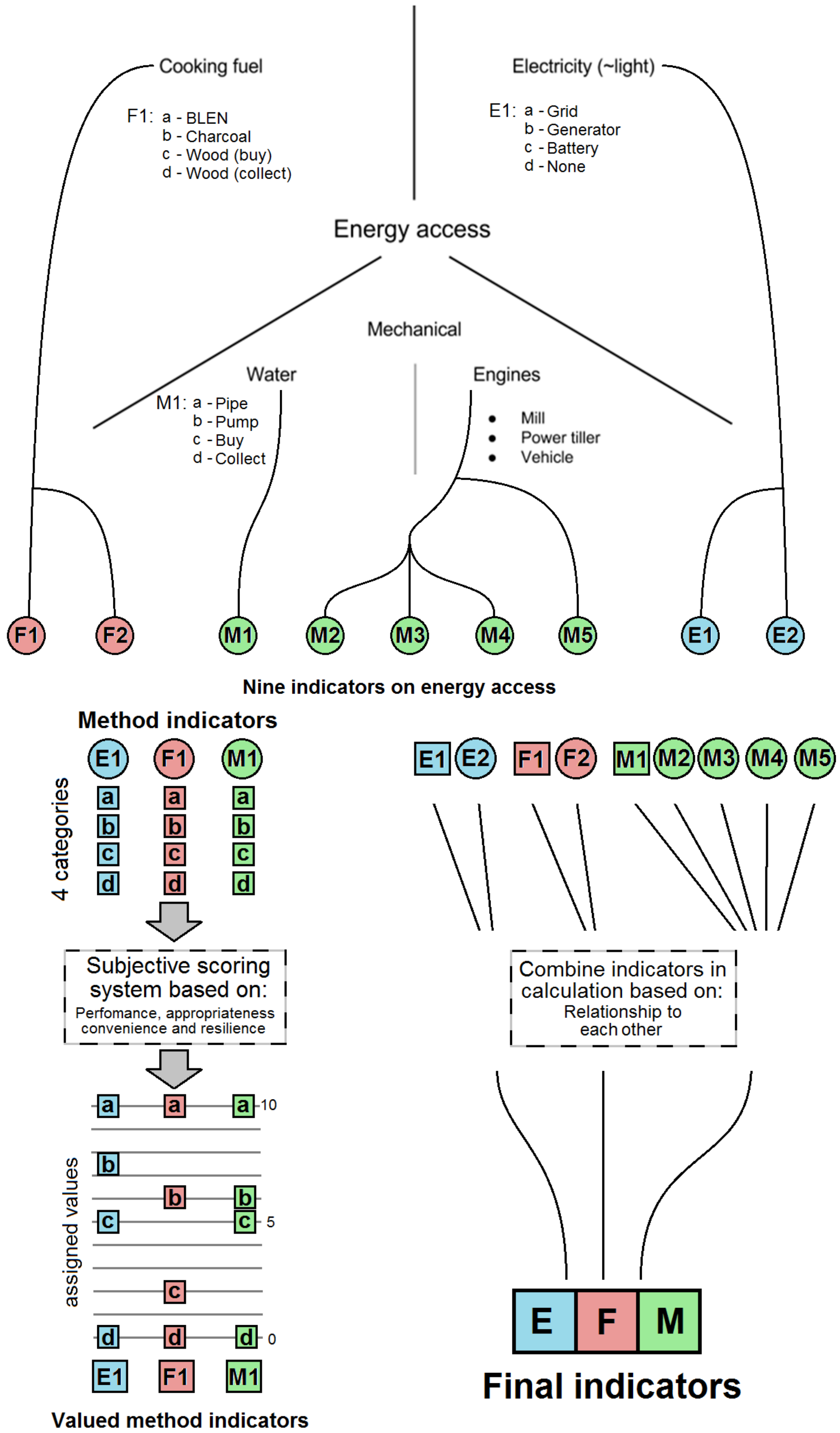


Figure 8.1: Extracting and processing indicators from the analytical framework

This tool is normative, though as will be described, the related decisions were informed through dialogue with participants in an attempt to see through their perspective.

To manage the design process, I applied the five criteria given by Ilskog (2008). To recap, these criteria are stated in bold – added to each is a justification for how the API can satisfy that criteria.

- **Simple to understand and apply**
    - Indicators will draw from data related to physical assets. Categorising these will facilitate data gathering. Also, the results will be normalised and kept as three elements, making it easier to interpret.
- **Transparent and inter-subjective**
    - The nature of the surveys is that the data is traceable and the categorical data is simple enough that it should allow agreement between measurers.
- **Robust**
    - Indicators are based on variables that are present in all locations of rural energy poverty (the bias of them to the particular case study locations is discussed further in the final chapter).
- **Comprehensive**
    - The elements outlined above are at the core of energy access for rural agricultural communities; they emerge from the framework devised within fieldwork.
- **Fair**
    - Though this research does not have acute focus on specific issues like gender, it has highlighted problematic issues like the drudgery of manual collection and health issues of burning crude fuels – these emphasise inequalities.

In describing Ilskog's criteria they are interpreted in terms of this project and as such the tool is already beginning to take shape. Surveys are used to find out how villagers are accessing energy in terms of what category their methods lie. The ultimate focus is upon capabilities, but to simplify data gathering, the subject in question here is that of assets: for example, does the household have a battery, a generator or a connection to the electricity grid. These asset-categories represent electrical energy. Along with the other forms, cooking fuel and mechanical energy, this provides a sufficient cover of the range of energies accessed in the home. Creating a scoring system that 'fairly' combines these into an index will be discussed in later subsections. That discussion is informed by experiences from fieldwork and guided by the aspects in the framework: performance, convenience, appropriateness and resilience. Finally, the results will be displayed for three case studies and example analyses made on them, comparing the data and commenting on its computation. Before all that, the initial step of data gathering is described for transparency and repeatability.

8.2.2 Data gathering

The first step of the tool is to gather data. This is done through a process outlined in the methodology but it is expanded upon here. Local research agents are used to hand out surveys – these agents acquire the data for the API and they themselves can be interviewed to acquire data for certain indicators. The surveys I used were designed with prior knowledge of energy behaviours in rural Cambodia from the spring fieldwork; if this API tool were applied elsewhere then the surveys may have to be piloted then adjusted. Essentially, to design a survey some knowledge is needed on what questions to ask. Such awareness can come from the literature and/or a preliminary stage of semi-structured interviews (as outlined in the methodology).

The use of local research agents is a tactic borrowed from the Rapid Rural Appraisal (Chambers 1981, p.101). In my research I employed village chiefs for this; they are my recommendation for studies in Cambodia but their role may differ elsewhere (see 10.2).

I found that the expense of employing a local agent was far less than my translator and his motorbike; this reduced the cost of fieldwork significantly. It was also a quicker way to amass the quantitative data. Though local agents may not give the surveys enough priority to get them done immediately, it is easy to employ several of them simultaneously. Within a single day I could enlist several agents, while they carried out the surveys on the general population, my translator and I could begin interviewing specialists in the villages, including some of those agents themselves (in my study, village chiefs) to check their biases.

To maximise the rapidity of the study, data can be collected whilst waiting for the surveys to come back. The non-survey data is the electricity tariff, the presence of clean cook fuels in the market and the quality of the road network. These three items form indicators as detailed later. They can be tracked down using a mix of visual clues and referral. The local research agents can be of use in navigating the village to find data for these indicators. Also, the road quality can be determined in the process of travel, with special focus on bridges as mentioned in section 7.6.1.

8.2.3 Selection of indicators for the API

This subsection describes the indicators that are to be used in the API. They are rudimentary supply based indicators for the three elements: electricity, cooking fuels and mechanical energy. Notably, the latter is crucial to rural farmers but has received relatively little attention in the literature compared with electricity or cooking energies. As such, that element is given special attention in the description of this index. Potential indicators to expand the other forms are given in 8.2.9.

Mechanical energy is vital in agriculture; it is involved in the provision of water, transport and in various tasks of specific machines. It is from these areas that the mechanical indicators will draw data. As providing water is the most vital function of mechanical energy, a household’s mechanical energy can be indicated using its water supply as a proxy. Yet, assets such as power tillers, vehicles and other engines are very enabling, and with enough of a different purpose that they should also be used as indicators of mechanical energy. These indicators of water access and engines are then consolidated; recall from Chapter 6 that is a substitution effect between them.

Below, an account is given of all the indicators used and a basic ordering of them. It is possible to give a more nuanced set of indicators that relate to the users' experience of using energy, as in the ESI (Practical Action), but that comprehensiveness is left to the qualitative tool. For this design, a simple system is used in order to maintain focus on the idea of priority and the function of providing appropriate information.

In Table 8.1 (next page), the category-based, 'method' indicators have greater influence in this tool – from interviews they were deemed more significant, that is, infrastructure and resource availability largely determined behaviours within energy access. However, they are moderated by additional indicators because there are more issues within energy access to consider than just them.

Element	Indicator	Options (in the order they will be scored)	Influence on energy access
Electricity	E1: Supply method (source of electricity in the household)	a) Grid b) Generator/Solar c) Battery d) No electricity	High
	E2: Cost	Is the grid tariff or battery recharge fee for that location more or less (20%) expensive than the village/case average	Medium *
Cooking fuel	F1: Type of fuel used in cooking	a) BLEN[4] b) Charcoal c) Wood (purchased) d) Wood (hand collected)	High
	F2: Clean fuel availability	Presence of at least one of the following: biodigester promotion in village, clean charcoal production or gas sold in local markets	Medium
Mechanical energy	M1: Water supply (asset used in getting it to the household)	a) Piped b) Pumped c) Delivered d) Collected (by hand)	High
	M2: Power tiller	Yes/no	Medium
	M3: Vehicles	Yes/no	Medium
	M4: Additional engines/machines	Yes/no	Low
	M5: Roads	Good/poor quality	Low*

Table 8.1: Indicators for the API and a basic ordering of them

Elements of energy access, indicators for them, and a guideline for how much each indicator should influence the final index. E1, F1 and M1 are the 'method' indicators, they are highly influential. * E2 and M5 are less significant but values for them will be multipliers rather than added scores since they have a combined effect with the other indicators: that is, good roads mean that power tillers and vehicles are more useful – this is discussed in more detail below.

[4] Recall that BLEN refers to Biogas, Liquid petroleum gas, Electricity and Natural gas (Putti et al. 2015)

8.2.4 Ordering of indicators options

In the table above, the method indicators each have four options, ordered a) to d). The rationale for the ordering of the method indicators is now given, this draws from interviews and appeals to the four aspects of energy access. The following is recap – a more concise list than that given at the outset of Chapter 7.

- Performance - Number and quality of tasks which can be done
- Appropriateness - Price and compatibility with users knowledge and desires
- Convenience - Time taken and effort involved
- Resilience - Users' health, self-sufficiency and environmental footprint

Electricity: Grid – Generator – Battery – None

For electricity, the grid allows the performance of the most electrical energy services. Also, as its supply is constant it is highly convenient. Thus, this is the top category for an electrical supply. Generators and solar cells add a degree of resilience as they are decentralised; solar is cheaper in the medium term (appropriateness) and both can feasibly be transported so offering electricity at a convenient location – however solar faces limitations in performance and generators in their running costs. Batteries are very limited in performance and mandate the arduous chore of being carried for recharging, although they are more portable than other supplies. So generators/solar cells make the second category and batteries the third – having no electrical supply is the fourth and lowest category.

Cooking fuels: BLEN – Charcoal – Bought wood – Collected Wood

For cooking fuels, BLEN stoves make the top category; it is argued that they do not impose the health risks of cruder fuels and so offer more resilience both in terms of the users' safety and possibly also the environment. Charcoal performs better as a cook fuel (lighter and hotter) so it makes the second category. Purchasing wood is less risky than collecting it, for instance, many regions in Cambodia suffer from landmines and these can make it difficult to access the forests. Thus purchasing wood will be deemed better than collecting it. Collecting can be a sustainable behaviour but this short term study found no way to ascertain that to a high degree of surety.

Mechanical energy: Pipes – Pumps – Deliveries – Collection

For water supplies, piped water is a far more convenient option than pumping or collecting, also, the water from pipes is usually from a reliably hygienic source. Pumping water is more convenient than collecting manually but less so than deliveries, however deliveries are less appropriate in terms of how the user wants to access that service: partly this is the price but also the lack of control the user has upon when that essential service is delivered. There is more than one way to deliver: either the water itself or the service of pumping can be provided, both count as delivery in this indicator. Again, manual collection fares worse than the other methods in most respects, especially convenience and performance.

The above are value judgements based on the four aspects of energy access; this is the role of the analytical framework. It is important to keep these judgements transparent as there is no intrinsic reason why implications from one aspect should take priority over another. For electricity, the aspect of performance took priority in the above decisions as, at least in the cases studied, that seems the most relevant aspect for access to electricity as a whole – that is, the crucial matter of what energy services that can be powered with each form od supply. With this transparency it is easy to adjust the ordering to fit new contexts. From the literature review, the electricity grid in Bangladesh was noted to be highly prone to outages. In a study in that location, interviewees may talk more about the reliability of their electrical energy than the services it provides, thus the aspect of performance would be become less significant than that that of convenience or resilience, so the grid may be demoted in favour of decentralised methods.

Normativity and subjectivity is inherent within this tool. Some judgments are contested by rural energy users (see the subsection on fuel choices in Chapter 7), but others are decided by them, namely, villagers' near unanimous preference to each own their own water pump. To show 'priority', the tool needs to order the methods in question, but the fact that these methods of accessing energy do not adhere to any natural order must be accounted for. Particularly, the argument that pumped water is 'better' than having it delivered is not as strong as that for why charcoal is 'better' than wood – this will be reflected in the scores attached to these methods. Before the scores are given, more of the architecture of the tool is explained.

8.2.5 Combining the chosen indicators

The indicators given above relate to very different kinds of information so the way in which they affect the overall index will have to match that. The following equations express their combination into sub-indices and the rationale is given below:

$$\boldsymbol{E} = E1 \times E2 \qquad \boldsymbol{F} = F1 + F2 \qquad \boldsymbol{M} = M1 + (M2 + M3 + M4) \times M5$$

E is the sub-index representing electricity. Within this, E1 is the primary indicator, it considers the method of a household's supply and then the secondary indicator, E2, considers the cost of this supply in that village compared to those in the rest of the study. Though readily measurable, quantity of consumption does not make a useful indicator here because there are unproblematic reasons for high/low consumption. For cooking fuels (**F**), the primary indicator is again the supply of energy (F1) and the secondary indicator is whether or not other options are available for moving towards cleaner cooking fuels (F2). The price of fuels is not a useful indicator since the costs of acquiring wood/charcoal can be hidden (notably, the time burden).

The secondary indicators, E2 and F2, differ in their implication: E2 relates to *every* electricity user for *each* unit of electricity they consume whereas F2 only relates to the option that villagers have. As such, the operation of E2 in the computation is multiplication whereas F2's operation is addition. This technique is novel in the project as it is not used in conventional indicator tools.

The mechanical energy index (**M**) is represented by several indicators (M1-5); like with the analytical framework, these are split into two components. Providing water is the most essential function of mechanical energy, so the first component is just that the primary indicator, M1. The other component contains the secondary indicators, M2-5; these refer to engines and the road quality in the area. The two components relate to different kinds of mechanical energy and thus they are added together. Within the M2-5 component, addition is used to combine the engine indicators; then this sum is multiplied by the road quality indicator because the road quality affects how each of those engines can be used.

The decision of what mathematical operation to use in combining the indicators is based upon how the indicanda (that which is being indicated) relate to one another. One effect is that using multiplication increases the sensitivity, so a change in the secondary indicator will have a bigger influence. Combining indicators in any way is a subjective process; clearly transparency is key as this allows a nuanced understanding of the relationship between indicanda to be conveyed through the tool's architecture.

Another technique used to improve this tool is to alter the combination of the indicators based upon the livelihood reported by the household. This makes the tool fairer as it is sensitive to the nature of the household and their energy needs. For example, if a villager is not a farming-household and uses a BLEN cook stove (so they don't need to collect wood) then they would have far less need for the capabilities given by a power tiller. Their score for mechanical energy should not suffer where they don't need that asset. Accordingly, the M2 indicator has neutral influence on the **M** score for non-farming BLEN-stove households. Otherwise, where the household needs that mechanical energy, M2 has either positive or negative influence on the scores depending on whether or not they can access a power tiller.

Similarly, the electricity tariff and cost of recharging batteries do not affect the households who generate their own electricity. So, the calculation for **E** will take that into account: for independent generators E2 will have neutral influence. Formally, the alteration of M2 and E2 could be written:

IF: E1 = ‘generator’; *then* E2 = 1; *otherwise* E2 is unchanged

IF: F1 = ‘BLEN’ & livelihood ≠ ‘farming’; *then* M2 = 0; *otherwise* M2 is unchanged

Here the multiplier, E2, and the addition, M2, are neutralised. For the condition that the IF statements are false there is a non-neutral weight added to these indicators to shift the affected score up or down. The weightings for all indicators are now given.

8.2.6 Assigning values to the indicators

The table below gives a set of scores that are determined in light of the arguments given earlier; the distance between these scores is not equal as in Practical Action’s ESI. The varying gap between them is intended to represent the difference in welfare caused by certain deprivations, for instance, a battery gives poor access to electrical energy when compared with the grid, but a battery is a lot better than nothing when one considers the capabilities given by having lighting, radios or mobile phones.

Assigning the scores is done by setting the top and bottom values (10 and 0) to the ‘best’ and ‘worst’ methods for accessing each of the three forms of energy. Within each form, the other methods are scored relatively within the 0-10 range based on discussion in 0.

Electricity E1		Cooking fuel F1		Water supply M1	
Grid	10	BLEN	10	Pipe	10
Generator/solar	7.5	Charcoal	6	Pump	6
Battery	5	Buy wood	2	Delivery	5
None	0	Collect wood	0	Collect	0

Table 8.2: Weighting of the ‘method’ indicators

The categories for the method indicators are assigned scores according to value judgements made with respect to the aspects of energy access in the analytical framework. Though subjective, these are well-informed decisions.

Just as the ordering of these methods is subjective, so is their scoring in the range between the top and bottom. They are all value judgements informed by analysis of empirical evidence. The data was taken mainly from household interviews and interpreted with a framework based on the four aspects. As such, these values are orientated around depicting energy access from the perspective of the user – though perhaps with more of an awareness of health and environmental issues than the villagers have.

There is large difference between BLEN, charcoal and wood cook stoves, so the gap between these options is large, reflecting potential health issues for the villagers using those fuels. Piped water is relatively high scoring due to the great convenience, whereas pumped and delivered water are close because they offer mixed benefits. Collection of water is so relatively low scoring due to the drudgery involved. Collection of wood is not so relatively low because it is just as crude a fuel as bought-wood, whereas the effort of charging batteries is mitigated by the associated capabilities of even low demand electrical energy services.

The next table gives the scores for the secondary indicators. These are set such that they have lower effect than the method indicators above. Their range is set by the guidelines given in Table 8.1 – but note that some scores are below zero, this implying a penalty for that case as opposed to merely lacking an advantage. In cases of multiple penalties, the calculation will then emphasise these overlapping deprivations.

<table>
<tr><th colspan="2">Weightings for multiplier indicators</th><th colspan="2">Additional scores for other indicators</th></tr>
<tr><td rowspan="2">E2 Electricity price</td><td rowspan="2">1.2 if cheaper, 0.8 if more expensive than average, 1 if the same or if household uses a generator (20% threshold)</td><td>F2 Availability of clean fuels</td><td>1 if clean fuels are available and -1 if they are not</td></tr>
<tr><td>M2 Power tiller</td><td>1 if owned, -1 if not owned and farming or wood collection household, 0 otherwise</td></tr>
<tr><td rowspan="2">M5 Quality of roads</td><td rowspan="2">1.1 if ‘good’ quality roads, 0.9 otherwise (see explanation of ‘good’ in chapter 7)</td><td>M3 Vehicle</td><td>1 if owned, -1 if not</td></tr>
<tr><td>M4 Additional engines</td><td>1 if reporting additional engines or machines, e.g. sewing machines, power tools, 0 otherwise</td></tr>
</table>

Table 8.3: Weighting of the secondary indicators

Weightings and scores are given for the remaining indicators, these are designed to show the difficulties imposed by those deprivations.

The table gives the multiplier indicators on the left and the addition indicators on the right. Recall that the E2, F2 and M5 indicators (italicised) are regional descriptors; they are assessed early on in the data gathering. Conversely, M2, M3 and M4 may vary with each household and are determined by surveys. Notice that both E2 and M2 will increase, not effect, or reduce the **E** and **M** score depending on the indicandum and condition of the IF statement. Finally, M4 incurs no penalty as it only relates to an advantage in terms of basic capabilities.

To account for overlapping forms of deprivation, the multiplier indicator, M5, is used to emphasise those cases. If the household has very few machine assets and the M2-4 indicators sum to a negative value, M5 will switch from 1.1 to 0.9 or from 0.9 to 1.1. With this switching the multiplier is made more effective and the overall tool more sensitive.

For the purposes of the formal statement below, let R equal 1 with good quality roads, and 0 without; also let the poor score on the indicator equal ‘a’ and the good score equal ‘b’, then:

IF: M2+M3+M4 > 0; *then* M5=a*(R-1) + b*R; *otherwise* M5=b*(R-1) + a*R

This formal statement and the other conditional indicators (E2 and M2) have been written as generally as possible to simplify conversion to code in Excel spread sheets or otherwise.

8.2.7 Computing the API

Examples are now given that feed data into the tool that has been designed – partly this is for clarity so that the techniques in the scoring mechanism can be demonstrated, but also by presenting some data at this stage, segue to the following processes is made more logical. That is, by viewing the tabulated data it makes sense to consolidate it; this is done by taking a normalised average. The examples chosen illustrate this and employ all of the parts of the design given above. The first example is a village from the Kandal case study and the second is from Samlout.

KANDAL												
Livelihood	E1	*E2	= E	F1	+F2	= F	M1	+(M2	+M3	+M4)	*M5	= M
Farmer	10	1.2	**12**	0	1	**1**	10	1	1	0	1.1	**12.2**
Non-farmer	10	1.2	**12**	0	1	**1**	10	-1	-1	0	0.9	**8.2**
Non-farmer	10	1.2	**12**	6	1	**7**	6	0	1	0	1.1	**7.1**
Farmer	10	1.2	**12**	0	1	**1**	10	-1	1	0	1.1	**10**
Farmer	10	1.2	**12**	2	1	**3**	10	-1	-1	0	0.9	**8.2**
Non-farmer	10	1.2	**12**	2	1	**3**	10	0	-1	0	0.9	**9.1**
Farmer	10	1.2	**12**	2	1	**3**	10	-1	-1	0	0.9	**8.2**
Farmer	10	1.2	**12**	0	1	**1**	10	-1	1	0	1.1	**10**
Non-farmer	10	1.2	**12**	2	1	**3**	10	0	1	0	1.1	**11.1**
Non-farmer	10	1.2	**12**	6	1	**7**	10	0	1	0	1.1	**11.1**

Table 8.4: Raw API scores for a surveyed village in Kandal

This village in Kandal has a mix of farming and non-farming households, their livelihood and fuel choice affects the score for the power tiller, M2 – non-farm households who don't collect wood aren't penalised. Also, there are four cases of M5 being switched due to overlapping deprivation of few machine assets. The sub-indices are given in bold in the shaded columns.

SAMLOUT												
Livelihood	E1	*E2	= E	F1	+F2	= F	M1	+(M2	+M3	+M4)	*M5	= M
Farmer	0	0.8	**0**	2	1	**3**	0	-1	-1	0	1.1	**-2.2**
Farmer	0	0.8	**0**	0	1	**1**	0	-1	1	0	0.9	**0**
Farmer	10	0.8	**8**	6	1	**7**	0	-1	1	0	0.9	**0**
Farmer	10	0.8	**8**	6	1	**7**	0	1	1	0	0.9	**1.8**
Farmer	0	0.8	**0**	6	1	**7**	6	1	1	0	0.9	**7.8**
Farmer	0	0.8	**0**	6	1	**7**	0	1	1	0	0.9	**1.8**
Farmer	10	0.8	**8**	6	1	**7**	6	-1	1	0	0.9	**6**
Farmer	10	0.8	**8**	10	1	**11**	10	1	1	1	0.9	**12.7**
Farmer	7.5	1	**7.5**	6	1	**7**	0	1	1	0	0.9	**1.8**
Farmer	7.5	1	**7.5**	6	1	**7**	6	1	1	0	0.9	**7.8**
Farmer	5	0.8	**4**	6	1	**7**	0	1	-1	0	0.9	**0**
Farmer	10	0.8	**8**	10	1	**11**	6	1	1	1	0.9	**8.7**
Farmer	10	0.8	**8**	6	1	**7**	6	1	1	0	0.9	**7.8**
Farmer	10	0.8	**8**	10	1	**11**	6	1	1	1	0.9	**8.7**
Farmer	7.5	1	**7.5**	6	1	**7**	0	1	1	0	0.9	**1.8**
Farmer	0	0.8	**0**	2	1	**3**	6	-1	-1	0	1.1	**3.8**

Table 8.5: Raw API scores for a surveyed village in Samlout

The surveyed households in this village in Samlout are all farmers. There is mixed access to electricity, a lot of charcoal use and few water pipes. Those with generators are not penalised for the expensive electricity (E2), the penalty for M2 is in effect (they're all farmers) and M5 switches in only two cases.

For the Kandal village (Table 8.4), the regional indicators E2, F2 and M5 are 1.2, 1 and 1.1 respectively: the electricity tariff is cheaper than the average in the study ($0.25/kWh vs. $0.33/kWh), gas for cooking is available in local markets and the roads are of good quality. Most of the households have good E1 and M1 scores due to the infrastructure in the village, but F1 scores are noticeably lower due to the lack of adoption of modern cooking fuels.

This village in Samlout (Table 8.5) scores differently to the one in Kandal, there is incomplete access to the electricity grid and at $1/kWh the tariff is more expensive than the average, so too is the price for battery recharging – note that the houses with generators do not receive this penalty. The fuel scores are better as charcoal is more prolific, as are the various engines in M2, M3 and M4, but the overall M scores are lower due to the poor water supply. Here it can be seen that there is compensability in the index as the water pipe infrastructure in Kandal offsets the lack of mechanical energy accessed by the villagers. This is in accordance with the experiences from fieldwork in those locations, that poor access to water in Samlout seemed more problematic (especially in terms of income) than the scarcity of power tillers in Kandal. In these large tables it is possible to see the influence of each indicator; however, as they stand, the tables are too cumbersome for the reader to ascertain the difference between the two villages. At this stage, a use of the data would be to locate households that face multiple deprivations, though this tool is intended to be operated at the village scale so data on these households must be combined to form data on the respective villages.

The simplest way to reduce these tables to an easily digestible size is to take averages of the data. Both arithmetic (mean) and modal averages are demonstrated in Figure 8.2. Mathematically, the mean contains all of the data within the set. The distance from the mean to each data point balances out so the mean lies somewhere in the middle of the data. However, the mode is the most frequently occurring data value, it is more likely to represent where the distribution is centred but in doing this it then doesn't represent the extreme ends of the data set. The two averages achieve different effects and both have their use.

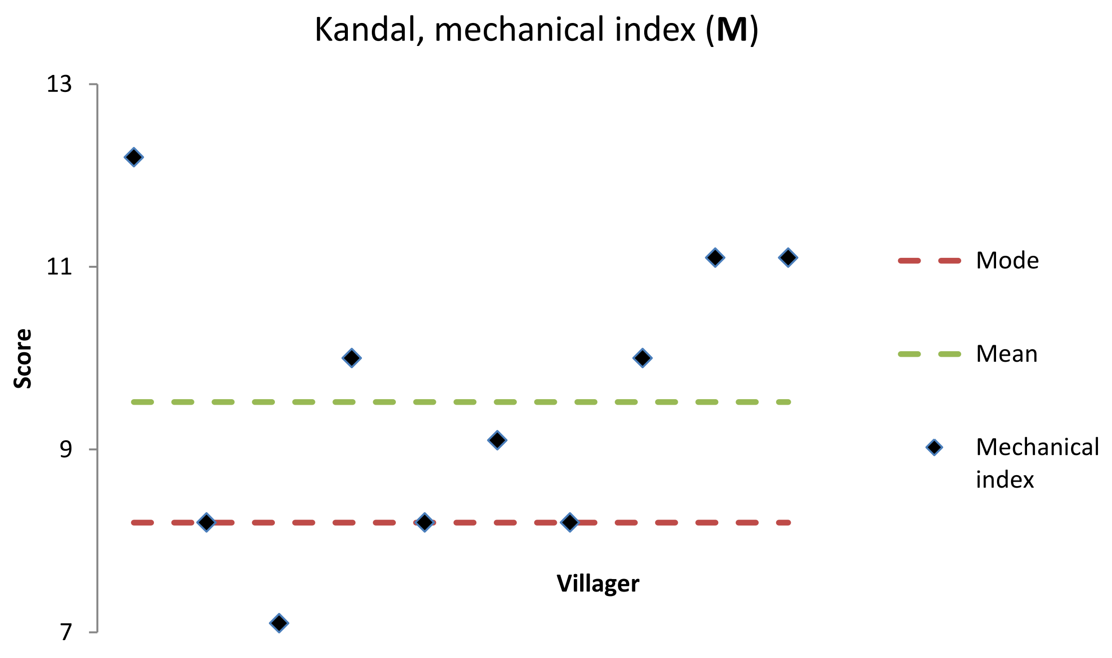


Figure 8.2: Different kinds of average

The M column from **Table 8.4** (above) is represented on this scatter plot; the mean (9.52) and the mode (8.2) are shown in green and red.

In that it contains all the data, the mean represents information from all the associated households. This then relates to everyone in the village, who has either high or low priority for developments in their energy access. Conversely, the mode relates to biggest cluster of data points, so representing information about the most populous group within the village and whether or not this large group has much priority in developments to the access.

With either choice of how to average the index, it can also be normalised in order to rescale values into the range [0-1]. This moves away from the scale which was used earlier for construction. The new scale is just as arbitrary but the benefit is that normalised scores are all within the same scale, so are easier to compare. To normalise, for each element X, the mean or mode $\hat{X}$ is compared to the minimum possible score X^-, and then divided by the range of possible scores $X^+ - X^-$, this is done for all elements with both averages.

$$API^E = \frac{\hat{E} - E^-}{E^+ - E^-} \qquad API^F = \frac{\hat{F} - F^-}{F^+ - F^-} \qquad API^M = \frac{\widehat{M} - M^-}{M^+ - M^-}$$

		Element		
		Electricity	Cooking Fuel	Mechanical
Indicator score	Maximum	12	11	13.3
	Minimum	0	-1	-2.2
	Range	12	12	15.5
Kandal	Mean	12	3	9.52
	Mode	12	1	8.2
Samlout	Mean	5.16	6.88	4.27
	Mode	8	7	1.8
Normalised average		**API^E**	**API^F**	**API^M**
Kandal	Using mean	1.00	0.33	0.76
	Using mode	1.00	0.17	0.67
Samlout	Using mean	0.43	0.66	0.42
	Using mode	0.67	0.67	0.26

Table 8.6: Using averages to consolidate the raw data

The top set of cells gives the possible scores: M^+, M^- and the range for each sub-index. The middle set of cells gives the two different averages for each location and each indicator, notice that for electricity and cooking fuel in Samlout the mode gives a higher score. The bottom set of cells normalise the averages – the difference between the two methods are proportionally most pronounced with Kandal's score for cooking fuels and least with its electricity.

From these normalised values a simple observation is that there is mostly good access to energy in Kandal – let down by cooking fuels – whereas Samlout has weaker access to energy overall but there is better consumption of clean fuels. For a development agency this implies that Kandal is a more suitable target for cook-fuel initiatives such as promotion of electric stoves, but that Samlout suffers from deprivations in all areas so needs a broader system-wide strategy on energy access.

The choice of which average to use should align with the purpose of the index, that is, to direct attention to the location which needs it most. The effect of using the mean would be to incorporate all the data, so being influenced by outliers; whereas the modal average would not be as influenced by extreme cases. Both choices offer some advantage, either in representing the whole village or the largest subsection. For this index, outliers are more problematic in the cooking fuels element – a few BLEN stoves would mask the problems of many wood-burning stoves. Equally, a few wood-collectors in an area when BLEN stoves are prolific could bring the mean down but those wood-collectors may be resistant to intervention – recall that wood collection is often a matter of taste and choice. Conversely, for electrical and mechanical energy, using the mean can capture more about the whole group. In the Samlout example above the grid users are the biggest subset but there are more non-grid users overall and the disparity in the electricity access of the whole group is itself a problem (inequality). As for the mechanical element, there are almost as many households who own pumps as collect water manually but the pump-owners lend/rent them out so it is important to be aware of them. Consequently, the mean will be used for the electrical and mechanical elements but the mode for cooking fuels.

8.2.8 Results of the API

The process above is now applied to the rest of the survey data, this covers 11 villages in the three areas of Kandal, Chambok and Samlout.

	API^E	API^F	API^M
K1	1.00	0.17	0.76
K2	1.00	0.33	0.71
K3	0.98	0.33	0.65
K4	0.93	0.33	0.54
C1	0.55	0.00	0.86
C2	0.52	0.00	0.88
C3	0.52	0.00	0.83
S1	0.43	0.67	0.42
S2	0.37	0.67	0.18
S3	0.42	0.67	0.49
S4	0.38	0.17	0.30

Table 8.7: API scores for the 11 villages

Each component for the API is given for all of the 11 villages, these values are then colour coded: red indicating a low score and a high priority, green a low priority, with yellow in the middle. The colours allow for easier comparisons, they help identify the highest priority areas (red) and those with multiple deprivations (at least two orange cells in a row).

One decimal place serves for the main region-to-region distinction, but two are given for additional fidelity between villages.

From the table it is evident that the foremost priority for energy access development is cooking fuels in the villages of Chambok. The modal average is zero implying that most of them are collecting wood by hand; promoting clean and safe fuels in Chambok is thus a priority in energy access development. However, the villages in Samlout are likely suffering multiple deprivations as they have the worst scores for access to both electrical and mechanical energies of the whole dataset – notably, S4 also scores poorly for fuel access so has an even higher priority for development in its energy access.

Overall, each of the three locations has a comparative advantage, electrical energy in Kandal, mechanical in Chambok, and cooking fuels in Samlout – though Chambok's lead in access to mechanical energy is slight since Kandal also has some water pipes. Also, Samlout's scores for fuels are only on the medium side of high: the weightings in the API prevent this comparative advantage seeming too advantageous – their access to cooking fuels is still problematic. Conversely, in Kandal the electricity scores are maximal, grid coverage is almost complete and the tariff inexpensive so, at least in terms of supply, there is seemingly little need for intervention. Likewise in Chambok, the high mechanical scores are testament to the water-pipe intervention that has already occurred and had successful impact. Yet the non-maximal score implies that there are still small deficits in mechanical energy access. Thus, the API gives an indication of what areas of access are strong and weak with respect to each of the locations studied.

Though the tool successfully gives a sense of priority, it needs support to produce a clear picture of energy access. For instance, on the demand side of electricity or further details on fuel behaviours – recall though, such quantitative methods were demonstrated in chapter 6.

The API tool will be demonstrated again in the next the chapter alongside those other techniques of chapter 6. That demonstration will show the symbiosis of the API tool to the qualitative indicator constructed below. For now, conclusions are drawn upon the design of the API.

8.2.9 Conclusions on the quantitative tool

The API has a simple objective: to gather data, quickly, which addresses the important parts of energy access and present it in such a way as to identify problematic locations. The tool relies on surveys and local research agents. With this method, nine indicators were evaluated that point towards deprivations in energy access over several locations.

Evidently, more indicators can supplement this set. I had considered using mobile phone reception, the numbers of light bulbs in the household or an audit of local markets as indicators – though I chose not to as testing such indicators is only a subsidiary task of the chapter, the dominant purpose here is to demonstrate the mechanisms by which indicators can be combined. Mechanisms are more generalisable than specific indicators. As it stands, this tool is functional and fits its purpose but the surveys were quite short so it is probable that more indicators could be added for added comprehensiveness or to suit the requirements of the agent applying the tool.

The main point of discussion was to demonstrate how different indicators can be combined into a tool with a transparent and subjective scoring mechanism. Though potentially a weakness, subjectivity is the strength of the tool. With subjectivity in the foreground, the scores were chosen not in an arbitrary manner but well-informed on the basis of communication with people in energy poverty. In any construction process there are subjective decisions about what indicators to use, how to gather data for them and how to manipulate it (Bhattacharyya 2012, p.261)(Patterson 1996). So, making judgements on values to assign to that data is legitimate and it still allows for robust data gathering. Furthermore, the scoring system can be fine-tuned with participation of the energy poor or other actors who would use the tool – ensuring that the tool is indeed indicating the priority areas where intervention can have most impact.

8.3 The qualitative tool

The motivation for constructing this tool is so that the more qualitative methods can be incorporated into an assessment of energy access. To function as a robust tool, these qualitative methods need to be built into a solid mechanism with clear guidelines like those for the API in 8.2. This section provides that protocol: essentially, the semi-structured interview technique with analysis organised by a framework built through participation.

The API above only provides superficial detail; it uses proxies for its indicators to reveal probable deprivations in energy access and thus suitable targets for development initiatives. However, the tool focuses on assets, so responses would likely be biased in the same material vein, for instance, an intervention to promote solar cells as opposed to teaching people how to use electricity. Accordingly, this qualitative tool is complementary. It uses a more interpretive analysis to deal with the social side of energy access, essentially, how people are using or want to use those assets. The way that this tool is married with the one above is demonstrated in the next chapter. Discussion here covers the design of the tool. This Qualitative Access Tool (QAT) is then applied to a particular intervention – biogas digesters – to exemplify how the tool operates.

8.3.1 Methods

The methods behind this qualitative tool were given in full in Chapter 5: semi-structured interviews and qualitative analysis to identify key themes, backed up with auxiliary methods that draw from an ethnographic style or research. This subsection generalises the construction of the QAT and links it to the methods of data gathering for the API.

8.3.1.1 Data gathering

Surveys and interviews are mutually supportive. The API draws data from surveys and supports that with details from interviews. Conversely, the QAT uses those surveys only to locate suitable candidates for interview – and it is the interview which is their main source of data.

The selection of participants (from survey data) is such that there are several interviewees associated with each part of the analytical framework. For each element (electricity, cooking fuels and mechanical energy) numerous interviewees are sought with the specification that some of them present evidence of ‘lower’ energy access and some with ‘higher’: for example, a grid user and a battery user. Thus, the maximum variety of different types of energy access in that location is studied. As much as the questions about their energy assets, the survey question on livelihoods is also an effective means of finding hitherto unseen methods of accessing energy. The semi-structured nature of the survey allows for new methods of access to be studied in detail.

The intention of this data gathering is to attain some cross section of energy access in the area. That is, speaking to enough people to be fairly sure that most methods of accessing energy have been observed; however, due to the rapid nature of the appraisal, this cross section can only ever be partial. The representativeness of this cross section is proportional to the quality of the analytical framework as it is that framework which guides the selection of participants and questions posed to them. In a rapid study it is nigh inescapable that the dataset won’t cover every detail. The objective is instead to use the surveys to estimate the scale of a deprivation and the interviews to gain an in-depth but timely assessment of that deprivation in energy access, with sufficient detail to plan intervention.

8.3.1.2 Organising analysis

The four aspects of energy access (performance, appropriateness, convenience and resilience) are used as a set of cross cutting themes to interrogate the main forms of energy used in the home (electrical, cooking fuels and mechanical energy). This is the basis of the QAT, to present findings from semi-structured interviews organised according to those aspects. The four aspects emerged during the dialectic processes of gathering and analysing data. They are flexible and not entirely distinct – the intention is that they represent the multidimensional complexity of the phenomenon (energy access) and encapsulate the main findings. With this, it is possible to use qualitative analysis in a comprehensive and rigorous way to make coherent conclusions on the issues within energy access. The function is the same as that of an indicator: describing the phenomenon, communicating details of a particular case and providing grounds for corresponding decisions to be made.

In the following subsection, the four aspects will be used to highlight the significant issues of energy access relating to biodigesters. This topic is chosen because it is separate from the full demonstration of the appraisal tools in the next chapter and it provides grounds to demonstrate the functioning of the QAT. The four aspects are given again to facilitate understanding in the following analysis. Note that each of the bullet points here is to convey a sense of what the aspects embody rather than constituting a precise definition of that aspect.

Appropriateness
- Affordability by poor villagers
- Compatibility with traditional behaviours
- Suitability to local environment
- Fitting technological sophistication
- Participant satisfaction

Performance
- Variety of energy services that can be accessed
- Extent to which services meet basic needs
- Effectiveness and efficiency
- Power and empowerment

Convenience
- Time taken to access energy services
- Timeliness of access
- Distance from power source to the point of use
- Effort involved on behalf of the user
- Regularity of maintenance or upkeep

Resilience
- Safety, risks and health concerns
- Environmental damage
- Seasonal weaknesses
- Fragility of the energy system
- Resistance to accidents or externals shocks

This is a copy of Figure 7.1 given in the previous chapter to refresh the reader on this thesis' meaning for the aspects.

8.3.2 Presenting findings

In the following table findings are given from the data on biodigesters that relate to each aspect of energy access. This shows how the tool conveys information. For an application of this tool onto a subject wider than biodigesters, these four aspects would be used for each component of that subject (for example, each of the elements of energy). The table summarises the QAT. For instance, the performance column details the energy services that the digester enables – the rest of the content relating to that aspect is given below. Similarly for the other aspects, the main points are summarised here and elaborated in the text beneath. The selection of content for this summary is highly subjective but as with the API, this actually strengthens the tool. The choice of what goes in the summary reflects what was significant in interviews with energy users – though it must pass through the researcher's analysis, it conveys the voice of participants in what they feel is important enough to focus conversation on. This does lessen the likelihood of agreement between measures but that is implicit in a dataset drawing from semi-structured interviews.

Performance	Appropriateness	Convenience	Resilience
Biogas cooking: *quick, easy, effective but limited gas*	Fits in with the farming livelihood (manure for slurry)	Less travel than with collecting wood and no chore of drying it	Clean burning fuel (indoor air pollution and environment)
Biogas lighting: *soft, warm, fewer insects*	Return on investment within a year	Cooking and lighting services are quicker to access	Independent biogas production and trading of manure
Slurry fertiliser: *high quality, easy to use*	Non-users are resistant to 'dirty energy'	Can't stockpile gas so must continue to feed it	Continual labour and manure requirement to maintain operation

Table 8.8: An overview of the QAT relating to biodigesters

Each column gives a summary of the biodigester with respect to each aspect of energy access. These statements emerge from discussion with rural users.

The four aspects are expanded upon in the following subsections.

8.3.2.1 Performance

The primary functions of the digester are to produce biogas and slurry fertiliser. This enables the energy services of cooking and lighting, and it improves farming livelihoods by allowing organic agriculture. Biogas flames are hotter and more controllable; the lighting is also softer. The slurry fertiliser is easier to spread than solid manure, has better nutritional value and contains fewer unwanted seeds. Cooking, lighting and providing fertiliser are not energy services exclusive to the digester but with that asset their performance is better than without it. It requires less from the user and effects a better result.

> The slurry can improve their livelihood can improve their rice production, before just meet household requirement, only sell to the market 50 000 riel ($12.50) per year, but recently she can get the benefit 9 million per year – Interview 8, Kampong Speu

In this case rice agriculture improved from subsistence to a substantial income stream. As for the fuel, the technical performance of biogas is let down by its limited supply – digesters are geared to provide for the consumption of a single household so any demand over that usual rate must be satisfied with another energy:

> He only use the biogas for cooking, he use wood when the household have a party or another ceremony. For just household requirement there is a surplus – Interview 56, Kampong Speu

In terms of the quantity, the digester can provide too much fuel. Some households use the excess for lighting though others prefer to use electric lamps. Users who produce surplus responded with interest in selling the biogas onwards if they had a device to do so.

8.3.2.2 Appropriateness

Overwhelmingly households responded that the high price of the digester was why they hadn't invested; though a minority said they didn't have the land for the asset itself or the spare labour for animal husbandry. Digesters are priced at $200-300, so their return on investment is within the space of a year if the household would otherwise purchase wood. For wood-collectors this doesn't apply, though as implied above, the effect of the bio-slurry as a fertiliser is more than enough to repay the investment within the space of a single growing season:

> Me: Does she still think that the digester was a good investment?
>
> Them: She use happily with the digester, she keep thinking it is a good investment for the household because she can get the gas for cooking and she can save a lot of fertiliser per year, can mix the slurry with the rice hay and kitchen garbage, it can change them into a good fertiliser ... if not broken, will use forever – Interview 67, Takeo

The change in attitude of long time users was to have far greater esteem for the digester, they realised its worth over the course of several seasons. These long-term users responded that they would be willing to pay more implying that investment is a matter of confidence. This issue especially inhibits spending in this context as the cattle which feed the digester are also the savings which might pay for it. A farmer thus needs to accrue a surplus and invest it in an asset which, at that point, is unproven but non-refundable.

For farmers who do adopt the digester, operation is symbiotic with animal husbandry. Also farmers in Cambodia traditionally use manure as fertiliser and none report slurry use as problematic, though some won’t use biogas as a cooking fuel. Whilst this current biodigester design is appropriate for farmers, it is only appropriate for them, that design uses manure and no other biomass. By tradition, the majority of rural households engage in animal husbandry but this particular application of biogas technology does exclude those who don’t.

8.3.2.3 Convenience

The digester is a highly convenient way to access energy for cooking. Users are not required to buy additional fuel, the gas outlet is part of the kitchen and the flame ignites and heats up quickly. This makes it easier for users to cook in a timely fashion and they can leave the stove unattended because the fire sustains itself. Also fuel collection is eliminated:

> Me: What is the most important benefit of the biodigester?
>
> Them: He explain the main important thing is saving time, can spend the time for [working as a] tuk tuk driver, if he don’t use digester have to spend the time to collect wood, he cannot earn another living – Interview 47, Kampong Speu

The freedom of time is highly enabling, in this case allowing for a whole other livelihood. The fuel access here also relates to the freedom from ensuring that the household has an adequate supply of dry wood. One villager stated that there were fewer arguments within the household because this cause of antagonism was removed. Collecting wood is an arduous task; using biogas is quite simply less tiring.

Whilst it is quicker to collect manure than wood, a problem with the digester is that fuel cannot be stockpiled to the same extent. This means that feeding the digester is a continual operation. The manure itself can be stored before being fed into the digester but this wastes methane. The slurry fertiliser can be stored but this takes up a few square meters of the residential land – the user also need to build suitable shelter else the nutritional value decays.

8.3.2.4 Resilience

Biogas is a healthy (smokeless) cooking fuel, sourced cleanly from the environment in a decentralised fashion. This means that users are less susceptible to respiratory diseases than if they used cruder fuels and less vulnerable to external changes in fuel supplies. Biogas is evidently volatile so some risk remains but no accidents were reported.

The benefit to the environment is ostensibly proportional to the amount of manure that is digested, minus any leakage from households with surplus. Significantly, the digester reduces the footprint of animal husbandry which is vital in light of the growing demand for meat in South East Asia (Hansen 2012).

Storage of biogas is determined by the volume of the digester, thus supply is limited. However biogas can be deemed a comparatively resilient supply due to the dampening effect of the rainy season. In this time wood is wetter but the digester still produces usable fuel. Moreover, a supply of manure can be acquired from various sources:

> He doesn't have any cattle so he have to buy manure from another household to support the biodigester … he have to buy around 7kg of manure for the digester... [costs $0.63 per day] – Interview 25, Takeo

Whilst the digester household can avoid rearing animals it must still happen in the area and that is ultimately limited by water access and pasture grounds.

For lighting, using an energy source which is decentralised gives some level of self-sufficiency. However, the lamp in which the gas burns is fragile and prone to breaking – this reduces the resilience of this method of accessing energy, particularly in busy spaces or areas prone to adverse weather.

Overall the system is highly effective in improving the users' health, principally from the clean burning fuel but also from the more nutritious, organic vegetables that can be cultivated. The weaknesses in the system are that villagers use cattle as their savings, so in financial crises the digester becomes inoperable, also the labour requirement is consistent so temporary shortfall here impinges upon fuel security.

8.3.3 Conclusions on the qualitative tool

In its application above, the QAT expresses how villagers' energy access is affected by a biodigester. At face value, this can be used to understand the impact of the digester in the associated areas and also estimate the effect it could have if digesters were proliferated elsewhere. Beyond that, the findings presented can inform decisions about how to promote and market the digesters in the future, or alternatively, how to redesign the digesters to be more attuned to meeting the users' needs. For instance, the decision to invest in the digester is tied into the initial cost – but the system reliably generates more value than this in the space of a year. So, giving potential users the confidence that they will earn a return on investment, or providing them with some guarantee, is the key to increasing their willingness to invest. Equally, constraints can be identified in the operation of the system, specifically in the land, labour and manure needed. With an awareness of these, an actor such as SNV could increase the operation of biodigesters (and thus the environmental gain) by formalising a system of manure sharing in a village so that more people can use the bio-slurry and more methane waste can be captured as a cooking fuel.

In my fieldwork, the qualitative interviews uncovered a narrative of energy access, the findings taken from that were organised into the above format as it is concise and intelligible. This tool does lack some of the robustness of the API – if another researcher were to approach the same case studies they may bring back different findings or recommend different aspects of energy access. However, though discussion here is based on my particular interaction with the people in the cases studied, the findings are nonetheless meaningful. Moreover, that meaning is not unique to my interpretation. It is information shared by many rural energy users, and it represents underlying patterns in energy behaviours which are common to enough of those people for me to have certainty in sharing them as findings.

The QAT has a descriptive and analytical function. It still gives an indication of the priority in energy access developments but in terms of specific issues rather than locations. It does this by getting closer to what energy access means in terms of its relation to capabilities and poverty. This is a more sophisticated discussion than ‘better’ or ‘worse’. It is more helpful in understanding energy access from the side of the villager as it is with their perspective in mind that the tool was constructed. It is dialogue with rural participants that both constructed and fed into this qualitative tool. The intention is to communicate, in the most fair and comprehensive way, issues that those people feel the need to talk about on the subject of how and why they access energy.

Through this approach, with its social awareness, the complexity of energy access can be conveyed. This is both in the spectrum of opinions and the subtleties of behavioural change. Such an understanding is not possible to convey with a focus on the physical underpinnings of energy access. It is the social attributes of energy access, just as much as their physical counterparts, that development initiatives seek to address. Essentially, energy is harnessed to make things easier for the user, and without dialogue *with* users on what they can do and what makes things easier for them it is impossible to appreciate this.

8.4 Overall conclusions

The underlying theme of the discussion chapters has been that quantitative and qualitative approaches to the field are different in what they represent; as approaches to constructing tools they play different roles. Chapter 4 saw their distinct applications, however, they are not incompatible and indeed each benefit from combining their comparative advantages. In terms of employing these approaches, the motivation was to exploit their advantages such that they make the best aid in planning and policy making. For each tool separately, this has been shown, in prioritising development to a particular case study in 8.2.8 or in the impact assessment of biodigesters in 8.3.3. The synergy of the tools is shown in Chapter 9.

The tools were constructed as such because the quantitative approach lends itself better to identifying and communicating what is going on and where. Equally, the qualitative approach tells more about how or why those events are occurring. These are both important processes; this chapter has described how they can be made fit for use in the field of studying rural energy access.

The quantitative tool is one of mapping: it simplifies the broad scope of energy access and, given a set of locations, pinpoints the areas where there are likely to be problematic issues. This is a superficial comparison, it does not specify what the exact problem is but rather draws attention to where to look for a problem. For this reason, the API is not condensed further into a single value as that would detract from its function. It is not meant to form a linear ranking of villages; rather, it produces an array of data that still relies on low and high scores but in separate components that do not compensate one another. It makes a judicious reduction, enough to distinguish the villages, establish a sense of priority, but not to lose too much fidelity or detail in what it represents.

The qualitative tool is a counterpoint. It is still a process of reduction, taking only the essential information, but the data input is broader (more methods) and so the output can then better inform decision making or impact assessment. The thrust of chapter 7 was that there is a lot of information to do with energy access that comes through the qualitative approach and that it is very significant. The tool here organised that information, making the salient issues more intelligible. This allows that significant information to be conveyed simply, though it does not compromise that significance by reducing it to too small a size. Thus, the QAT does justice to the complexity of energy access. Moreover, the tool operates with the awareness that energy access is so much dependent on the person accessing that energy. Crucially, it is they whom this tool addresses.

9 The appraisal of Samlout

Picture 9.1: The Samlout province in Cambodia

9.0 Introduction

This chapter demonstrates the appraisal: a combination of the two tools and approaches from the previous chapters. The appraisal is applied to four villages within the Samlout region of Cambodia. Content here can serve as a standalone case study on energy access demonstrating the methods I designed; for that reason, it contains some methodology so that the procedure is transparent and, hopefully, easy for future researchers to replicate. Overall, it showcases the tools and also the styles of analysis seen throughout these discussion chapters. Thus, the tools are embedded in report with additional statistics and description. Ultimately, that report allows for conclusions on energy access advancing from the more methodological concerns of Chapter 8.

The initial results presented are the API for the four villages. These scores show what deprivations the villagers are likely to face. Based upon those scores, more focused quantitative study is undertaken, drawing from the approach in Chapter 6. Discussion exemplifies how surveys link to interviews. Then, interview extracts are given to appreciate the nature of particular villagers' energy access, akin to the approach in Chapter 7. Finally, the QAT is applied. This represents energy access in terms of the four core aspects: performance, appropriateness, convenience and resilience, for each of the forms of energy: electrical, cooking fuels and mechanical (including water). Overall, this report, and the tools within, form a detailed indication of the state of energy access in Samlout and lay the groundwork for the planning of useful intervention.

9.1 Procedure

I spent six days in Samlout, during this time I enlisted chiefs from four villages to carry out the surveys. Two of these village chiefs were interviewed themselves. They took three days to complete their task and returned 47 of 50 the surveys I gave to them. From these surveys I conducted eight follow-up interviews and a further nine household interviews. The choice of these nine was not influenced by the chiefs; I sampled by opportunity or by seeking out specialists in the village, such as the mechanic and the household that charged batteries. Additionally I interviewed a representative from the school, hospital and pagoda.

Interviews: 8 follow-up, 5 specialists, 4 opportunity, 3 community buildings, 2 village chiefs Total = 22 (+47 surveys).

9.2 Applying the API

	API^E	API^F	API^M
S1	0.43	0.67	0.42
S2	0.37	0.67	0.18
S3	0.42	0.67	0.49
S4	0.38	0.17	0.30

Table 9.1: The API for four villages in Samlout

Notice that the colour coding differs from that in Chapter 8. The value of 0.67 for the cooking fuel element is now the highest; those cells are green as API gives them the lowest priority.

This table gives the API as calculated by the method set out in the previous chapter. Recall the use of the modal average for cooking fuels – this comes at the cost of fidelity in the sense that many villages attain the same score, but it reaffirms that most common behaviour of using charcoal.

Electricity

Interpreting these results, the element of electricity is of moderate concern (the cells are yellow) and there is little to distinguish the priority for intervention between villages. The difference is probably that villages 1 and 3 have a few more household connected to the grid or with generators. Overall the access for that element seems quite poor (low scores) and so it is to be expected that most villagers are deprived of high demand electrical energy services such as pumping, cooking or refrigeration. Thus, intervention with electricity that targets all areas is of medium priority – important but not necessarily in the short term.

Cooking fuel

Scores for fuel access are fairly high in villages 1-3; there is low priority to address their fuel behaviours (green). Conversely, village 4 scores very low – rather than charcoal they are mostly using wood. Access to cooking fuels in that location is the highest priority issue (red) due to the risk of respiratory diseases. An obvious solution would be to promote BLEN stoves or to at least find out if or why access in village 4 differs with the other villages.

Mechanical energy

Here the difference is clearer. In particular, village 2 stands out as a priority (red). People in that location, and to a slightly lesser extent village 4 too (orange), are likely more reliant on their own physical effort in the transport of water. This drudgery is a cause for concern though extent of that is to be confirmed by studying the proximity of water sources. Again, village 3 scores relatively high in this element, people there likely have their own pumps or other machines. Overall, intervention here is of medium priority but specifically in villages 2 and 4.

The above is a basic reading of the API. The tool serves to indicate priority: region-wide intervention with electricity and water, and specific intervention associated with the red cells. Suitable action is to carry out further study into the differences between the high scores of village 3 and the low scores of village 4 in order to help plan those interventions.

By focusing analysis on the seemingly 'better' energy access in village 3, it is possible to learn what poverty mitigating capabilities are enabled through their access. This comparing this to the access of people living in village 4 can allow the understanding of what is, or is not, problematic with their energy access. This targeted study uses techniques that were visible in Chapters 6 and 7, giving the quantities and qualities of their access.

9.3 Targeted study

This more in-depth analysis is not part of the API or QAT. It links them but is separate from those tools – it functions as the report in which they would be embedded. This chapter section gives data from the surveys and interviews that are not directly visible in the output of the tools; the level of detail it provides is greater yet not absolutely necessary for some stages of planning, that is, the conclusions of the tools. Study here relates more to the granular complexity of people's energy access, giving the fuller picture rather than an indication.

9.3.1 Village 3: High energy access

Village 3 scored highly in the API; their survey data is given below. It shows consumption of the different forms of energy and also stacking of different methods. For comparability, consumption is in dollar terms. Totals are in the rightmost columns. Data on electricity, cooking fuels, water provision and machine access is shown; this follows the divisions of analytical framework.

Household size	**Grid**	**Generator**	**Battery**	**Gas**	**Charcoal**	**Wood**	**Pipe**	**Pump**	**Well**	**Mill**	**Power tiller**	**Vehicle** (moto)	**Total** (monthly)	**$ / person**
3			2.5			-			-				2.5	0.83
8			3			-			-			18.8	21.75	2.72
6			5.55		11.3				-		8.23		25.03	4.17
4			3	8.75	8.75			6.25				7.5	34.25	8.56
***5**			**3**		**-**			**6**		**22.5**	**6**	**10.5**	**48**	**9.6**
3	5				11.3	7.5		12.5				0.38	36.67	12.21
***1**			**5**		**6**			**3.75**					**14.75**	**14.75**
***7**		**42.5**			**7.5**	**-**		**11.3**			**22.5**	**50**	**133.8**	**19.11**
3			1.5			-	9.75				37.5	18.8	67.5	22.5
4			3.75		13.5			6.25			33.8	37.5	94.75	23.69
3	15			2.5	8.75			15			18.8	18.8	78.75	26.25

Table 9.2: Survey data from village 3 in Samlout

Data in this table has not been condensed, just converted to a common unit. Here it is possible to see stacking and the amount that each villager spends (in $/month) on the various methods of accessing energy. Cells are left blank where the household does not carry out that method and a "-" is given when they do but that method is without cost. The far right columns give their total spending per month, and their spending per person per month. The households of size 5, 1 and 7 have been highlighted to indicate that it is these who were chosen for follow-up interviews.

Spending is colour coded in the table: hue relates to the form of energy and tone to cost, darker meaning more is spent. It is easy to see that the generator is almost the highest figure for spending, yet other than that, the costs of electricity are almost the lowest in the table. The households are arranged according to the per person monthly spending on these energies; it can be seen that the households who collect their resources are more likely to be in the lowest per person consumption bracket, but that higher consumption households are more affected by their spending on engine fuel as they all own power tillers and motos.

Taken at face value, the table shows which elements of energy access are more expensive for the user, it also shows which users spend more and which methods are the most common. Recall, the motivation of participant selection is to find how the various ways of access energy can be linked to capabilities and poverty. So, various methods of access are sought for follow-up interview, these are detailed below.

Picture 9.2: The façade of a more expensive home

The design of this household uses modern materials, it is easier to clean and cooler, though the lady living here chose the design for its aesthetics.

The generator household was chosen for a follow-up interview. The generator, power tiller and the level of consumption in the household implies that they are likely representatives of high energy access in the village.

The household is wealthy. The ceramic tiles and glass used in their house are indicative of this, as are the electrical assets on display. The household's daily expenditures total to $20 (including non-energy spending) – this is more than anyone else in the area. Consequently, they also represent affluence in rural energy access.

Through interview, this household signified high performance and resilience in their energy access: they own their own a pump, power tiller and dynamo so are able to satisfy most of their energy needs through the assets that they own. However, when talking to the mother of the family I found that this energy access is uneven, only the men of the household can start the generator – she explained what this meant to her:

> Me: When does she use the fan?
>
> Them: I use the fan only at night, because in the afternoon we do not start the machine.
>
> Me: What time in the afternoon do they start the machine?
>
> Them: At six in the evening.

> Me: If she cannot use the machine, does it make a big difference to her lifestyle – when the men are not here and she cannot start the machine?
>
> Them: Is not very difficult when we don't have electricity, because normally we use candle, we think electricity is very important only when we have some guest or a special occasion.
>
> Me: Is there anything that they use electricity for other than the special occasion?
>
> Them: Normally we use a lot of electricity power like some people are sick in the house so we have to stand by the light for a long time, or when we have guests we have to stand by the light – Interview 103

She could only use electricity from six in the evening and when the men were around. This is an inconvenience to supply, but as she explains, electricity is not vital day-to-day. Other electrical vectors might give them more timely supply but the household chooses to use the generator only. Moreover, their supply is reliant on the stability of fuel prices; this makes them vulnerable as their other behaviours depend on the power tiller which also uses fossil fuels.

Assuming that they do have fuel in the household, their energy behaviours are effective, if a little expensive. Being able to use electricity to give lighting through the night is not guaranteed with a battery, nor is it possible with the grid during blackouts – this is a significant advantage of the generator in the case of emergencies. Thus this household is highly resilient but only to the extent that their fuel supply is safe and that their power tiller is in working order.

The second household was chosen because they produced charcoal and owned a rice mill. As with generators, such assets are rare and I needed to learn about the workings of that livelihood in this village. The miller explained that she could make a 20 000 riel ($5) profit per month with her mill and as a by-product she had a supply of rice flour that could be used as feed in her pig husbandry. So whilst the rice mill only has one function, it enables many capabilities due to the rice, flour and husks it outputs. The $5 profit is quite a slight income per month but the lower costs of raising pigs gave this household a comfortable livelihood.

She also explained her traditional method of charcoal production, the essentials of which have been passed down through the generations:

> We use semi-tractor to collect the wood ... then we put the wood in the hole [indicates size to be $3m^2$], use the banana tree to stake around the hole, maybe a meter high, then we take the grass to cover it ... when we burn the wood we use the time approximately one hour, but after that one hour we take the land to cover it and we wait for four days till the charcoal can be used - Interview 105

This burial method is not as clean or efficient as kiln techniques (Kattel 2015) but it is nevertheless effective. For 15 days' production they can make 30 sacks of charcoal, enough to last a single household over a year. Although production takes significant labour in the short term, it is a low-cost investment which provides them an ample supply of fuel; moreover, this is a fuel that burns cleaner than wood, thus boosting the convenience (labour saving) and resilience (health benefit and fuel storage) of their energy access. Notably, though this household has a decent income for the area, they only reported average use of electricity through a battery.

The final follow up interview was chosen because it was a household with just one member; this is unusual and so deserves attention if the appraisal is to communicate all states of energy access across the village. The respondent in this case owned a shop by one of the main roads through Samlout. Her shop is a general store – the local economy is too small to accommodate a specialist retailer. The shop doubles-up as a communal area akin to a café, people buy food and drinks from her and consume them on the premises.

To encourage this, her shop had a light and radio powered by her battery, so part of her retail was the energy services of those devices[5]. As her shop is run out of her household, her survey responses indicated a relatively high level of consumption; indeed, she used more electricity and proportionally more charcoal than bigger households. On her own, she would not consume that much energy, but she did as part of her livelihood:

[5] This behaviour of interviewee 104 was noted in Chapter 7, page 217

> Them: I sell coffee for drinking, is why one day I use about 2kg of charcoal ... when I have more customer to come here I use the light to 8.30pm or sometimes 9, but normally if by 8 I have no customer, I turn off
>
> …
>
> Me: What difference does it make using the battery light?
>
> Them: When I get the battery I am more comfortable with my business. When I use the candle and it is getting windy the candle can blow off but with battery light it is no problem – Interview 104

Speaking to this villager brought out more depth to the figures for her energy access. Her domestic consumption is nearly inseparable from her business consumption; the larger battery that she uses because of her work is part of the energy access of her home. Immediately this has implications for data gathering, more generally, it raises questions about the line between the home and business.

Picture 9.3: A small/medium sized village shop

Customers relax here; it is her shop and her household.

If she could afford the grid, the retailer said she'd use it for a refrigerator; currently, she has to import pre-frozen ice and store it in cool boxes. The energy service of cooling is rare in villages and only really viable through these outlets, usually in the form of a cold drink. Due to its rarity, the survey didn't ask about this energy service but it can be studied through interview.

Through these interviews the survey data in the tables is given more depth. This reveals more about behaviours behind consumption figures. For instance, the relatively poor retailer who consumed a lot with her business, the wealthier miller whose household used very little electricity and the very wealthy household with unequal access internally. The varied behaviours of these households is characterised through the qualitative approach and some story is attached to the numbers. Seeing how they each access different energy services crystallises an image of energy access in the region, at least from the angle of high consumption. The next subsection focuses on the lower scores from the API.

9.3.2 Village 4: Low energy access

The table lists categorical and quantifiable data, again, mimicking the style of Chapter 6. It is extracted from the four interviews conducted in village 4.

Interview #	107	108	109	110
Household size	2 adults + 6 children	2 adults + 2 children	6 adults + 6 children	5 adults
Livelihood	*Farm*: rice, soy bean, corn	*Farm*: green bean and soy bean. *Retail*: food	*Farm*: rice, soy and green bean	*Farm*: green bean. *Production*: charcoal.
Daily expenditure and main costs	$4.25: school, food and travel	$5: food	$7.5: food, coffee and tea	$3.75: food
Electricity supply	Battery	Battery	Battery	Battery
Lamps	1	2	3	1
Other devices	Mobile, TV and VCD player	None	Mobile and VCD player	Mobile and VCD player
Fuel type	Wood	Charcoal	Wood	Mostly charcoal, some wood
Fuel source and collection	Forest, gathered by power tiller	Purchase from nearby neighbour	Farmland, gathered by power tiller	Produce themselves
Fuel storage	20 days' worth	(no data)	15-20 days' worth	10 days' worth
Water	Hand pumped well	Collect from pond behind house	Pump from stream using power tiller	Hire someone to pump from stream
Cleaning method	(no data)	Boil drinking water, filter water for soup	Boil for tea. Use filter or rainwater for drinking	(no data)
Vehicle	Moto	Moto	Moto	Moto and bicycle
Other engines	Power tiller	None	Power tiller, tractor (hire), soy bean mill	Power tiller

Table 9.3: Data extracted from surveys which were then followed up with an interview

Interviews 107 to 110 were conducted in village 4 of the Samlout region; the table contains data extracted from them. It is split into five sections: general household information, electrical energy, cooking fuels, water provision and other mechanical energies. Unlike Table 9.2, this is not numerical data on consumption yet it does accord with the style of chapter 6 by breaking down each topic and classifying behaviours within them. For example, the table lists the assets owned by the household, the resource upon which they rely and methods of acquiring them.

The table provides details as a counterpoint to the priority scores given earlier. The API indicated that village 4 was likely in need of development in their electrical and mechanical energies, but most of all in their access to cooking fuels. As can be seen, collection of wood is indeed the most common behaviour. Three of the four households use this crude fuel, though one of them stacks it with charcoal. This prompts study into these people's energy access to understand the consequences of using wood, surface water sources and batteries. The wood collectors I spoke to described that the availability of wood fuel in Samlout is not a problem. The area benefits from a community protected forest scheme so woodland areas have plenty of dead wood lying on the ground that is legal for consumption. However, there are problems of deforestation from encroaching farms and unmanaged charcoaling activities, also, historically land mines have been sown in the area but this threat is receding with aid from NGOs. An issue remains in physically difficult the task of acquiring sufficient fuel for domestic consumption:

> Me: You collect wood, where from?
>
> Them: We collect the wood from the forest, is very far from here. If we walk we have to spend the whole morning. Before we carry by our hands but now we have semi-tractor so is easier
>
> Me: Is it easy to pay for fuel [diesel], can you afford it easily?
>
> Them: It is easy for use to afford the fuel
>
> Me: When you go to collect the wood how many people do that?
>
> Them: Sometimes 3 maybe 4 people
>
> Me: Do you spend all day doing that?
>
> Them: A whole day
>
> Me: How long does the wood last for?
>
> Them: On average we can use for 20 days
>
> Me: How do you cut the wood?
>
> Them: When we take the dead wood from the forest it is big, we bring it here and cut it smaller. We use the big saw to cut it, then the axe to make it smaller – Interview 107

The quantity of wood that can be collected is not a problem but it is a large task to collect it. Before it is usable it takes preparation, every few days the father and son would chop the logs to sticks which can be burned in the stove. In total, these tasks are a noticeable drain on the household's time, yet, the way in which the collection and chopping fall into routines mitigates some of the problem. Though it takes many of the family a whole day to get the wood, this is infrequent – nevertheless, it still interferes with other jobs or schooling. The chopping is a small task and as it occurs in the home it can be fit, conveniently, around other chores. Notably, the labour involved is hard to quantify: small tasks may be uncounted and larger tasks may be a day's work for many people, but that doesn't equate to a definitive number of hours. Another issue is the mechanical aids they have to help them in collecting wood: the semi-tractor to haul it and a saw to cut it. Without these there is acute drudgery; mechanical energy is relevant in alleviating this but the extent it does depends on the user.

Overall, the households in this village had poorer access to water supplies. Closer to the centre of the region, water wells were more frequent and villagers would lend pumps to one another to access them. Here pumping was less common as indicated in the API scores. Perhaps because village 4 was less densely populated or the people couldn't afford pumps themselves, they would collect it manually or hire in the service of pumping:

> Them: I get the water from the stream, I hire someone to pump for me. When we hire they just carry their machine and start to pump for us
>
> Me: Would she get her own pump or is she happy just to hire the labour?
>
> Them: I want to get my own it is easier, but the problem is the money – Interview 110

This implies that villagers in the area are paying more for their water, since they are also paying for the labour to pump it. Though, they tend to be pumping upstream from the same sources as the other villages so the quality is likely no worse. Nevertheless, it is surface water; accordingly filters have been promoted in the region. These function effectively but not appropriately as they aren't compatible with how the people want to use them:

> Me: Does she use the water filter anymore?
>
> Them: It is not broken but I stop using it for a while because normally we are not at home. We go to the farmland for a while and we boil our water – Interview 110

The problem villagers have with these filters is that they just take too long to clean the water and have too small a reservoir to draw from. Since the availability of cooking fuels is not a constraint, villagers are less prone to transition from boiling their water to filtering it.

In their electrical access, village 4 also scored poorly. The electricity grid was not present at all this far from the centre of the region, almost everyone relied on batteries. This involves limited access to electrical energy services:

> Them: I use battery and these three lights, also have VCD player but that one cannot watch TV, only VCD player
>
> …
>
> Them: I don't have any radio or TV so I don't get any news from them, but I get the news from the villagers, when something important happens they tell me – Interview 109

This household can access artificial lighting, communication through mobile phones and entertainment from the VCD player, these are significant energy services but due to the limited quantity of electricity it is a different lifestyle than grid users. Simply, they use electrical devices much more frugally. If the grid arrives they say they'd consume more but they feel ambivalent about this – access would be improved but at greater cost. One battery user expressed her interest in the grid was because she would be able to power more lights around and outside the home. Her focus here was on safety because the lights can fend off animals from the forest. Such threats are erratic and their incidence is difficult to quantify – the more meaningful issue is that greater electrical access could bring a consistent feeling of security. Another user from the village planned to use grid electricity for her livelihood:

> Them: The thing that I want in using electricity is electrical motor for pumping water because I want to plant chilli crop and other things like. I also want to get refrigerator, not big but small
>
> Me: What difference would that make to their life?
>
> Them: Is easy to keep the food, when I cook only one time I can keep it for another time – Interview 108

The above plans for using the grid electricity demonstrate that some villagers are ready for it. The wants that they have of grid electricity can be conceived as deprivations that they face currently. The high performance grid would enable many capabilities that would enrich their lifestyles but just as much as they desire these, they talk about the problem of the battery being that it is difficult to carry to be recharged. Grid electricity is enabling, indeed, if it were cheap enough it could alleviate the villagers' poor water supply, though intermediate solutions (such as solar generators) could be a more cost appropriate intervention since the core issue is with the inconvenient recharging of batteries.

9.4 Applying the QAT

The focused study above considered some of the high and low consumers within the villages. The function there was description and analysis of energy behaviours, illustrating what kind of access and the range of methods the API was representing. Now the qualitative tool is applied to the whole Samlout region. In the previous chapter the mechanism and process of the tool was demonstrated for analysis of a single device, biogas digesters. Now discussion is less methodological, it considers energy access more broadly, focusing on the common energy behaviours, comparing them with others in the vicinity and studying them through the four aspects. This serves the overarching purpose of understanding problematic issues and the feasible impacts of energy access based development. The principle methods of accessing energy, which relate to the biggest possible development impacts, are in the following behaviours:

- Using batteries for electricity
- Cooking with charcoal
- Pumping or manual collecting water
- Using motos or power tillers for mechanical energy

Understanding how these behaviours relate to the alternatives is the key to understanding energy access in Samlout.

9.4.1 Electricity

Performance	Appropriateness	Convenience	Resilience
Battery: *lighting, communication, TV*	Battery is more expensive per unit but cheaper overall	Batteries need charging	Batteries rely on fossil fuel generators
Grid: *pumps, refrigerators, washing machines*	Grid tariffs are high enough to inhibit demand	Grids are timely and easy to use	Grids are managed by a public/private utility
Electrical energy services can also be bought on the market	Buying energy services is preferred given the high costs of the grid	Smaller batteries are portable	No penetration of clean, renewable electricity

Table 9.4: An overview of the QAT relating to electricity

9.4.1.1 Performance

The electrical energy services a battery can provide are the essentials of lighting and communication:

> When I have more customers to come here I use the light to 8.30 or sometimes 9 … the candle can blow out but with battery light it is no problem – Interview 104
> Is really helpful with the phone because sometimes I call to a trader and they give me one price, I call to another trader and their price is higher so is benefit for me – Interview 105, language clarified

These two businesses gained from the battery's electrical energy services. In the first example the shop keeper gained another 2-3 hours of business in the evening. Electric lamps are more effective than the candles, boosting the performance of her access to the lighting energy service. The second example is a soy bean farmer, her ability to farm isn't really improved by the battery but the return she gets from that farming is. Mobile phones are low voltage but highly enabling.

The limit of the batteries can be seen in the villagers' desires for the grid:

> The thing that I want in using [grid] electricity is electrical motor for pumping water because I want to plant chilli crop, and other things like I also want to get refrigerator ... is easy to keep the food, when I cook only one time I can keep it for another time – Interview 108

Typically, the wealthier households would talk about investing in refrigerators or washing machines if they could access the grid. Poorer households expressed similar interests but it is unclear if they could afford those higher-powered assets or even the electricity to run them. There are businesses that marketed electrical energy services, such as the sale of refrigerated products or the rental of a karaoke music system. Currently this is the only way villagers can perform those services – though villagers may want high-powered assets in their homes, they can still attain effective access through the market.

Picture 9.4: Electrical assets in a wealthy home

The stereo system here belonged to a wealthy household; it is more expensive than what other households could afford. If poorer households are to access this kind of entertainment it must be on the market as a service since they likely cannot afford the asset itself.

9.4.1.2 Appropriateness

> I think if we compare between the battery and the electricity when I use battery is better. When I use electricity I am afraid of the shocks, one more thing I spend more money, when we have electricity [cable] we always use more! When we have a battery so we don't use it often – Interview 108

Though the battery offers performance of fewer services, this is preferable for some villagers. If they aren't going to use grid power for substantively improved capabilities or income generation then the tendency to consume more electricity may lead to a bill that outweighs the advantages of a better supply. The electricity grid (at the time of study) is in the process of extension in the Samlout region. Consumers can buy from an independent power provider who is licensed to sell electricity in the area. At $1/kWh the tariff is relatively expensive even for Cambodia. In the central region the provider has changed hands to the public utility; the tariff is only $0.33/kWh so more households and businesses are connected there. In that region, the price of electricity is appropriate for high consumption, enough to make a fridge a viable asset in a shop. The households outside of the centre are waiting for this transition before they connect; for most people, $1/kWh is simply more than electricity is worth:

> I want to connect but because the price is very expensive, about one dollar per kilowatt hour, when the price is going down I want to connect – Interview 104

For this reason of expensive tariffs, it is possible that electrical energy services may be more financially sustainable if attained through their substitutes; for instance, improving water infrastructure instead of promoting electric pumps.

9.4.1.3 Convenience

A common complaint of the battery is necessity of recharging it:

> I don't [want] to take my battery to charge; is big and heavy – Interview 110

> In the morning my brother takes my child [to school] also he takes the battery, in the evening I have to go to get it back – Interview 105

It is a chore to carry the battery and a deprivation to cope without it whilst it is being charged, for some this is a daily occurrence. One effect of this is added drudgery, thus countering the convenience of services like telecommunication. The grid, and to a lesser extent generators, do not suffer this same inconvenience as the electrical power source is accessible directly at home at the touch of a button (at least for grids).

The standard 12 volt car batteries are cumbersome but there are other types of battery which aren't so difficult to carry:

> Normally the people use the big battery in the house for the light and the DVD player. The small one they take to the farm … is lighter and the farm is far from there house. Sometimes they go overnight to protect the crop or something else, they use the small one not the big one – Interview 95

These smaller batteries are still sufficient for low power applications like lighting; they hold less charge though for some endeavours they are enough. Having the choice of the large or small battery increases the convenience of the user's supply.

9.4.1.4 Resilience

As renewable technologies haven't penetrated the Samlout region, the generators used to recharge batteries run on fossil fuels. This inevitably poses a risk:

> Me: What will you do when the price of fuel goes up?
> Them: Even though the price of fuel increase I need to continue my business, even though the price increase I still charge the same price, sometimes don't get benefit sometimes get loss, I am still doing this – Interview 95

This interview with a battery charger revealed that the margins for the service he sells are slim. Reports indicated that there were four chargers in the area; they represent a crucial link in the chain between the user and the primary source of energy. The operations of these four businesses are determinants of the electrical energy behaviours of all battery users in the villages. So, the reliability of the villagers' access to electricity is governed by these chargers' ability to run their business. Equally, a grid connected household is subject to the operation of infrastructure but in that case, the utility company and the government have responsibility of maintenance and their running costs can be moderated over a larger consumer base. The four chargers in Samlout are the key to access in the village and in turn, they are reliant on the stability of fuel prices. The battery charger above said that when the grid reaches him he will use grid electricity to charge batteries for the villagers who can't connect. This would add a degree of resilience to the supply as there would be multiple ways to recharge batteries – though, this faces the same environmental concerns of grid electricity which will likely also be linked to fossil fuel emissions for some time. Intervention with renewables into the villages would resolve this issue.

9.4.2 Cooking fuels

Performance	Appropriateness	Convenience	Resilience
High use of traditional 'Lao' stove	Freely available wood	Solid fuel can be stockpiled easily	Solid fuel use associated with higher indoor air pollution
Low use of modern BLEN stoves	Little desire for modernisation	BLEN stoves are easy to use	BLEN stoves are only part of stacking, no full adoption
Widespread production and use of charcoal	Cheap charcoal with familiar method of production	Charcoal deliveries operate in the area	CPF sustains wood supply but is mitigated by encroachment

Table 9.5: An overview of the QAT relating to cooking fuels

9.4.2.1 Performance

> Charcoal we use for a long cook, long time cook. For the cook that we use for the short time we use gas – Interview 100

Very few households in Samlout could afford gas or other BLEN stoves. Those who could expressed that the niche of modern fuels is where the household is short on time or has enough money to be willing to pay for a cleaner cooking method. Whilst wood poses stark difficulties of air pollution in the household, charcoal is argued to be less problematic, at least at the point of use. It functions effectively as a cooking fuel when compared with wood: it is easy to kindle, burns consistently and reaches a high temperature. Though BLEN stoves outperform charcoal burned on a Lao stove in all these respects, charcoal is often preferred because it is cheaper – it can be manufactured locally:

> We use semi-tractor to collect the wood, we cut the wood, then we dig the hole maybe as big as this <indicates $3m^2$> we put the wood in the hole. Use the banana tree to stake around the hole, maybe a meter high, and then we take the grass to cover it. Then we take some land and put on the grass and we burn it, after that we take the land to cover it … we wait for four days till the charcoal can be used – Interview 105

The production of charcoal relies on other areas of energy access – mechanical power to collect and cut wood, then a precise application of thermal energy to burn the biomass in an oxygen free environment. The quality of charcoal that can be produced represents the cook's energy access and that of those refining it.

9.4.2.2 Appropriateness

A significant portion of the population (around two thirds) use charcoal as their primary cook fuel, its production is a widespread activity but the method is traditional and inefficient. The traditional 'burial' method (see above) is familiar to villagers, so any intervention to change behaviours may feel inappropriate. As there are few operational costs to the traditional method of manufacturing charcoal then any modernisation that, for instance, uses metal kilns or other technology would face barriers in adoption:

> It is not hard to make charcoal from wood, almost everyone can do it – Interview 105

Equally, the construction of biodigesters is specialist knowledge and requires training; those who are excluded by that skill-gap will likely refuse such promotion and continue with charcoal. This is not to say that villagers are inseparably attached to charcoal, just that there are barriers to change in what kind of technology they can and want to use.

Beyond the barrier of skills and technology is the bottom line of price, villagers are well aware of the benefits of these more modern fuels but many simply cannot afford the transition:

> I really want to use gas stove and electricity stove but I don't have the money – Interview 106
>
> I don't have enough money for buying charcoal and gas, for the wood I can collect it by myself – Interview 109

Household 109 doesn't produce charcoal themselves and even though it is a relatively cheap fuel they cannot afford it. Most livelihoods are low-income farming, so there is less impetus for households to modernise their fuel supply given that the strain on their finances is more pressing than the strain on their time. Canned gas is the only alternative to crude fuels in these villages and even that is unaffordable by all but the wealthy households. Since wood is freely available and charcoal is easy to make in this well-forested region they will likely remain the standard fuels until intervention occurs that matches their price and technological sophistication.

9.4.2.3 Convenience

The technical performance of charcoal has already been mentioned: it ignites quicker than wood but slower than gas. It is also somewhere in-between in terms of how easy it is to use – this is crucial for some users:

> When I repair the moto or machines I get dirty which is why I need to use the gas stove, I just go 'flick' to press it and I get power – Interview 94

The modern BLEN stoves are most convenient for the user at the point when they need to access that energy, both in terms of setting up the stove and controlling the heat. However, the energy access of charcoal is better in another sense since that fuel can be sourced more conveniently. Those who manufacture charcoal themselves can have a stockpile to use over several months and those who purchase it usually have it delivered:

> Me: Where does she buy charcoal?
> Them: I buy it from the trader, they deliver from a semi-tractor around here – Interview 104

Charcoal is easier to carry than wood but a large sack of it is still unwieldy – because of this and the high demand for the fuel, charcoal is sold from the roadside. Deliveries are door-to-door, making charcoal a highly convenient fuel to access for the end user.

Also, because the charcoal fuel burns cleaner than wood, it creates less smoke, less soot and results in less cleaning:

> Charcoal is not dirty, not black at all, is better than I use gas. Even when I use gas we get a blackness on the pot or pan – Interview 104

9.4.2.4 Resilience

A main concern of using charcoal is that, though cleaner than wood, the smoke emitted is still air pollution and is linked to health complications. The local hospital in Samlout gives advice on about how to avoid the dangers of cooking smoke but not to change fuel type.

BLEN stoves are cleaner but only affordable by the wealthier, though even those households stack modern fuels with wood.

With its Community Protected Forest, the region is resistant to external shocks in the market price of cook-fuels – though the area still lacks resilience due to the unsustainability of illegal logging and the danger of landmines. This is another concern of charcoal, that the forests from which it is drawn are not necessarily protected effectively:

> He said that he tried to educate the people to obey the law but not 100% do they obey the law ... If the people have a small piece of land they try to cut down the tree to extend their land … in the future, the people think that they cannot go to the forest for wood, they need something like electricity. A lot of people think that. They understand the trees produce the oxygen but they have no choice – Interview 90

This village chief explained that it is the encroachment of agricultural land rather than fuel harvesting which is threatening the forests. People are aware of the problems in deforestation, but as he explains, they feel they have little choice.

Picture 9.5: Trees cut for larger scale timber or charcoal production

This kind of logging is not permitted but the enforcement to stop it is not always effective.

9.4.3 Water

Performance	Appropriateness	Convenience	Resilience
Wells accessed by hand or fuel pumps	Cheapest methods are: collection, then pumping, then buying	Wells and natural water sources are unevenly distributed	Ground water sources are favoured
Wells dug by NGOs and businesses	Wells are too expensive for most villagers	Energy requirements vary depending on location	Sharing of pumps allows more households access
Limited use of filters and bottled water supplies	Pumps are shared	Storage and transport assets make this task easier	Water access is vulnerable to increases in fuel price

Table 9.6: An overview of the QAT relating to water

9.4.3.1 Performance

The majority of households are supplied with water through wells, 12 out of 19 household interviewees used them, mainly with fuel pumps although in a few cases by hand. Most of these wells were built through NGO activities; just one can serve multiple households. The more recent wells appear to be dug through private industry:

> I have one well behind my house, is drilled into the ground … the drillers are not in the village, in another district from another province, but we get phone number … when another villager wants a well they ask for the number – Interview 94

The ability to dig wells and source clean water is significant. Though the price of this service is expensive, especially where the ground is hard, as a capability is it relates directly to the satisfaction of basic needs and because it can be done without external intervention it represents an empowered population.

> This well is a drilling well, it was built seven years ago, spend the money $2000, very expensive because I did the first time in this village, now around $800-1000 is the most expensive … before I used water from the stream, but in the dry season not enough water, which is why I needed to drill the well – Interview 101

This household grew durian trees as part of their livelihood. This is a lucrative business but it requires a lot of water. Without abundant natural sources, a well is a necessary asset for this kind of high-demand livelihood.

In terms of cleaning their water, filters have long been promoted in the area by the World Vision organisation though the more common practice is to boil water before use. An alternative is to buy bottled water for drinking, this is safer than other sources and doesn't require boiling nor is it at risk of heavy metal impurities. The choice of methods allows stacking for the maximum benefit to the user:

> I drink bottled water; the pumped water is for cooking and washing – Interview 96

9.4.3.2 Appropriateness

In terms of price, collecting water manually is the cheapest option, certainly when the source is a well built through external intervention. Where the expense of digging these wells can be afforded, they reduce the unit cost of providing water as the wells are located close to the household:

> We spend the time about 45 minutes pumping and less than one litres of gasoline [$1-1.25]. We get eight small jars of water [~3000 litres] – Interview 99

As a further reduction in costs, within Samlout the behaviour of sharing assets like water pumps was quite common, only half of those who pumped their water actually owned the pump themselves:

> The machine is not mine, it belongs to my parents. When I need to pump the water I just take the gasoline I spend on the gasoline and can pump the water to use in my house … when I use my parent's pump sometimes I am a little bit afraid, if I have my own machine I can use it freely – Interview 105

Though the user here saved money, her satisfaction in the way she accessed this energy service was mitigated by the stress of breaking the equipment that she did not own. Sharing these assets is not always appropriate in the eyes of the user.

Other options for accessing water are slightly more expensive: to hire someone with an engine to pump water costs around $0.75-1.25 for 500 litres. Higher quality bottled water is even more costly, large refill bottles work out at $0.03 per litre; again though, stacking allows for a broader, and feasibly more satisfying, choice:

> I use the rainwater. When it is done raining I take water from the river for cooking rice or the food. But for drinking I buy, you see there, drinking water … I spend 300 riel per bottle ($0.15/litre) – Interview 95

9.4.3.3 Convenience

An advantage of the bottled supply is its convenience. It is potable water in a handheld container. Even some of the thriftier households would use this source – the refill bottles are delivered along main roads so the household neither has to fetch the water nor the fuel to boil it.

For the water pumpers, the convenience of their supply is proportional to how close they are to the well and how many jars they have around the home to pump the water into. This volume of storage dictates how long they can last until they have to pump again. Though the clay jars are the standard of water storage, feasibly any plastic container can be recycled for this purpose:

> I can store 600 litres; … 20 cartons, one carton can store 30 litres – Interview 91

Additional storage can mean fewer trips to the well which is advantageous as those wells do not have even coverage to the whole area, the nearest can be many hundreds of meters away. Some households are better served by water sources than others. In particular, a small cluster of households in one village were fortunate enough to live nearby to a natural spring. Those households downhill from the spring did not need any additional energy to pipe it to their house or agricultural land:

> There is a spring, a natural spring, it has water all the time. I use the pipe to flow from that spring all the time ... can use for the other crops freely, because the water just come out automatically – Interview 93

The convenience of living by this natural source is an implicit access to the energy needed to transport that water. Though they are few in number, villagers in the opposite situation (uphill and far from water sources) require deliveries of water which puts a great cost and difficulty upon them.

9.4.3.4 Resilience

The health concerns for villagers here relate to the cleanliness of their water source. The majority of the households use wells to access ground water which tends to be cleaner than surface water sources such as rivers or ponds. Nevertheless, diarrheal diseases are a common complaint in the local hospital, medical professionals there told me that their main preventative course of action is to instruct villagers to boil surface water.

In the dry season the surface water supplies are less plentiful or unusable so the strong penetration of many water wells throughout the area adds a safety net for that season. However, as many of the households borrow pumps to get at the water in these wells there is a degree of redundancy removed from this energy access – a few broken pumps would amount to proportionally more households without water. Equally, the fact that these pumps are powered by fossil fuels makes their usability dependent on that one factor of fuel supply. Alternative energy sources for pumping would alleviate this issue though the only other method observed in the villages was hand-pumped wells.

9.4.4 Mechanical energy

Performance	Appropriateness	Convenience	Resilience
High ownership of motos	Motos are suitable to the terrain	Power tillers and motos mitigate remoteness	Road network is poor
Medium ownership of power tillers	Power tillers are appropriate for farmers with a few hectares	Various agricultural machine assets save on labour	Rainy season worsens dirt paths
Indirect access: travelling traders and sharing of assets	Sharing assets is enabling but ownership would be preferred	Heavy machinery is difficult to use	Mechanical assets are high dependent of fuel

Table 9.7: An overview of the QAT relating to mechanical energy

9.4.4.1 Performance

Villagers in Samlout usually owned a moto (34/47) and just under half owned a power tiller (21/47). As a simple asset, the moto is enabling. It can be used in basic tasks such as collection of resources or for general transport:

> He has two motos, no car ... his sons use the motos to go to school. For him and his wife, [they use] to go to the farm – Interview 89

> We have one moto for my children going to school and sometimes use it to buy food from the market … but for the fish and some meat I buy from the moto traders who are selling – Interview 108

The motos are lightweight and fuel efficient so can be used, affordably, for many tasks. They make it easier to get to school, bring crops back from the farm land and traders can use them to make door-to-door sales. This kind of trading improves the villagers' access to markets and as they are daily deliveries, they somewhat compensate for the lack of refrigeration in the household.

Greater mechanical power is given by power tillers or tractors. Essentially, they can output more force so can perform a greater range of mechanical energy services:

> I hire the tractor from a villager who lives near my farmland, you see the way <points to mud path> when it is raining I cannot use my moto or semi-tractor, I hire that tractor to help me – Interview 109

As with many other assets, villagers do not each need their own to feel the benefit of the associated capabilities, instead they can rent as and when they need that service. With this, they still have those freedoms but without the onus of ownership.

9.4.4.2 Appropriateness

Motos are suitable vehicles for remote regions like Samlout. Partly, this is because they are smaller and more nimble than cars, thus better able to navigate the poor quality roads in the area. Also, they are easier to fix – the mechanic in the village needed fewer tools and less expensive equipment to repair motos.

Similarly, the power tillers are more versatile and lighter than full tractors. The kind of mechanical aid that is necessary depends on the size of the farm:

> Because his land is not big, he himself harvest the soy bean using hand cutter … he said that if he get bigger land he want to use semi-tractor … with the big land he must use the big machines to help – Interview 93

Though not all of the households in the area own a power tiller it is not a stark deprivation where they are only small land holders; in those cases there is less demand for the mechanical energy. However, those who seek another livelihood on top of their agriculture may require these mechanical aids as they save time on various tasks. The sharing of assets can enable those capabilities associated with agriculture or domestic life (for example, when collecting resources) but not always in a satisfactory way:

> It is common to share in the village ... it is not easy to borrow from each other, if we have our own it is easier because when we borrow from others, we have to repair when it is broken or the problem might need replacement – Interview 107

The act of sharing assets is enabling but it is not the preferred method of accessing those energies. Though it is common and works in practice, it is not the most satisfactory state.

9.4.4.3 Convenience

Principally, the convenience of mechanical assets is that they reduce the amount of effort expended by the user. In effect, vehicles can reduce distances and mechanical tools reduce heavy workloads:

> The wood we collected from near the forest is very far from here if we walk we have to spend the whole morning. Before we carry by our hands but now we have semi-tractor so is easier – Interview 107

With such assets, the household expends fuel and in return saves on their labour. The case above is for a routine task of collecting wood but it also applies to a variety of livelihoods with specific machines that can be used for specific tasks:

> We use the grass cutter. I have four machines. If we hire the people who cut by hand is very difficult, if we use the machine we can reduce the labour for hiring – Interview 100

In this example the household would bring in labour for cutting grass and equipping those hired hands with machines reduced the overall expenditure. However, there is a limiting factor to the convenience of machines and engines as there is non-negligible effort required to use and operate the heavier equipment. For this reason, there is less of a gendered aspect to motos than there is to power tillers. Finally, unlike the other resources, fuel is not sold to the household by delivery so there is that inconvenience in the supply.

9.4.4.4 Resilience

The two main issues that complicate mechanical energy access are in the quality of the road network and dependence on fuels. Particularly fuel dependency is problematic because those fuels tend to be *fossil* fuels.

Fuel security is an issue which jeopardises the resilience of mechanical energy access. There are few substitute energies to power engines apart from fossil fuels so the access that villagers have to mechanical energy services is highly sensitive to fuel prices and fuel availability. Without infrastructural support, villagers tend to rely on their own machines and these rely on the supply of fuel to the area. This is acutely problematic because many of the other forms of energy are in some way dependent on fuel powered machines, for instance electricity generators, the trailers that deliver cooking fuels or the engines that pump water. The poor quality roads disproportionately affect those who are further away from the centre of the region and live more remotely:

> When my house is far from the road in the village like this, we find it very difficult travelling because the road is very bad, especially in the rainy season, my children go to study with difficultly. Actually my husband works with the village chief and tells him about that but nothing happens – Interview 106

So whilst vehicles like motos are enabling, their effect is hampered. In terms of the road network, within Samlout it is mostly winding dirt paths and crude wooden bridges. Though these are enough to allow trucks to pass, carrying loads of around a tonne, they are unreliable and offer poor resilience as transport network. If one of these bridges were to break then many farmers would find it harder to sell their produce and many villagers would have less access to the deliveries that run through the village. Especially, in the wet season the smaller dirt paths become intractable, posing further difficulty on remote households.

Picture 9.6: Construction vehicles operating on roads around the village

Road building and resurfacing has consequential benefits for many other factors in energy access. On these roads it is easier to import and export goods, people can travel easier and there is less risk of road accidents.

9.5 Generalising the QAT

The qualitative tool is divided into three mechanisms, each existing on a scale of abstraction:

1. Mechanism one is related to elements that are tangible or outwardly visible, these can be readily communicated without ambiguity.

2. Mechanism two explores the underlying behaviours behind those visible elements, this relates to people, their knowledge and opinions.

3. Mechanism three is framed by the analytical processing of the researcher: how they decide to represent the rich, context-specific, information gathered and what meaning they feel ought to be put forward to those reading the final report.

At the first and most basic level, one deals with the rudimentary details of the phenomenon in question - in my study this was forms of energy access in the home (cooking, providing water and using electricity). The operation of this mechanism is to form an underlying structure for interviews, and over time, to iteratively refine that structure so that it supports the production of a set of questions that prove useful. Initial ideas taken from the literature review (or other preparatory sources) are gradually adapted to the case study. The information that these 'basic' questions retrieve should be relatively quantifiable; they generate the first tranche of data. Significantly, just as this mechanism structures the interviews, it also structures the data set and guides early analysis.

The second mechanism brings in interpretative methods. The 'basic' questions above are used as a starting point to explore the narratives that participants are willing to share. Essentially this is to align the researcher's understanding with that of those living within the context studied. Thus, this step begins the departure from the knowledge in the literature review. Early on, this mechanism is crucial: to explore, form conjectures and test the extent to which different participants are telling the same story – or if not, to bring out the complexity that causes dissonance.

The final mechanism involves the researcher overlaying her/his analysis onto the structures above. In my case, this was done by using the four aspects of energy access (performance, convenience, appropriateness and resilience) as a way of both categorising the findings and creating more meaning in the concept of energy access. Effectively, this mechanism retreats a step towards the theory but with a newly formed grounding in the context. It gives those reading the final report an intelligible account of the case study, formed into a coherent message from the researcher and unencumbered by superfluous details.

Between all the mechanisms there is overlap, effectively, they each operate continuously. The 'basic' data gathering is vital throughout and the refinement of the 'base' questions doesn't stop, improvements may become fewer but there is always room for adaption and improvement. Equally, the option of following up enquiries (as in the second mechanism) should be available throughout the entire project; any participant can possess and submit interesting content at any point in the study. Finally, the more analytical process of the third mechanism does not begin at some arbitrary midpoint of the study but is a continual process which gains momentum over time – before one enters the field proper, analysis has already begun. Towards the end of the study analysis become less about guesses and assumptions and more about making the kind of connections that are only possible with experience.

9.6 Conclusions

This chapter has applied both the quantitative and qualitative approaches to the study of energy access in Samlout. The API identified the likely areas of problematic issues, focused study pursued these and expressed details of them, and then the QAT gave a comprehensive account of energy access throughout the region. With the quantitative approach (Tables 9.2 and 9.3), specific values for consumption were given, as were lists of the associated assets; this produced a basic indication of villagers' energy access and its cost. The qualitative approach then supported this by conveying the perspectives of those energy users and studied these with reference to poverty. This laid the groundwork for interventions that might encourage development, simultaneously; it also acted to evaluate previous interventions in the area – for example, water wells and filters. Conclusions are now given on the results of the appraisal, this forming an answer to the final research question on using the output of the RRA style energy access appraisal.

There is strength in Samlout's energy access; ostensibly the resilience of villagers is good because they have assets which make them fairly self-sufficient: power tillers, wells, pumps and generators. However, there is a weakness here because engines are at the core of most coping strategies. If their engines cannot run, then their capabilities are taken away, so they are at risk of poverty. The high reliance on fuel could be alleviated by infrastructure such as water pipes and grids as these would substitute those energy services which demand fuel. Transition to alternative fuel sources is a long-term technological goal that is sought more globally; as that technology may take some time to reach this kind of village, more short-term options must be available to mitigate the risk of poverty. The effect of the holistic perspective on energy access is to see that fuel security is endangered by dependency from multiple core capabilities, but that equally, it can be bolstered both by initiatives from the side of supply or demand.

Another effect of the appraisal is in assessing the impact of the Community Protected Forest scheme. This impact is considered in relation to those who use the forest for fuel or other resources as opposed to monitoring the rate of deforestation. From discussion with the villagers, it is evident that the woodlands here are encroached upon due to want for land, building materials or as part of charcoal production. The implication is that charcoal production will continue, despite the fact that the villagers are aware of the long term consequences, because other cooking fuels are unaffordable or otherwise not compatible with the skills that the villagers have. Charcoal is made traditionally and if the villagers are to transition to more efficient methods then the intervention must be sensitive to the fact that they will be more comfortable using their current technique. Furthermore, with the issue of encroachment, the farmers feel ‘they have no choice’, so in order to reduce the motivation for them to turn the forests into farm land they need other options for improving their income.

Finally, the appraisal in this chapter can inform the planning of electrification policy by conveying discussions with battery and grid users about the way they use electricity and their desires for electrical energy services. Due to expensive grid tariffs, villagers can access few electrical energy services, mostly those available with a battery. To some extent this is mitigated because high demand electrical devices are owned and marketed by retailers, for example, a karaoke music system, refrigeration and battery charging. A third of interviewees want specific high demand appliances if the grid tariff drops; until then, they will be reliant on buying the energy services rather than owning and using the assets themselves. In the centre of the region electricity is cheaper so it is feasible that the high demand services could be accessed, for instance, a laundrette. Concentrating electrical consumption in the centre of the region would raise awareness of, and build demand for, electrical appliances; so, if the tariffs become cheaper outside of the central region, the consumer base there is more likely to maintain financial sustainability. However, a more immediate concern for battery users than ‘what they would like if they were to be grid-connected’ is the burden they bear in recharging their batteries. Resolution of that issue, for instance, through more decentralised generation, would make their energy access far more convenient.

An effect of conducting an appraisal in the manner demonstrated is to return timely and relevant information about the case study. The data gathering in Samlout took less than a week, which allowed for the majority of the energy landscape to be discovered and the most important issues to be indicated. The holistic perspective of this energy access appraisal ensured that the complexity of energy access was captured using methods refined over the last few chapters. This meant that tables could portray relevant data and interpretive analysis of interviews could yield useful information. Together, the two tools gave a fair indication of how energy is accessed and in what areas work can be done to develop this energy access with the aim of alleviating poverty.

10 Conclusions

This final chapter reviews the research project. The aims and research questions are recollected in order to place the findings. Then, the methods are reflected upon so that those findings can be moderated in context of the project's limitations. Only with this transparency can the definitive conclusions on the project be asserted – thus forming a knowledge contribution in the field of energy access.

10.1 Findings

The aims of this project were to study energy access for its more social elements, hence, to learn more about the process of rural data gathering and how it can be improved. Here, I was trying to find people's opinions about way that they access energy and the associated assets like their electrical connection; also I wanted to discover effective ways to extract and convey that information. Specifically, my main objective was to conduct an appraisal of energy access and the construction of indicators, qualitative and quantitative, was the key to that.

Research questions:

1. How do people access energy in selected case studies in Cambodia?
2. What are the strengths and weaknesses of the qualitative and quantitative approach to data gathering with respect to energy access?
3. For an analytical framework built during fieldwork, what indicators or methods can be used to assess energy access and what are their limitations?
4. What kind of implication can be drawn from using an RRA style of assessment into energy access?

Questions 1 and 2 have already received thorough treatment; specifically, Chapters 6 and 7 went into great detail about both approaches, exploring the way in which energy is accessed by the rural Khmer in my case studies. Chapters 8 and 9 restate and reinforce answers to these first questions; beyond that basic content, the tool construction in Chapter 8 answers question 3 and its application in Chapter 9 forms an answer to question 4.

The following text summarises the main findings of the thesis, the items of particular note are italicised.

The overriding implication from this research is that *energy access is sufficiently complex that it is meaningful to give it a qualitative representation in addition to quantitatively scoring it in some linear range*. As a case in point: in interviews villagers express desire to use grid electricity but they often also accept the appropriateness of batteries. The electricity grid can do better than a battery according to some, but not all, criteria. The same is true for different methods of accessing cook fuels and mechanical energy. As there are no objectively better means of accessing energy (the closest to an exception is probably piping water), these methods cannot be ranked in a linear fashion and herein lays their complexity. *There is no better or worse way to access energy, overall it depends upon what energy needs a person has and upon what energy services the wider community can offer*. Nevertheless, thinking in terms of energy access is helpful in understanding capabilities and poverty.

Energy access itself exists on various scales beyond the household. For instance, community buildings, key figures within the community, local infrastructure, marketed energy services and the availability of resources are all interesting subjects to consider. This is not entirely new to the discourse, the early chapters of this thesis documented Practical Action’s efforts to bring the community into the remit of an energy measure – however, *this awareness of the community must extend not just to entities such as schools and hospitals, but to many social structures that are wider than just the household.* Resonating through much of the literature is an ethnocentric ideal of ownership, this permeates into the measurement of energy access, so methods tend to look at what the household owns or to what kind of centralised infrastructure they are connected. Yet, at least within the villages I studied in Cambodia, this ideal does not hold true. Not only is the household a vague unit to analyse (in Cambodia they are each part of larger 'groups', often forming extra-family relationships) but the individuals within are less inclined to own their own assets since sharing is so much more sensible when everyone is poor. Beyond the sharing of assets, I observed behaviours in the community of pooling resources, giving aid to those who need it and conducting energy services at the inter-household level. *For a complete understanding of energy access, analysis must operate on many scales, including the individual and the inter-household society in which they exist.*

In addition to the theory about energy access, the important findings from this project are in how to assess or appraise it; this involved constructing two tools. The first attempts to reconcile the amount of information on energy access with the rapid decision making facility of indicators; this is the Access Priority Index. The focus of this tool is upon *the core forms of energy: electricity, cooking fuels and mechanical power*. These energies cover the most relevant capabilities related to welfare and poverty. However, in assessing the access to those forms of energy, analysis should not reduce them all to one single figure – rather, it is more meaningful to *retain these factors as separate quantities in order to be aware of the difference between them*. In doing this, the resultant index is not geared towards ranking locations based upon some single aggregate; instead it can be studied to see how different locations compare in their various scores. This exploits the comparative advantage of the quantitative approach but does not overstep its limitations.

The Qualitative Assessment Tool was designed to complement the API; it is intended for use in interpreting and representing interview data. The QAT is used to make rigorous description of energy access; it is guided by an *analytical framework for aspects of energy access: performance, convenience, appropriateness and resilience*. The designation of aspects for this framework was informed through the interview process as well as auxiliary ethnographic methods. The intention was to understand energy access from the users' perspective. Using the forms of energy (listed above) and the aspects of access to it, the QAT is a rubric for appraising energy access in a fair and open ended assessment. This contrasts to contemporary tools for monitoring energy access in which the participants' assets and capabilities are compared to the standards native to the researcher.

The research process was to refine a method for extracting information on rural energy access. The final interview structure was orientated towards finding out the following:

- Details of how electricity, cooking fuel, water and mechanical energy are sourced
- Opinions of the user on their access, for example, their *investment* into a power tiller, the *difference* between cooking fuels or the *change* that an electricity cable would bring
- Knowledge householders have on the rest of the community and the activities within, for example, sharing assets and energy services.

The topics within this interview structure, the aspects of energy access focused upon, and the awareness of how each interview fits into the dataset as a whole can be seen in the final iteration of the analytical framework:

Analytical Framework: Final

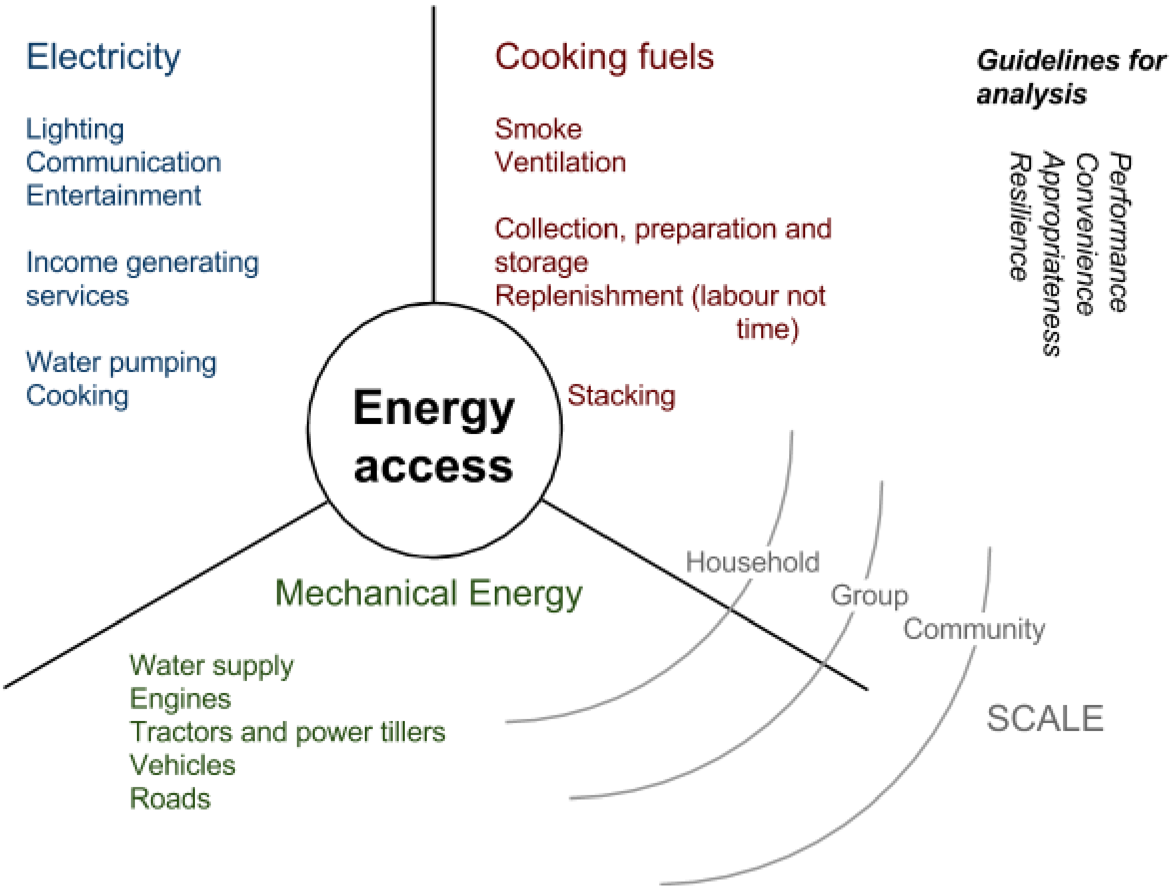


Figure 10.1: The final analytical framework

This framework encompasses the issues which I found to be of highest importance and most informative, in the analysis of energy access.

10.2 Undertaking Rapid Rural Appraisals

This section provides the essentials of the strategy for an RRA as used in this project. Note, however, that the following protocol is created from experiences in my Cambodian fieldwork. The particular cases studied and details of those contexts are discussed in the methodology chapter. There, it is also stated that substantive findings which emerge from this study are most relevant and quite specific to those locations (for example, biodigesters behaviours). However, the motivation of this research was on alleviating poverty – but not explicitly in Cambodia. So, although matters of context were given much attention and although the findings were framed as specific to that context, it is not that content which is the fundamental output of the research. Rather, it is the more generalisable process of how to act when gathering data under time and resource constraints. Thus, that process, which takes into account the specifics of a given location, can be applied elsewhere for similar initiatives of gathering data effectively and efficiently. Consequently, the style of mixing methods in data gathering is not anchored to Cambodia or even to the theme of energy access.

10.2.1 Constructing an RRA

The following tutorial is for transferring the development of the procedure used in this research to other contexts or in projects couched in other themes of analysis. The guidance of these bulleted steps shows how to carry out a whole program of developing and applying an RRA.

- Preparation: conduct a literature review or similar reading of information about the target location(s) and theme(s) considered. Establish contacts in the field and acquire the skills/assets needed to carry out operations there.

- Initial field visit: pilot the main methods (for example, interviews) to see how feasible they are. Also, immediately begin to make observations about the environment.

    - It is important not to be restricted in methodology: information from an unreliable source can be verified elsewhere – whilst an uninformative source or method yields no further avenues of enquiry.

- Carry out a preliminary analysis to check if methods are appropriate before investing more resources into the associated strategy. At this point, the analytical framework of the preparation stage will likely be revised. Equally, this is a suitable opportunity to make changes to the research team or project aims depending on issues of feasibility.

- Primary field work: commit to a larger stage of data gathering – this continues the scoping of the field but is more focused on establishing details of how methods work best (for example, refining useful interview questions). This step is critical; it forges a working understanding of the phenomena in the particular and specific context of the study.

    - Methods are refined in this stage; that process of change puts a strain on consistency in the dataset. Less consistency means that it is harder to establish patterns in analysis, though it increases the likelihood of identifying methodological improvements. Substantive findings take less priority at this stage of the research. This trade-off is mitigated by continual analysis in parallel to the data-gathering.

- Reflection: review the methods used against the data that is being gathered. Draw findings and decide what kind of tools would be most effective and efficient in generating the data needed to make such inferences.

    - Whilst the earlier steps engaged in broadening the ‘toolkit’ of helpful methods, at this stage these methods need to be narrowed down to select those that are most appropriate for a *Rapid* Rural Appraisal

- Applying the tools: ideally, the tools should draw from a variety of methods to allow for the greatest perception and also to encourage robustness through triangulation. The scoping element of the research is now reduced in order to promote the efficient data gathering. The efficacy of this step is dependent upon the suitability of the tools for the context and the researcher's general understanding of the environment. Poorly chosen tools will only output poor data and anything less than a solid understanding of the field is not conducive to good decision-making about the data gathering – especially in a short time frame as with an RRA.

- Carry out final analysis using the frameworks revised in the field. Whilst it is possible, and often tempting, to reproduce the vastness of the dataset in a final report, this violates the core aim of the project which is that of communication. There is merit to providing a wealth information backed up by an array of indicators, this gives substantial, comprehensive detail of the field and allows the dedicated reader to conduct their own analyses. However, the overriding purpose of the RRA is that it provides conclusions itself, these being driven by those who have more experience in the context in question – thus, the focus is to deliver a coherent message or recommendation and back this up with sufficient data from the field so that it is both convincing and that there is also a route for further work in the area.

10.2.2 Conducting an RRA

The penultimate step above, applying the tools, is expanded upon in the flow chart below (Figure 10.2). This gives the procedure of how I carried out my RRA with the particular tools I designed – those demonstrated in Samlout. Evidently this may need to be adapted to any novel tools developed using the above steps, but it serves to show a general method for combining quantitative surveys and qualitative interviews.

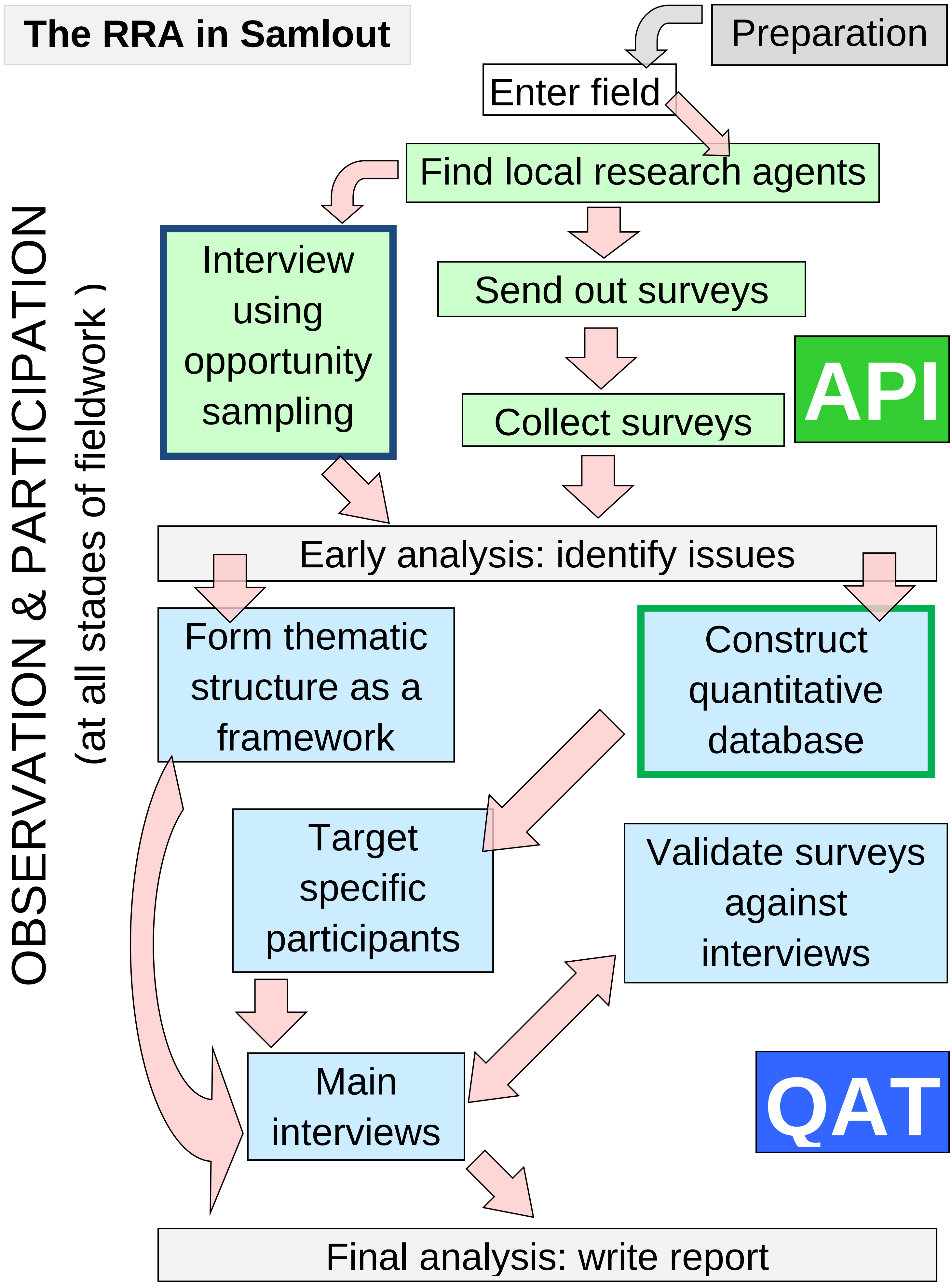


Figure 10.2: Flow chart for applying the API and QAT in an RRA

10.3 Reflections on this project

Ideally, reflections on the project will guide future researchers in similar projects – and at least they can shed some light on the generalisability of the findings though study of the limitations of the methods.

10.3.1 Cases studied, sample size and bias

My research focused upon a few locations within one nation, Cambodia. The nature of the country was outlined at the end of the literature review and in Chapter 5: it has a tropical climate, 40 years ago it was suffering genocide, and it is situated in the South East Asian region. These factors have some effect on knowledge that can be taken from the research. Neighbouring countries straddle it in terms of indicators on poverty and energy poverty, so from the outset it seemed feasible that findings are transferable elsewhere. Though due the Khmer climate, findings were blind to the importance of certain energy services, like ambient warmth, for the part they play in energy access. So, cooler or higher altitude regions will likely differ in their access, though the tools developed should work similarly – so too for other factors such as the different wealth or resources in other countries. A bigger issue is the relatively recent history of war. Due practical limitations of the project, I couldn't devote study to how that conflict has affected people's energy access or how it influenced the tools I developed. A likely problem in generalisation is that the role and function of the village chief may be particular to Cambodia – I am unsure if their counterpart in other countries would be an equally appropriate local research agent.

Within Cambodia, I spoke to quite a variety of people, though not in enough different locations to give perfect coverage of all the polar types. For example, I did not visit the North Eastern regions at all. These are poorer and less populated; given that they're unknown and more remote, it is hard to estimate how their energy access differs or how well the tools I designed would function there. In fieldwork I was motivated to study the safest and easier to reach locations. So, for all that it is a very poor country, the poverty and energy poverty of the people I studied was not extreme. The poorest in Cambodia, and around the world, may have very different energy access and ways of communicating it. In particular this may weaken the transferability of the API as its component indicators may not be able to differentiate locations of more extreme poverty.

The cases that I did study were varied enough to give me confidence in applying the tools elsewhere or making judgements on as yet unseen kinds of energy access given what I have observed. Mostly, this confidence is due to my data set's relation to the range of energy access I studied in the literature. Ambient warmth is the only energy services I didn't get to study. However, though illuminative of the many issues within energy access, my case studies were not without their biases; getting around them is a continual process of understanding the bias in order to work around it. For instance, I suspect a bias in Chambok may have been for villagers to over emphasise the benefits of their ecotourism project, so I detracted findings about the associated livelihoods; whereas in Samlout they may have been trying to give answers that would have resulted in lower electricity tariffs, they probably weren't feigning their interest in electrical appliances but I doubt that the poorer households would really buy them even if the price per kWh fell. I was aware these effects in my analysis so could counter for them. Consequently, I am more suspicious about my data from peri-urban Battambang (interviews 84-88) as I had the least opportunity to recognise any site-specific biases endangering my research there; they definitely seemed poorer, but that could've been due to less NGO activity, the less favourable weather or simply because my translator at the time wore an expensive camera around his neck.

Evidently, biases are not just geographic. Within almost every community I visited there were noticeable variations: the household size, acres of farm land, income and the supply of resources. These factors were easy to observe and account for in the analysis – most of them were addressed in the interview itself so I had a good idea which households they affected. However, other personal biases were not accounted for: I did not have any accurate determination of interviewees' fallibility or their openness and honesty with me. These issues are intrinsic to the interview method and I had to rely on the social awareness of myself and my translator to navigate them, and triangulation with other interviews and other data.

10.3.2 Review of methods

This subsection considers the effectiveness of research methods. The project was inspired by the participatory approach to development, though the particular aim was to gather information in a style similar to an RRA. As such, the main research method was interviews which tended to be more extractive than participatory. The people in my case studies did have notable influence through the semi-structured interview; this in turn led to each reconstruction of the analytical framework. I heeded the analytical approach of villagers, the way in which they would measure and talk about their energy behaviours. Also, the ethnographic influence to my data gathering, particularly, observation of people as they accessed energy was essential to the learning process. This mixture and flexibility of methods, and the focus of the people in question, was of great help to the project and allowed for the creation of tools to can convey what people expressed to be the important parts of their energy access.

The interview topic of biodigesters provides good grounds for reflections on interview methods. Note that the interview content given below has been alluded to earlier – its function here is to inform methodological criticism rather than to argue one way or another about biodigesters. One objective of mine was to find what the users felt about biodigesters and the process of using them. More generally, this was to uncover opinionated data. However, as mentioned in Chapter 6, an immediate hurdle in responses to these queries was that interviewees often seemed to recite the promotion given by NBP. For me this wasn't providing new information or the kind of personal, opinionated data that I found more interesting. By observing body language, particularly that they would look up and count off each statement on their fingers, I realised that the villagers felt this was a recall-test of their training. Essentially, the question was miscommunicated. Thus, the solution was to ensure my translator understood what kind of information I sought, that is, their exact opinions, and for me to ask questions that probed into what they were saying, for example, "*of those benefits about a biodigester, which is more important to you*". This reaffirms that synchronising objectives with the whole research team is an important tactic to use in rural appraisals, as is continually checking interpretations with one another.

Another problem with the interview technique is in interpretation, the example to demonstrate this issue is in my enquiry on why people might not want to invest in a biodigester. The surface level answer was that they did not have enough money but I eventually reinterpreted that to be an issue of confidence. This is a basic application of interpretive analysis and it sets the QAT apart from the API. I understood that the poor are risk averse (Chambers 1983), I knew that many had enough capital to invest in a digester and I noticed the large shift in their opinion (and valuation) of it over time. It was not the lack of money, but rather the lack of faith in the as yet unproven digester, holding them back. Interpreting the meaning behind what they were saying allows for a different recommendation for promoting biodigesters, such as by guarantees rather than loans or subsidies.

Clearly, the interview method faces limitations in what interviewees are willing to talk about. In terms of biodigesters, the elephant in the room was that many villagers "*think energy from the shit is not good*" – Interview 68. I had assurance that the fuel itself burned cleanly but this was from fellow outsiders with a similar kind of education to me. Evidently, people are entitled to their own opinion on what is clean and useable; indeed, it was exactly that which I wished to learn. However, due to our different statuses, I sensed that interviewees were inhibited from saying some of these things. My informant B told me explicitly that people don't invest in digesters because they don't want to be handling faeces all their life. Interviewees wouldn't say this, in part because it might seem undignified conversation but also because it would contradict the promotion of the biogas group I represented. People aren't inclined to sound ignorant in interviews – it helped having informal conversations with other villagers outside of interviews, combining methods is helpful in learning about these embarrassing or contentious issues.

A final difficulty discussed here stems from the methodological decision to focus on a small sample size. The advantage was that I could collect more qualitative data from each discussion but the trade-off was that I forewent largeness in the data set. For instance, the quote from interview 8 on page 277 expresses a phenomenal increase in income from using bio-slurry, this is technically feasible[6] and the implication is sound: an increase in production should cause a much higher increase in profit – but the argument would be better supported with more similar stories. Along the same line, I could not figure out how shared the responsibility of operating the digester was between different family members or if there were some kind of emerging convention for the role of different people. The use of engines and cook-stoves is quite gendered but I could not tell this about biodigesters with my small sample. I think it an interesting result that children were often involved in the decision making process of investment, though this result would have gained much from styles of interview that spoke to the different family members separately. The methods I chose led to interesting and useable findings, though feasibly there is scope for a more in-depth intra-household study of energy access.

10.3.3 Discussion of the research team

This last subsection of reflections considers the research team: translators, local research agents and partner organisations.

Employing several translators was necessary due to their availability and location. Due to their differences, the interviews in which they each took part are clearly designated –

[6] It equates to about four extra tonnes of rice, which is realistic from even a small-holding farm upon introducing fertiliser

crucially, the interviews did not feel the same for any two translators. All of my translators were from a rural background in Cambodia; this made it easier for me as an outsider, both in ingratiating and communicating with participants from the villages. Their fluency was a primary factor in their effectiveness. With poorer proficiency, ‘if’ statements or those that involve hypothetical situations can be too complex to have their meaning conveyed. However, even with good language skills there is a difference in styles: literal translations are different from interpretations where a speaker’s words are modified to make more sense to a foreigner’s ears.

The translator’s level of technical knowledge is also a key factor. Certainly, for the discussions I had about biogas and biodigesters it helped to have a translator who knew about how they worked and the terminology around them. Good general knowledge on energy was necessary so that the interviewees meaning wasn’t lost, for instance, in conveying the units of energy that villagers used. Equally, specialist knowledge on research methods was essential in the recruitment of local research agents. The village chiefs who carried out surveys needed to understand stipulations of the procedure so that I could rely on the data.

The choice of the village chiefs as the agent to carry out surveys came from recommendation both by my translators and members of SNV and NBP. Within Cambodian villages the chief is a nexus of social relationships; they do not have dominance over the villagers but they are known and trusted members of that society. In my overnight homestays in villages the chiefs would be informed both as a measure of protection but also because villagers desired that openness with the chiefs. As research agents they benefitted from a knowing household and having a slight degree of patronage, this allowed them to survey a broad selection of people – though as in Samlout, best-practise is not to let them determine the entire interview sample.

The main project partner was the Dutch development group, SNV. Contacts there were invaluable in the planning and logistics of case studies. Their influence on the project's direction was only slight (the initial focus on biodigesters) and though tighter partnership may have meant I had less control, it may have been more useful in terms of understanding how a development organisation would use the kinds of tool I constructed. Consequently, the impact of this project will likely be more for academics than practitioners.

10.4 Closing remarks

The following discussion culminates the project and creates a point of departure for further work in the field.

10.4.1 Synthesis of the tools

The nature of how energy is accessed in fieldwork locations has been covered already, as has the design of the tools to appraise that access. This subsection discusses how the qualitative and quantitative approaches come together for mutual support, this reaffirming an answer to the third research question. The effect of each tool will be discussed so that their strengths can be identified, then the method and benefit of their synthesis will be made clear.

Chapter 9 demonstrates the appraisal; by design the quantitative methods are lightweight, they can be deployed rapidly and return a sizeable dataset. The second phase of qualitative methods support this with greater depth and description of what the surveys portray. The function of the first tool is more of an audit since it is a checklist of physical assets, these are used as proxies. Vitally, the API is not measuring energy access, just indicating the priority for development or further study based on the proxies of energy related assets. Though, applying that tool also establishes a link with the community by engaging a local research agent. This creates an insider informant and forges a potential contact for future activities in the area – the data gathering mission can then segue into a development initiative. The local research agent is the key to the village. Through the procedure of the API they help the main research team quickly and cheaply find a varied network of candidates for further study in the village. Also, depending on the standing of the local agent, they can vouch for the whole research team, thus facilitating further actions in the area.

In effect, this quantitative approach is useful for its exploration and census of an unknown location. Evidently, data gathering through household surveys is hardly a new approach – the novel outcome of this tool is to bring a subjective scoring mechanism to the fore, one that is guided by dialogue with rural energy users. The mechanism of the API combines data on physical assets and condenses it fairly. In the early phase of assessing energy access it is helpful to have this kind of information as a first step in identifying polar types within the village. Also, it is an efficient allocation of the study's resources: basic data to do with access does not require a full interview. Although, the API requires some methods more intensive than just surveys, for instance, the electricity tariff is a necessary indicator and it is also useful to be aware of issues such as: the frequency of blackouts, the legal status of wood resources and the hygiene of water bodies – with this, the 'census' of the surveys becomes contextualised. This begins the synthesis of the approaches.

The cooperation of the tools is furthered by using the survey data as a sample to find candidates for the follow-up interview. Again, this is for the efficient allocation of resources in the study: the point is that fewer people have to be interviewed to ascertain a picture of energy access in the village if they are presupposed to make a better cross section. The QAT relies mainly on interviews but is backed-up with observations or other ethnographic styles. These additional inputs into the researcher's understanding are so very important in a rapid study, especially because interviews are not always effective (see the limitations above). Essentially, the QAT seeks to harbour features of anthropology, interpretation and immersion into an alien setting, but to conduct them rapidly within a short timeframe. The premise of an RRA, and the tools of this project, is that the majority and the most significant information pertaining to energy access development can be found succinctly if multiple methods are combined wisely. The overall assessment appeals to the strength of different approaches, using observations and informal conversations to build up a general awareness, surveys to scope out the village and then finally well-targeted interviews to provide that in-depth information necessary for decision making.

Committing to these brief stints of data gathering can risk the research becoming rural development tourism, so whilst they must be treated with caution, they can still inform planning effectively because they are so timely. The range of data is broadened and the speed of exploration is accelerated when the methods are combined properly. The survey is not just a census but is also a probe, it acts to orchestrate the interviews and qualitative methods, which in turn allow for a deeper understanding of what the quantitative analysis can reveal. Thus, the qualitative tool has a role in assessing energy access; an implication is that rapid appraisal techniques, subjective scoring mechanisms and interpretive analysis should all be considered viable in methodology. Specifically, this relates to the aims of groups such as Practical Action in their call for more data on energy access.

10.4.2 Energy access development pathways

Some of the main drivers in the energy access literature are the significant quantities of death and illness caused by indoor air pollution, and the detriment to lifestyles that do not benefit from electrical energy services such as lighting or mechanical services such as pumped water. People in energy poverty have poorer health, their economic productivity is supressed, their engagement in media and culture is limited, and it is possible that the energy access they do have is more damaging to the environment. This subsection considers how that statement of energy poverty relates to Cambodia and what the research implies can be done about it. Discussing the pathways for developments in energy access answers the final research question on the output of the tools – it is relevant to the UNDP, SNV and other energy-related development actors operating in the country.

In Cambodia, the sustainability of woodland resources is a contentious topic and this is as much an issue of land rights as it is of forest management. There are success stories, such as with the CPF scheme in Chambok which has provided a measure of safety to the fuel access of the villagers there. However, the fuel they are using is wood or at best charcoal – everyday this is filling rural kitchens with smoke. Elsewhere, in Takeo for instance, biogasdigesters are successfully providing clean fuel to villagers whilst simultaneously improving their agriculture. In the areas where it is feasible, biogas technology is highly recommended yet some innovation is needed to bring the benefits of that technology to those who are unable or unwilling to use it. Though communal biogasdigesters are problematic and the pressurised canning of gas is a difficult procedure, these are vital avenues to pursue to ensure that the maximum amount of methane pollution is diverted to villagers' cook stoves. Other types of clean cooking fuel: natural gas and electricity; can play their part in development pathways. Electricity must become cheaper and generated cleanly for it to be a viable option and the finite supplies of gas must be prioritised for those areas that cannot use other methods, that is, where it is too arid for biodigesters and too far from grid electricity. As a more short term solution, the method of charcoal production would benefit from being modernised but also regulated so that the transition to cleaner fuels can be facilitated as departing from traditional methods will create a skills gap.

In terms of electricity, the overriding message from the last few chapters has been that the grid benefits users mainly because the supply is without limit and does not necessitate a chore of carrying batteries around to be recharged. Accordingly, the suggestion for many communities is that a mini-grid or solar home systems could suffice in the medium term. Particularly, the evidence shows that people can access electrical energy services outside of their homes, so whilst there is a need to provide convenient lighting solutions within the home, much of electrical access beyond this can be given elsewhere in the community. In particular, the communications and computing services which are impossible without electricity can be provided in schools or other community buildings; many of the associated assets are too expensive for rural farmers to risk investing in but it is crucial that there is some place in the villages for them to make communications and access media. It has been stated that owning assets, such as TVs and mobile phones, does not imply that a person has all the capabilities those devices offer – for this reason a short term recommendation is that educational promotion is made to rural areas about the potential of the devices that they already own: for example, the use of VCDs or mobile phones for remote learning and other information services available via telecommunications networks.

The final element of access, mechanical energy, is predominantly addressed through water infrastructure. Piping clean water to the homes of villagers or digging wells nearby for convenient access is vital infrastructure – from my research it is this element of energy access which is paramount in Cambodia. In terms of irrigation, the traditional behaviour relying on the rains is deep-set but endangered by the distortion of the regular weather patterns due to climate change. Resolving this could make the biggest impact on rural people, most of whom are farmers – more effective management of water systems is needed to reduce risk from flooding and drought. With more effective systems of irrigation farmers can grow crops in more than one season, vastly improving their income and food security. Alternately, as in Samlout, other non-flooding forms of agriculture can be promoted, for example, corn and soy. Though this will reduce the demand for water, it is still imperative to the resilience of villagers that water systems in their area are responsibly managed and that they can access the mechanical energy necessary to move that water to where it needs to be. The backbone of mechanical energy that rural people do access is given through the power tillers that many of them own and share. These machines run on oil, so in the long term their fate depends on the market for this and the transition to biofuels – if prices rise it will directly affect rural livelihoods. Fuel consumption can be decreased with more convenient water systems that would reduce the energy intensity of pumping.

10.4.3 Energy access as a lens to view poverty

This closing section of the thesis remarks on energy access in relation to poverty – on the utility of studying access when trying to understand poverty and upon the linkages between capabilities and energy.

The perspectives on poverty studied at the outset of this thesis can each been seen with the energy access lens. Income, assets and capabilities are related to energy access; the relationship is two-way as these factors determine what energy behaviours are possible and in turn, the effect of energy consumption governs each of those factors. Accordingly, it has been stated that the energy access lens is panoptic – this is its strength in that almost everything is related to energy in some form, so simply by understanding energy access, anything that is causing or sustaining poverty should be visible. Moreover, by taking a holistic view of energy behaviours, their interrelations and the broad range of related issues can be understood.

However, this research does have limitations to lay upon the all-seeing nature of the energy access lens: in the process of exploring what the qualitative approach on energy access can convey, the evidence mounted that there are issues of land ownership, identity and social conventions which are highly influential on poverty but are only tenuously associated with energy access. Since they turned up in this study, these issues are not invisible to the energy access lens – yet, it is increasingly clear that this lens must be applied within a study that takes a broad and open outlook on energy else it will fail to observe the political and social issues that are closely related to poverty but only indirectly to energy.

There is room to augment the energy access lens with approaches that would complement its scope, for instance, the energy-food-water nexus (FAO 2014). Though, attempting to broaden the scope indefinitely or even to understand all energy behaviours is unrealistic. The point of the associated assessment tools is to focus upon the most significant information, and whilst an inclusive and extensive framework is necessary for this, it is flexibility in the research methods which ultimately achieves that goal. In particular, the RRA style of research in data gathering should not be underappreciated.

In terms of energy access, an early motivation for this project was to redefine its measure; a stimulus here is that the de facto method of the Global Tracking Framework is simply to take the quotient of the population with a grid connection or modern cooking fuels. Throughout, this thesis has argued that there is more meaning to the concept of energy access than just availability of electricity or gas. There are many forms of energy and numerous aspects by which to consider access to it – its assessment should be far more complex and nuanced than a mere pair of binary indicators on electricity and modern fuels. By appreciating the social side of energy access, as in this thesis, its complexity grows to the extent that normative measures are incapable of assessing it and instead the appraisal methods are more suitable. With this more in-depth approach, the ideal of participatory development is brought to the centre as the analysis and opinions of the rural energy users become integral to the study, in line with Chambers' approach to development. Poor people are not reduced to numbers in a headcount, rather, their way of thinking is held as paramount. The conception of energy access in this project is to treat it less as an issue of statistics and objectives, and instead as more of a dynamic state of affairs which do not exist on a unilinear spectrum – though there are desirable and undesirable facets to a given state of energy access there is not an objective 'best' state of energy access to attain, rather less problematic states to work towards. Fundamentally, the means to analyse energy access for what needs developing and what is helpful development, comes from interpreting the users' perspective – in particular, the analytical framework that they inspired is one route to that.

In terms of tackling poverty, the energy access lens has a very basic advantage of being able to target those problems that hinder both survival and prosperous socio-economic development, with this all considered in the context of a sustainable environment. By removing their deprivations of energy poverty, a person is less restricted in their livelihood and lifestyle; these deprivations are quite plain to see in the analysis of what assets a person can use to access energy (thus assets are the constituents of the surveys) but also the discussion of the associated capabilities is highly informative about the meaning of that energy access (which is the central point of interviews). So, energy access can cut to the core of poverty but at the same time, it is easy to study; though it holds such great sway upon people's lives, it is remarkably easy to talk about (possibly with the exception of illegal energy sources, a topic which I avoided this time).

Truly, the greater strength of the lens is that it can make a bridge between the outsider and those they study. We all access energy in our daily lives and though these practices can seem so alien outside of our familiar territory, the underlying functions are universal. It is about satisfying basic needs. When talking to people about their energy access I found them both knowledgeable and willing to submit their knowledge – some of my participants were less open than others but information on how they access energy is something which they are quite willing to share, it is neutral ground. As a user of energy myself, especially one who was living with them in that context, I found it easy to relate to their explanations. The next step of planning initiatives to alleviate their poverty will always be the more difficult one, but the first step of understanding their situation, so providing the right knowledge platform for planning, is made easier with the energy access lens. Moreover, it is integration and interaction in that first step which facilitates the bottom-up style of development. It is not through the imposition of electricity grids or biodigesters that poverty will meet its end, but rather, through the amplification of the voice of the poor and acceptance of what they consider to be important, to be equally important, as aims on a global agenda. When the needs of poor people, for energy and in the way they want to access it, are recognised as principal in global development, then society can make progress.

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Appendix

Chapter 2

Correlations

Data is correlated using MS Excel's 'correl' function which applies the following formula to two arrays of data, X and Y:

$$correl(X,Y) = \frac{\sum(x-\hat{x})(y-\hat{y})}{\sqrt{\sum(x-\hat{x})^2\sum(y-\hat{y})^2}}$$

Where $\hat{x}$ and $\hat{y}$ are the arithmetic averages of X and Y.

	GINI	GDP/capita
Malaysia (2009)	46.21	7312
Philippines (2012)	43.03	2606
Fiji (2008)	42.83	4178
Thailand (2010)	39.37	4782
Indonesia (2011)	38.14	3648
China (2011)	37.01	5574
Lao PDR (2012)	36.22	1446
Vietnam (2012)	35.62	1755
Cambodia (2011)	31.82	879.2
Timor-Leste (2007)	30.41	551.7
Correlation	**0.769136… ≈ 0.77**	

	HDI	MPI
Cambodia (2010)	0.584	0.212
China (2009)	0.719	0.036
Fiji	0.724	-
Indonesia (2012)	0.684	0.066
Lao PDR (2011/2012)	0.569	0.174
Malaysia	0.773	-
Philippines (2008)	0.660	0.064
Thailand (2005/2006)	0.722	0.006
Timor-Leste (2009/2010)	0.620	0.360
Vietnam (2010/2011)	0.638	0.017
Correlation	**-0.66149… ≈ -0.66**	

Chapter 3

Percent changes in reserves of gas and oil fuels.

	GAS		OIL	
	Total World reserves (Trillion cubic metres)	Growth in reserves (%)	**Total World reserves (Thousand million barrels)**	Growth in reserves (%)
1980	71.6	-	683.4	-
1981	74.6	4.27	696.5	1.92
1982	77.0	3.14	725.6	4.18
1983	78.6	2.14	737.3	1.62
1984	81.3	3.43	774.4	5.04
1985	83.6	2.86	802.6	3.63
1986	89.6	7.11	907.7	13.10
1987	92.1	2.79	938.9	3.44
1988	96.2	4.52	1026.7	9.35
1989	106.9	11.09	1027.3	0.05
1990	109.4	2.34	1027.5	0.02
1991	114.6	4.75	1097.8	6.85
1992	117.1	2.19	1103.8	0.55
1993	118.3	1.01	1104.3	0.04
1994	119.1	0.70	1118.0	1.24
1995	119.9	0.66	1126.2	0.73
1996	123.6	3.04	1148.8	2.01
1997	126.8	2.58	1162.1	1.16
1998	130.1	2.64	1142.4	-1.69
1999	133.4	2.50	1281.8	12.20
2000	139.4	4.54	1300.9	1.49
2001	153.9	10.34	1305.4	0.34
2002	155.3	0.95	1354.9	3.79
2003	156.0	0.42	1362.1	0.53
2004	156.5	0.37	1366.2	0.30
2005	157.5	0.59	1374.4	0.60
2006	158.4	0.57	1383.7	0.68
2007	161.7	2.13	1419.0	2.55
2008	169.8	5.01	1490.0	5.00
2009	169.2	-0.40	1529.5	2.66
2010	176.4	4.28	1636.6	7.00
2011	185.8	5.32	1675.3	2.37
2012	185.4	-0.21	1697.9	1.35
2013	186.5	0.60	1701.0	0.18
2014	187.1	0.31	1700.1	-0.05
Average	130.3625	**2.90**	1197.9951	**2.77**

Source: (BP 2015b)

Chapter 5

Interview and survey scripts

Spring fieldwork

Interview script 1

Name, household composition, livelihood

What do you use biogas/electricity for?
Tell me about your first experience?
What can you do now that you couldn't before?

How do you keep track of your energy consumption?
What other fuels do you use?
How reliable are those fuels?

How has biogas/electricity affected your life?
Did you expect these benefits?

Who in the household knows how to use the energy system (biodigester)?
How did you/they learn?
What kind of help do you receive in maintenance?

If wood/kerosene were cheaper, would you use them?
How would you like your service (relating to NBP) to improve?
What would you be willing to pay for this?

Review: language too complex, questions too specific.

Interview script 2

Name, household composition, livelihood

How do you cook?
What do you do for lighting?
How do you get your water?
What else do you use biogas/electricity for?
What can you do now you have the biodigester/electricity cable?

How do you keep track of consumption?
What size is your biodigester?
What fuel did you use before biogas?

Do you use other fuels now?
How much do they cost?

What are the benefits of using biogas/electricity?
update what is the most important benefit to you?

Who provides training/education for using that energy?
How do you conduct maintenance?

Would you prefer a bigger or cheaper biodigester? **question scrapped, hypothetical statement**
How much effect does the slurry fertiliser have?

How many animals do you have?
What income does the household make?

Interview script 3

Name, household composition, livelihood

How do you cook?
What do you do for lighting?
How do you get your water?

How much fuel do you use per week?
How many lights do you have?
How much water do you use per week?

How much time/money does the biodigester save you?
What other fuels do you use?
Does the rainy season have any effect?
Who decided to invest in the digester?
Do you prefer the fertiliser or the fuel?

How does electricity affect your life?
What electrical 'materials' do you have?
Do you use the phone for 'personal' or 'business'?

Would you prefer a biodigester, a water pipe or an electricity cable?

Autumn fieldwork

Interview script 1

1. How many people are in your household?
2. What does each family member do?
3. Where do you get your food?
4. Who cooks the meals?
5. What stove do they use?
6. How do you get your water?
7. Who collects the water?
8. (if pumped/collected) How do you clean it?
9. Do you use the same water for irrigation?
10. Where do you get your wood?
11. (if applicable) Who collects it?
12. (if applicable) How long does it take to collect?
13. (if applicable) How much does it cost?
14. How much wood can you store?
15. How do you light your home?
16. How many lights do you have?
17. What do you use the lights for at night?
18. How many animals do you own?
19. Do you have a biodigester?
20. (if applicable) How big is your biodigester?
21. (if applicable) How much difference does the slurry make?
22. (if applicable) How do you fertilise your crops?
23. How long have you been using batteries/grid?
24. How much does a battery/grid connection cost?
25. What electrical appliances do you use?
26. For how long do you use each of these per week?
27. How do you travel to the provincial town?
28. How do you contact people outside of the village?
29. How do you get news?
30. Do you own any engines or machines?
31. How much fuel do these use?
32. How much does this fuel cost?
33. What do you share with your family/neighbours in the village?
34. Do you use electricity or machines in your livelihood?
35. How much income do you make through your livelihood?
36. What are your biggest expenditures?

Interview script 2

1. What is your name
2. What do you do for your livelihood
3. Who is the head of household
4. How many children live here
5. Who else lives in the household
6. What do the other members of the household do
7. Where do you get your food
    a. How far is the market
    b. Do other traders come to the house
8. Who cooks the meals
9. What stove do you use
10. Where do you get the wood/charcoal/gas
    a. Who collects it, how long does it take
    b. How much does it cost
    c. How much can you store
    d. How often do you need to get more fuel
11. Where do you get your water
    a. Who collects the water
    b. What kind of pump do you use
    c. How much does it cost
12. How many jars do you have
13. Do you boil your drinking water
14. Can you buy ice near here
15. What do you do for irrigation
    a. Is there always enough water for irrigation
    b. Do you farm in the dry season
16. How much agricultural land do you have
    a. How much can you grow on this land
    b. Is fertiliser expensive
    c. Where did you learn to farm
17. How many animals do you have
    a. Do you use the manure for fertiliser
    b. What do you feed the animals

18. How do you light your home
    a. How many lights do you have
    b. Where are they
    c. What do you use the lights for at night
19. Is this style of house traditional
    a. Where are the materials from
    b. Who built the house
    c. How do you repair the house
20. Do you have any engines or machines (tractor, pump, generator)
    a. Are these common in the village
21. Do you have a moto or car
    a. Where do you drive mostly
    b. Who owns the moto/car
22. How much fuel do you use
23. Where can you get your engine/moto repaired
24. Do you share any engines with other households in the village
    a. How much does it cost
    b. Do you only share with your family
25. Do you have batteries or a connection to the electricity grid
    a. How much does it cost
    b. What did you do before
26. What electrical appliances do you use
    a. Where did you learn about them
    b. Does everybody in the village own that
    c. What uses the most electricity
27. Do you own a mobile phone
    a. Is this for personal use or for business
    b. Do you use it to contact a middleman to sell your rice
28. Do you use the radio or TV to get news
    a. How else do you find out about the world
29. Are there communal spaces or restaurants to meet in the village
    a. How often do you go
    b. What do you discuss
30. What are your daily expenditures

Interview script 2 (translated into Khmer)

១. តើអ្នកឈ្មោះអ្វី?

២. តើអ្នកប្រកបមុខរបរអ្វី?

៣. តើអ្នកណាជាមេផ្ទះ?

៤. តើអ្នកមានកូនរស់នៅក្នុងបន្ទុកគ្រួសារប៉ុន្មាននាក់?

៥. តើមានអ្នកណាខ្លះរស់នៅក្នុងបន្ទុកគ្រួសារ?

៦. តើសមាជិកគ្រួសារទាំងអស់នោះធ្វើការអ្វីខ្លះ?

៧. តើអ្នកបានម្ហូបអាហារពីណា?

ក. តើផ្សារនៅចំងាយប៉ុន្មានពីផ្ទះរបស់អ្នក?

ខ. តើឈ្មួញនោះមកដល់ផ្ទះទេ?

៨. តើអ្នកណាជាអ្នកចំអិនម្ហូប?

៩. តើអ្នកប្រើចង្ក្រានអ្វីសំរាប់ចំអិនម្ហូប?

១០. តើអ្នកយកអុស, ធ្យូង, ឬ ហ្គាសពីណា? អ្នកណាជាអ្នករក, ហើយចំណាយពេលប៉ុន្មាន?

    ក. តើវាថ្លៃប៉ុន្មាន?

    ខ. តើជាទូទៅ រក ឬទិញទុកម្តងប៉ុន្មាន?

គ. តើរយះពេលប៉ុន្មានទើបទិញ ឬរកថែមទៀត?

១១. តើអ្នកយកទឹកពីណាមកប្រើប្រាស់? អ្នកណាជាអ្នកដងទឹក?

ក. តើអ្នកប្រើប្រាស់វិធីណាដើម្បីបូមទឹក?

ខ. តើអ្នកចំនាយលុយប៉ុន្មាន?

១២. តើអ្នកមានពាងប៉ុន្មាន?

១៣. តើអ្នកចំអិនទឹកសំរាប់ផឹកឬទេ?

១៤. តើអ្នកអាចរកទិញទឹកកកនៅម្តុំនេះបានដែរឬទេ?

១៥. តើអ្នកប្រើអ្វីសំរាប់បញ្ជូលទឹកក្នុងស្រែ?

ក. តើអ្នកធ្វើស្រែក្នុងរដូវប្រាំងដែរឬទេ?

១៦. តើអ្នកមានដីស្រែប៉ុន្មានហិចតា? តើអ្នកអាចដាំស្រូវបានចំនួនប៉ុន្មាន?

    ក. តើជីរសំរាប់ដាក់ស្រែថ្លៃដែរឬទេ?

    ខ. តើអ្នករៀនដាំស្រូវពីណា?

១៧. តើអ្នកមានសត្វគោក្របី ចំនួនប៉ុន្មាន? តើអ្នកប្រើជីអាចម៍គោ ឬអាចម៍ក្របីដែរឬទេ?

    ក. តើអ្នកយកអ្វីសំរាប់អោយក្របី ឬគោស៊ី?

១៨. តើអ្នកប្រើអ្វីសំរាប់បំភ្លឺផ្ទះ? តើអ្នកមានអំពូលភ្លើងប៉ុន្មាន?

    ក. តើវានៅឯណា?

    ខ. តើអ្នកប្រើភ្លើងអ្វីសំរាប់បំភ្លឺពេលយប់?

១៩. តើអ្នកមានផ្ទះម៉ូតបែបប្រពៃណីដែរឬទេ? តើវាធ្វើពីអ្វី?

    ក. តើអ្នកណាជាអ្នកធ្វើផ្ទះ?

    ខ. តើអ្នកជួសជុលផ្ទះដោយរបៀបណា?

២០. តើផ្ទះរបស់អ្នកមានគ្រឿងចក្រឬទេ ដូចជា ម៉ាស៊ីនបូមទឹក, គោរយន្ត ឬ ម៉ាស៊ីនច្រូតស្រូវ? តើវាមានច្រើនទេក្នុងភូមរបស់អ្នក?

២១. តើអ្នកណាជាម្ចាស់ម៉ូតូ ឬឡាន?

២២. តើប្រេងសាំងប៉ុន្មានលីត្រ?

២៣. តើអ្នកយក ម៉ូតូឬឡានទៅជុសជុលនៅទីណា?

២៤. តើអ្នកមានអោយអ្នកដទៃខ្ចីគ្រឿងចក្ររបស់អ្នកទេ ក្នុងភូមិអ្នក? តើវាថ្លៃប៉ុន្មាន?

ក. តើអ្នកប្រើវាសំរាប់តែគ្រួសាររបស់អ្នកមែនទេ?

២៥. តើអ្នកមានអាគុយ ឬតើអ្នកបានអ្វីសំរាប់ភ្ជាប់ភ្លើងមកប្រើក្នុងផ្ទះ? តើវាថ្លៃប៉ុន្មាន?

ក. តើអ្នកធ្វើដូចម្តេចពីមុន?

២៦. តើអ្នកប្រើប្រាស់ប្រភេទភ្លើងអ្វី? តើអ្នករៀនវាដោយរបៀបណា?

ក. តើអ្នកផ្សេងទៀតក្នុងភូមិប្រើប្រាស់ភ្លើងដូចអ្នកទេ?

ខ. តើប្រភេទសំភារៈអ្វីដែលអ្នកប្រើភ្លើងច្រើនជាងគេ?

២៧. តើអ្នកមានទូរសព្ទ័ទេ? តើអ្នកប្រើប្រាស់ផ្ទាល់ខ្លួន ឬការងារ?

ក. តើអ្នកប្រើវាដើម្បីទំនាក់ទំនងទៅឈ្មួញស្រូវដែរឬទេ?

២៨. តើអ្នកប្រើ វិទ្យុ, ទូរទស្ស៍ ដើម្បីទទួលព័ត៍មានដែរទេ? តើមានវិធីណាដែលអ្នកអាចដឹងពីព័ត៍មានពិភពលោក?

២៩. តើមានទីកន្លែង ឬភោជនីយដ្ឋានសំរាប់ជួបជុំដែរឬទេ? តើអ្នកទៅញ៉ាំកញ្ញាប់ទេ?

៣០. តើអ្នកចំណាយប៉ុន្មានជាប្រចាំថ្ងៃ?

Survey 1

Name:____

Address:______________________________________

Main occupation: ______________________________

Number of people living in the household: ________

	Please tick if you use or buy	How much does this cost you per month
Electricity cable	□	________________
Generator	□	________________
Battery	□	________________
Water pipe	□	________________
Water pump	□	________________
Water from truck	□	________________
Wood	□	________________
Charcoal	□	________________
Gas	□	________________
Motorbike	□	________________
Power tiller	□	________________
Rice miller	□	________________

How much agricultural land do you have? ________

How many animals do you have? ________________

Thank you for completing this survey, would you be interested in taking part in an interview next week: yes/no Phone number________

Survey 2

Name ________________________________

Address ________________________________

Main occupation __________________________

Number of people in household ______________

Tick if you collect, use or buy		How much does this cost you per month? (riel, dollar, hours, litres of fuel)
Electricity cable	☐	____________________
Generator	☐	____________________
Battery	☐	____________________
Water pipe	☐	____________________
Water pump	☐	____________________
Water from a truck	☐	____________________
Wood	☐	____________________
Charcoal	☐	____________________
Gas	☐	____________________
Motorbike	☐	____________________
Power tiller	☐	____________________
Rice miller	☐	______________________

Thank you for completing this form, would you be interested in taking part in an interview next week: yes/no

Participant Consent Form

A verbal translation of this form was given by the translator before participants signed.

Title of Research Project: *Energy access: changes inspired by electricity*

Name of Researcher: Jacob Gower

Participant Identification Number for this project: ______________

1. I confirm that I have been informed about the research project and I have had the opportunity to ask questions about the project. ☐

2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason and without there being any negative consequences. In addition, should I not wish to answer any particular question or questions, I am free to decline. *+44* 7593971864 ☐

3. I understand that my responses will be kept strictly confidential. I give permission for members of the research team to have access to my anonymised responses. I understand that my name will not be linked with the research materials, and I will not be identified or identifiable in the report or reports that result from the research. ☐

4. I agree for the data collected from me to be used in future research ☐

5. I agree to take part in the above research project. ☐

________________________ ________________ ____________________
Name of Participant Date Signature
(*or legal representative*)

________________________ ________________ ____________________
Name of person taking consent Date Signature
(*if different from lead researcher*)
To be signed and dated in presence of the participant

________________________ ________________ ____________________
Lead Researcher Date Signature
To be signed and dated in presence of the participant

Copies:

Once this has been signed by all parties the participant should receive a copy of the signed and dated participant consent form, the letter/pre-written script/information sheet and any other written information provided to the participants. A copy of the signed and dated consent form should be placed in the project's main record (e.g. a site file), which must be kept in a secure location.

Chapter 6

Correlations

Household size	Monthly cost of wood	Cost per person
6	1.875	0.3125
12	2.5	0.2083
4	3	0.75
3	10	3.3333
8	11.25	1.4063
4	12.5	3.125
6	12.5	2.0833
7	15	2.1429
7	21.429	3.0612

Average	**1.8248**

Household size	Monthly labour in collection	Hours per person (decimalised)
-	0.375	-
8	2.25	0.2813
4	8.75	2.1875
5	11.25	2.25
4	12	3
9	13.75	1.5278
7	15	2.1429
10	45.623	4.5623

Average	**2.2788**