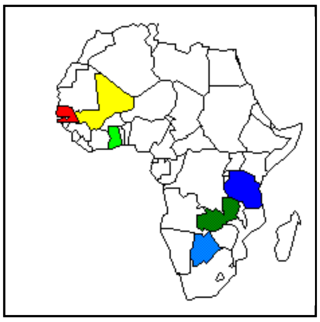
Intelligent Energy Europe



COOPENER

DEA
Development and Energy in Africa

Contract no. EIE/04/201/s07.43094

DEA

Development and Energy in Africa

Intelligent Energy – Europe (IEE)

Type of action: COOPENER

Key action: VKA11.1

Literature Survey Report

Start date of the project: 1 May 2005
Duration: 30 months
End date of the project: 31 October 2007

Project manager. Gordon A. Mackenzie
Risoe National Laboratory (DTU), Denmark
gordon.mackenzie@risoe.dk
tel: +45 4677 5171
Project website: www.deafrica.net

RISØ DTU

ECN
Energy research Centre of the Netherlands

Authors: Sten Dieden with Cheng Chia-Chin, Nicoline Haslev-Hansen, Miriam Hinostroza, Gordon A. Mackenzie.

Title: DEA Literature Survey Report
Department: Systems Analysis (SYS)

Abstract

This Literature Survey Report is part of the COOPENER project "Development and Energy in Africa (DEA)" initiated on 1 May 2005. The report covers project Work Package 2..

The 30-month project is implemented by Risoe National Laboratory (Technical University of Denmark – DTU[1]), Denmark as project coordinator, in collaboration with the Energy Centre of the Netherlands (ECN), and in partnership with six African Centres:

- Botswana: EECG
- Ghana: KITE
- Mali: Mali Folkecenter (MFC)
- Senegal: ENDA-Energy
- Tanzania: TaTEDO
- Zambia: CEEEZ

The overall objectives of the DEA project are:

- that national energy policy is better informed to take into account the complex linkages between energy interventions and social and economic development, and
- that energy interventions are better designed to contribute to real development needs, especially poverty alleviation and income generation, and otherwise achieving the Millennium Development Goals.

The immediate objectives of DEA are:

- to establish and apply an Assessment Framework for evaluating development and poverty impacts of energy interventions, and
- to engage in a dialogue with energy policy makers and other stakeholders on the basis of the framework, with a view to incorporating these issues in energy policy.

This literature review aims to identify and comment on recent literature that can guide and assist in the empirical investigation into links between energy and socio-economic development, as relevant to small- and medium-scale energy projects in developing countries. The literature surveyed is relevant to assessment of the impact of energy on micro level development, and either presents theoretical linkages between energy provision and micro level development or attempts to empirically identify such linkages. In addition, the review discusses theories, models, or approaches that may serve as guidance for the conceptualization of causal relationships between energy and development.

From the study of the literature we conclude that the project's immediate objectives seem well served by impact assessment studies. Both the conceptual and empirical approaches of impact studies are flexible and adjustable to the differing interventions, contexts and stakeholder groups, represented in the project. Such studies are furthermore suitable to the project's budget and are practically novel to the field of energy in development.

DEA Report number: Risø 2.1
May 2007

Contract no.:
EIE/04/201/s07.43094

Group's own reg. no.:
1215139

Sponsorship:
European Commission IEEA COOPENER Programme

Cover:

Pages: 53

Risø National Laboratory (DTU)
Energy for Development (EfD)
Systems Analysis Department
P.O. Box 49
DK-4000 Roskilde
Denmark
Telephone +45 46775171
gordon.mackenzie@risoe.dk
Fax +45 46321999
www.e4d.net

Table of contents

Preface

Development and Energy in Africa (DEA) is a project under the European Commission's Intelligent Energy - Europe programme COOPENER. Ultimately DEA aims to "support decision makers with the implementation of more sustainable energy policies, …" in line with the key action VKA 11.1 of the COOPENER programme. The project will do this by identifying and quantifying, where possible, the elements of concrete energy interventions that contribute to sustainable development (SD) and systematising this in an Assessment Framework which can enhance policy to promote energy for sustainable development.

The principal aims of the Development and Energy in Africa (DEA) project are (i) to identify and examine the developmental impacts of energy innovations and actions linked to improving energy access and poverty alleviation and (ii) to use the information obtained to improve on-going and future energy interventions through the energy policy makers and institutions in the countries concerned.

Specific energy activities in six African countries (Botswana, Ghana, Mali, Senegal, Tanzania and Zambia) will be examined with respect to development impacts and a methodological framework developed to feed results back into the conception and design of new projects. The Project is aimed at national energy- and development-policy makers, initially in the six participating African countries, but with a view to wider application in Sub-Saharan Africa. The project is also relevant for international and national energy, development and environment practitioners.

1 Introduction

The two overall objectives of the DEA project are, firstly, that national energy policy in developing countries becomes better informed to take into account the complex linkages between energy interventions and socio-economic development. Secondly, energy interventions should become better designed to contribute to real development needs, especially poverty alleviation and income generation, and otherwise achieving the Millennium Development Goals. Further, the immediate objectives of the DEA project are firstly, to establish and apply an Assessment Framework for the evaluation of development and poverty impacts of energy interventions. Secondly, on the basis of the framework, we aim to engage in a dialogue with energy policy makers and other stakeholders with a view to incorporating these issues in energy policy.

With the first, immediate objective in mind, this literature review aims to identify and comment on recent literature that can guide and assist in our empirical investigation into links between energy and socio-economic development, as relevant to small- and medium-scale energy projects in developing countries. Since we concern ourselves with small- and medium-scale energy projects, it is assumed that such projects will not have identifiable impacts on the macro economic level in the short run. We are thus especially interested in literature relevant to assessment of the impact of energy on micro level development. The literature which is relevant here will therefore either present theoretical linkages between energy provision and micro level development and/or attempt to empirically identify such linkages. In addition, we search for theories, models, or approaches that may serve as guidance for the conceptualization of causal relationships between energy and development.

The remaining five chapters of this literature study are organized as follows. As an aid in understanding empirical assessments, the next chapter discusses perspectives, models or theoretical linkages between energy provision and micro level development in the literature. Especially, the chapter introduces the Sustainable Livelihoods approach to the assessment of impacts from energy on development. While somewhat abstract, the approach provides perhaps the currently only comprehensive yet specific perspective on the issues under investigation here. Chapter 3 contains empirical substantiation of energy's role in development, starting with studies that link various energy interventions to the achievement of the Millennium Development Goals. Succeeding subsections summarize findings from a major investigation into impacts of rural electrification in the Philippines, findings in other literature surveys, and results from studies looking specifically at energy impacts on micro-enterprises in developing countries. Chapter 4 looks at methods for the quantification of consumer benefits from modern energy provision and the corresponding data requirements. Chapter 5 reviews the general features of "evaluation" or "impact assessment" studies from development interventions. Conclusions are drawn in the final Chapter 6.

2 Theories and models of linkages between energy and development

The focus of the DEA project rests with *demand side impacts* of energy interventions. In this chapter we shall derive an impression of the extent to which theories can help us predict and where to look for such impacts. In very general terms, the energy *supply* sides in developing countries face two overriding problems. Firstly, there is a widespread production and use of traditional energy sources, which pose several types of problems. Secondly, the access to modern energy sources is very unevenly distributed (Barnes and Floor, 1996). Approaching development impacts from a demand side perspective one wants to keep in mind however, that what is specifically in demand is not fuels or access to energy sources. It is *the services that energy may provide*, such as lighting, cooking, space heating, or pumped water (Muleguetta, Dunnet, Khennas, and Rai, 2006). Hence, in order to identify development impacts one would wish to understand *how end-users benefit from the access to such services*.

Reviewing the literature on the above issues, we shall first get an impression of how energy would enter the activities of the commonly modelled "agricultural household" of Economics theory. Thereafter we acquaint ourselves with the broader, more comprehensive Sustainable Livelihoods Approach. In the third section, we return to the overriding challenges facing the energy sectors in developing countries, by looking at the "energy ladder" model, which describes development from a household fuel use perspective, with some advice for how to boost such development. Finally, it is conceivable that once the supply of modern energy has commenced, many demand side effects add up to yield aggregated effects beyond what one may expect. Some theoretical support for such notions is reviewed in the last section of this chapter.

2.1 Lessons learned from an agricultural household model

In Economics, one of the most common means to analyze household livelihood generation in developing countries is the "agricultural household model"(Nakajima (1970), Singh, Squire and Strauss (1986)). In the model, a household is thought to derive income from the sale of agricultural produce, wage labour and/or non-labour (transfer) incomes. Typically, the model is applied to analyze how changes in various prices affect households' allocation of time into agricultural home production, off-farm wage labour and leisure. Here, however, the model will simply serve as a point of departure for intuitive reasoning about the role of energy services in household's production activities.

In the standard model, it is assumed that a household is endowed with fixed amounts of both agricultural land and of time available for labour. Based on notions of economic rationality and the prevailing prices of labour time, production inputs and final produce, the household time is optimally allocated into the three aforementioned activities. In the simplest version of the model it is furthermore assumed that the household can buy any amount of labour from outside or sell as it desires (from its fixed endowment) at a given wage rate.

As a first step, it useful to conceive of home production as encompassing a wider range of activities than merely agricultural production. Such activities can be classified into income-generating activities and (non-remunerated) domestic activities, such as cooking, catering for young and elderly, collection of fuelwood or water, and the accumulation of skills. The latter would include both pupils' homework as well as access to information via radio, television or telephony. Furthermore, it is noteworthy that collection activities indicate a dependence on local environmental conditions.

In this context, it is intuitively conceivable that access to affordable, modern energy can facilitate cooking, water heating, lighting and operation of tools or appliances, which in turn can enter a wide range of home production activities. In very general terms and under the assumption that households can afford to invest in equipment, improved energy services can *increase the productivity of labour* in activities that utilize electric light, tools, appliances or machinery.

Energy services can also *enable the household to engage in new income-generating activities* which become feasible with tools or appliances driven by modern energy, such as welding, soldering or cold storage. Turning to the *domestic activities*, it is easy to imagine that cooking and water heating may become *less time consuming, cheaper, and/or less cumbersome* with equipment driven by modern fuels. Hot water would also be a core component in the catering for young and elderly. Improved light may facilitate homework and extend business or domestic activities into the evening hours Access to electricity also *facilitates the use of media* - for both information collection and leisure activities - and allows for charging of cellular telephones.

With respect to water, improved energy facilities may *facilitate irrigation and water access* for domestic purposes. Finally, the switch to modern fuels *reduces the taxing of local natural resources and the need to allocate time into fuelwood collection* activities. The issue of time allocation lies at the heart of the model. It is quite conceivable that *time may be shifted* between different activities, as the productivity of labour is increased with modern technology and/or the need for labour in certain activities is reduced. The extent to which time saved is an asset crucially depends however, on the returns to time in alternative uses.

Hence, in summary, from the above set-up it seems conceivable that energy services may (i) increase labour productivity in household production; (ii) enable the household to engage in new production activities; (iii) facilitate or reduce labour time allocated to some activities; (iv) expand the number of hours available to activities previously dependent on (strong) daylight; (v) improve access and processing of information; (vi) enhance leisure activities; (vii) facilitate water access; (viii) reduce environmental degradation; and (ix) yield a more beneficial allocation of household time, depending on opportunities, needs, and preferences. It is however important to keep in mind, that the generalized impacts on this list apply to the household's own activities. As will be returned to below under the Sustainable Livelihoods Approach, the household operates in a context of for example employment opportunities, legislative and social regulations, as well as community and public services. That context may also be affected by interventions aimed at energy provision.

2.2 The sustainable livelihoods approach

The Sustainable Livelihoods Approach (SLA) represents a way of organizing, understanding and working with the complex issues surrounding poverty, which can be modified and adapted to suit local circumstances and priorities (Muleguetta *et al*, 2006). The framework can also be used as a tool for designing livelihoods evaluation as a conceptual framework for identifying influences and interactions as a 'checklist' for designing indicators of change; and as an aid to analyzing, understanding and structuring relevant data.

SLA has also been used extensively in development impact assessments of various sectors. DFID has developed a SL framework to see how these impacts can be enhanced by providing "empirical proof" of results and impacts of energy projects to poor's livelihoods. The aim of this section is to discuss how the Sustainable Livelihoods Approach (SLA) can be applied in practice in the assessment of energy sector interventions. Firstly, the definitional issues and the ideology surrounding the approach are drawn together. Thereafter some of the central conceptual and methodological of the approach are presented. Finally, the concepts and methodology are illustrated in application to energy issues.

2.2.1 Definitional issues and the ideology

In the words of Chambers and Conway (1992) "a livelihood comprises the capabilities, assets (stores, resources, claims and access) and activities required for a means of living". A livelihood is sustainable when it (i) can cope with and recover from stress and shocks; (ii) can maintain or enhance its capabilities and assets; (iii) can provide sustainable livelihood opportunities for the next generation; and (iv) contributes net benefits to other livelihoods at the local and global levels, in both the long and the short term.[1]

The Livelihood thinking was developed by Chambers (1987) in response to the many failures of the conventional development concept and its applications through international development cooperation. Since the onset, the approach has also been influenced by recognition of the importance of participatory approaches in analysis of development and poverty as well as by the growing focus on policy frameworks, governance, and the role of communities in enhancing development (Eade and Williams (1995), Scoones (1999), Ellis (2000), DFID (2002)).[2]

SLA contends that development activities can become more effective through a systematic understanding of poverty, its causes and of the means by which poor people in differing contexts generate their livelihoods. The approach takes on a wider, cross-sectoral view of the opportunities for development and how these relate to peoples aspirations and priorities. From a viewpoint that traditional analyses, with predominantly technical and income focuses, have only very limited capacity to capture multi-dimensional aspects of development interventions, SLA focuses on people and communities both in analysis and in the setting of development objectives (Cherni (2003), Muleguetta *et al*, 2005).

[1] The literature reviewed for these purposes is not particularly clear on what *sustainable* livelihood is. As with the now commonly used term 'sustainable development', uneasy compromises between different objectives embedded in the same definition are common. In very general terms however, 'sustainable livelihoods' appears to relate to a wide set of issues subject to the broader debate about the long term relationships between poverty, environment and development.

[2] The SL approaches have been used by different organizations and agencies such as UNDP, IDS, Oxfam, CARE, and DFID. These institutions and others have contributed to the evolution towards understanding the livelihoods approach and how the concept of sustainable livelihoods can be promoted in practice. The wide range of users has led to different representations and frameworks of sustainable livelihoods, all of which address similar basic concerns but reflect different priorities of each organization. Carney, Drinkwater, Rusinow, Neefjes and Singh (1999) summarize the highlights of the above mentioned agencies' livelihoods work and draw preliminary lessons about the practical application of livelihoods approaches.

2.2.2 Key concepts and terminology

The theoretical model underlying the SLA assumes that each person/household in a community is able to achieve a *livelihood*. The model is illustrated in Figure 2.1 and each of its core concepts will be reviewed below. It is furthermore assumed that *livelihood resources* are available subject to a particular vulnerability context. Further, pertaining *institutions and processes* are thought to enable or constrain the achievement of sustainable livelihoods for different groups of people as they design their *livelihood strategies* which are subject to all of the above and yield *livelihood outcomes*.[3]

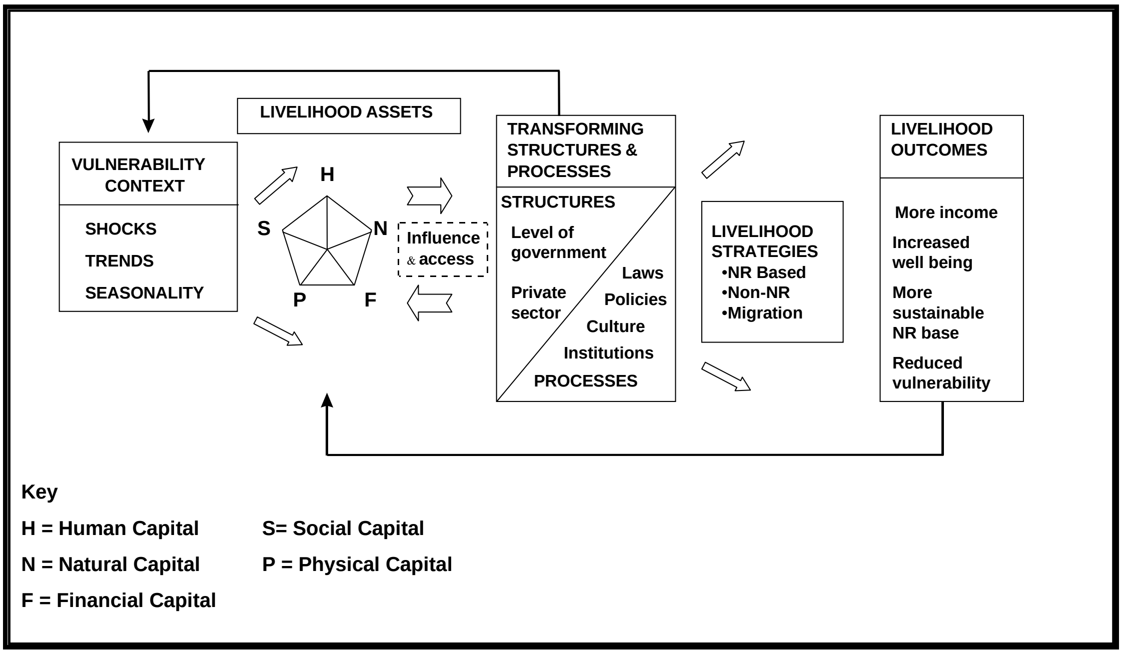


Figure 2.1 The Sustainable Livelihoods Framework

2.2.2.1 Livelihood resources

Livelihood *resources* are often referred to as assets or different types of 'capital'; natural, human, social, physical, and financial capital. An accurate and realistic understanding of people's strengths (i.e. their "assets" or "capital") is crucial to analyse how they endeavour to convert their assets into positive livelihood outcomes (Bebbington, 1999). Among the five categories of assets financial capital is probably the most versatile as it can be converted into other types of capital or it can be used for direct purchase (achievement) of livelihood outcomes. However, financial capital tends to be the asset least available for the poor, which makes other capitals important as substitutes. The different types of capital are discussed in more detail in Box 2.1.

2.2.2.2 The vulnerability context

The vulnerability context forms the external environment in which people exist and gain importance through direct impacts upon people's asset status (Devereux, 2001).

[3] In the practical application of the model it is also assumed that the achievement of sustainable livelihoods can be assessed through relevant "outcome indicators".

It is made up of e.g. policy settings, politics, historical circumstances, agro-ecology and socio-economic conditions.

Livelihood assets/capitals	Description
Human Capital	Skills, knowledge, ability to labour and good health that together enable people to pursue different livelihood strategies and achieve their livelihood objectives.
Social Capital	Social resources upon which people draw in seeking for their livelihood outcomes: networks and connectedness. Social capital is often determined through birth, age, gender or caste and may even differ within a household.
Natural Capital	Natural resource stocks from which resource flows and services (such as land, water, forests, air quality, erosion protection, biodiversity degree and rate of change, etc.) useful for livelihoods are derived.
Physical Capital	Basic infrastructure and producer goods such as affordable transport, secure shelter and buildings, adequate water supply and sanitation, clean, affordable energy and access to information.
Financial Capital	Two main sources of financial capital can be identified: ▪ Available stocks comprising cash, bank deposits or liquid assets such as livestock and jewellery, not having liabilities attached and usually independent on third parties ▪ Regular inflows of money comprising labour income, pensions, or other transfers from the state, and remittances, which are mostly dependent on others and need to be reliable.

Box 2.1 Elaborations on the types of capital recognized in the Sustainable Livelihoods Approach.

2.2.2.3 Institutions and processes

Institutions can be formal or informal and. processes are found imbedded in matrices of institutions and organizations. Also known as “Transforming Structures and Processes”, the institutions, organizations, policies and legislation shape livelihoods. Structures can be thought of as the ‘hardware’ that set and implement policy and legislation, deliver services, purchase and trade. Using the same allegory, processes can be thought of as the ‘software’ that determines the way in which structures and individuals operate and interact (DFID, 2000).

2.2.2.4 Livelihood strategies

Livelihood strategies denote the range and combination of activities and choices that people make in order to achieve their livelihood goals, including productive activities such as agricultural intensification or extension, livelihood diversification, or migration, but also investment strategies and reproductive choices (DFID, 2000). Strategies can be described at an individual, household and village level, as well as at regional or even national levels.

2.2.2.5 Livelihood outcomes

Livelihood outcomes are the achievements or outputs of livelihood strategies. The approach stresses that outsiders should investigate, observe and listen, rather than jump to quick conclusions or making hasty judgments about which outcomes people pursue. It should not be assumed that people are entirely dedicated to maximizing their income. Rather, one should recognize and seek to understand the richness of potential livelihood goals. This, in turn, will help to understand people's priorities, why they do what they do, and where the major constraints lie (DFID, 2000).

2.2.3 Concepts and terminology applied in an energy setting

2.2.3.1 The Vulnerability Context

In an energy setting the vulnerability context is represented by structural conditions that will set the conditions for energy requirements and opportunities. Such conditions identified in the literature relate to geography, population density, trends in governance and in technology, and to shocks.

Geography The geographical context determines various aspects of energy access and availability e.g. the extent and form of the biomass resource, the availability of falling water, wind, insulation, and other sources of energy such as coal, oil, gas, geothermal energy. Geographical conditions will also affect both the choice of energy infrastructure such as pipelines and power distribution, as well as the cost of improving such structures.

Relative location or remoteness can add to the costs of all energy supply options but it can increase the relative attractiveness of renewable energy supply (such as micro-hydro and photovoltaic systems) relative to other options that require transportation of fuels. However, for the latter options one should not overlook the cost of frequent visits from urban-based technicians required to maintain such systems.

Climatic conditions, which are derived from geographical location, determine the needs for energy end-uses such as space heating or cooling. The need for energy also fluctuates in relation to seasonality, which encompasses e.g. variations in temperature; agricultural seasons and availability of raw materials. Transport-dependent costs of installing and maintaining infrastructure or delivering fuels, equipment and spare parts, and maintenance vary according to the season. Energy supplies that depend on, for instance, water, biomass and wind also vary by season. The moisture content of biofuels and their combustion characteristics are also affected by the season.

Population density The population density in a particular area can affect certain conditions like market size, costs and prices. For instance, load density, or the amount of the service used or purchased along an electricity line, or the choice of a kerosene distribution route are major determinants of unit costs and prices. Low densities favour modular options such as photovoltaic systems over grid extensions. Rapid changes in population put particularly pressure on the sustainability of biomass and other fuel systems

Trends in governance and in technology Trends in governance and politics determine the threats and opportunities for poor people access to energy services. Political promises of grid electrification may undermine people's willingness to invest in alternative decentralized options.

Technological trends in recent years involve massive technical innovation that has altered people's ideas of what is possible. Improvements in small-scale energy conversion technology have increased efficiency and reduced costs, particularly with photovoltaic cells, but also small fossil fuel engines, wind generators, micro hydro biogas, and biomass gasification. The use of gas for power generation using gas-fired combined cycle gas turbines has meant that electricity can now be generated on a relatively modest scale at costs that are competitive even with the largest coal-fired plant, reducing the power of natural monopolies.

Shocks Major energy-related shocks have tended to be associated with the availability and price of oil products, which affect both the micro and macro economy. All energy delivery systems are vulnerable to natural and man-made disasters, to war and conflicts.

2.2.3.2 Livelihood assets

A number of linkages between livelihood assets and energy can be conceived. Below some of the conceivable linkages are presented as pertaining to each type of capital.

Natural capital The main natural capital asset of poor people in developing countries is likely to be biomass that can be used as a fuel such as wood, twigs, leaves, crop residues, dung and human waste. Other energy-related natural capital assets include falling water, wind, and solar insulation. However these sources require other forms of capital to convert them into useful energy. The sustainability of the sources is affected not only by their use as fuel, but also by changes in land use. For instance, fuelwood becomes less available when land is cleared for food production. However, changes in land use that improve access can also induce exploitation of local natural resources.

Social capital Networks and social relations often determine individuals' access to:

- natural resources - e.g. fuelwood from a particular location
- energy-conversion technology that is owned by others - grain mills, baking ovens, machines for preparing land or irrigation pumps
- other people's skills - electricians, engine repairers; and
- information about technical or managerial alternatives

Human capital Healthcare, education, communication can be improved as a result of energy for lighting, pumping, refrigeration and communication. Access to skills is also required for many aspects of energy service delivery, and for some aspects of energy use.

Physical capital The productivity of labour and other inputs into commercial or domestic production can be enhanced by access to energy sources and end-use technologies such as stoves, lamps, household appliances, machines, and radios. These technologies convert energy into a useful form that enables inanimate energy to replace the drudgery of human labour. In some instances it is also conceivable that access to these conversion technologies may decrease the costs of (or time spent on) production and product prices Also transport services can be improved through access to reliable and reasonably priced fuels.

Financial capital Improved income and lower prices help improve financial capital. Thus, cheaper and more convenient fuels in association with conversion technology devices that improve productivity would enhance this type of capital. However, in the absence of hire-purchase or down-payment schemes, the "lumpiness" of investment into energy conversion devices means that poor people often cannot accumulate enough cash to buy them, even though there would be considerable cash savings over the medium-term future. The same applies to lower prices associated with bulk purchase of fuel, e.g. when kerosene is often bought by the cupful. Modern renewable energy conversion technologies share a similar characteristic in that high initial capital costs militates the benefits of lower recurrent fuel costs relative to fossil fuel based technologies.

2.2.3.3 Institutions and Processes

In an energy setting, linkages with institutions and processes can be conceived of at the national, local and community government levels, as well as the micro levels such as firms, NGOs, legislation and gender relations.

National government The responsibility for the supply of electricity and for the regulation of all the energy supply industries – such as electricity, fossil fuels, and much of the monetized wood and charcoal markets – often rests at this level. National government is also responsible for much of the “enabling environment” required for efficient public and private sector development in the energy service industries. The government is the main source of subsidies of energy related services, for energy price control and for energy taxes, and the taxes on imported energy conversion technology. It is the main regulator determining the type of ownership and degree of competition at each part of the energy supply chain.

Local government Responsibility for smaller scale energy infrastructure, and particularly the rate and direction of grid extension, is often found at this level. Transport infrastructure, which affects the availability, reliability and cost of fossil fuel delivery costs, is in most cases also under the influence of local governments. Similarly, local government is also responsible for regulation and permits associated with small-scale energy retail businesses, such as electricity supply to rural bazaars, the production and sale of charcoal; access to communal resources such as water for hydro power; and “way leaves”[4] for electricity.

Community The mobilization, organization and development of schemes to introduce decentralized energy supplies – such as diesel mini-grids or micro-hydro - and in the regulation of such schemes often take place at this level.

Firms The main providers of energy services are often found at this level, as are also, often in partnership with government, the suppliers of energy related infrastructure. Small and micro firms are likely to be the main actors in the supply and use of energy services that are used by poor people, such as informal retailers of electricity in urban slums, sellers of kerosene, candles and charcoal.

Non-governmental Organizations NGOs can play important role in interventions to improve energy services at the local level for instance through the introduction of appropriate energy technologies, organizing community-based initiatives to meet locally defined energy needs. NGOs represent important sources of technical and other information and are sometimes restricted by funding inclination or expertise to a limited range of technical options.

Laws Regulation of the provision of energy services, including public health and safety, is done through legislation. The same applies to contract tender procedures for infrastructure construction and monopoly powers of the state and utilities in the supply of energy services.

Gender relations Women are the main users and suppliers of energy at the household level in poor communities. Women’s empowerment may result from reduced indoor air pollution, reduction of time consuming tasks such as fuel and water collection, milling, grinding, food preparation, and other productive tasks. Improved lighting

[4] Permission to cross, or a right of way across, land; also, rent paid for such right.

can provide safer night-time environment, access to the outside world through radio and other information and communication technology, better light for reading and other night-time tasks and less frequent pregnancy. The poverty impact of energy-related interventions will be largely determined by the end-use technologies that are adopted, and the impact on gender relations will in turn depend on the extent to which women are empowered to choose.

2.2.3.4 Livelihood Strategies

New or improved livelihood strategies may arise when time is saved and allocated into new activities due to the access to improved energy services or from fuel switching. Two examples at the household level are the use of improved biomass stoves that reduce cooking time or improved and extend lighting, for instance when electrical light replaces candles or kerosene, which facilitates the conduction of tasks during evenings.

In the best case the improved livelihoods may become self-perpetuating process, when increased production efficiency that results from improved energy services yield earnings that allow households to pay for improved energy services. Opportunities can arise from an assortment of technologies ranging from agro-processing to the use of mechanical devices or household appliances in small and micro enterprises.

Further, a strategy that involves households pooling energy demand can alert decision makers to required local economies of scale associated with energy supply technologies. Such technologies would involve grid connections - including investment in transformers and distribution systems - and instalment of micro hydro generators or small diesel engines, as well as the acquisition of mechanised transport services. Pooling efforts may also yield political or commercial pressure to gain access to energy services that improve not only home production or household consumption activities, but also community facilities in the field of health, education, outdoors lighting for security purposes as well as access to information and communication technologies.

2.2.3.5 Livelihood Outcomes

Despite the reservations referred to above, the most common livelihood outcome mentioned in the Sustainable Livelihoods literature is income. More income may come from the sale of energy services, from energy related productivity gains, from energy related expansion of supply options and quality, i.e. doing things that are impossible without in animate energy, or from extending the working day through improved lighting, and from better access to fuel based transport.

Other outcomes that also result from energy interventions would be captured by the wider concept of increased well-being. Such outcomes encompass reduced indoor air pollution from the use of improved fuels or improved stoves or the reduced burden from fuel collection and processing when electricity is provided. Better lighting in schools and street lighting may increase education. Health conditions in the population will benefit from medical services that utilize improved lighting, refrigeration of vaccines, and communication will improve health. Access to information through radio, television and other information technology will improve well-being through a sense of inclusion in the "modern" electrified world.

Furthermore, households' vulnerability may be reduced in a number of ways. Energy-driven irrigation may result in a more stable water supply, which would also have positive health impacts. Better lighting and the supply of less flammable fuels may result in an increased sense of security. Improve food security, when energy services render production based on a wider range of raw materials, agricultural output from mechanisation and pumped irrigation, post harvest processing, improved storage and fuel based transport. An associated diversification across a greater number of crops or income sources may reduce financial risks. In the long run households may also benefit from a more sustainable use of natural resources when “mined” biomass is replaced by more convenient, efficient /or renewable fuels.

2.3 The energy ladder

Where people don’t have access to modern energy, they are undermined in productive undertakings or in their efforts to raise their living standards (Barnes and Floor, 1996). Two obstacles to such efforts are the loss of time and money associated with reliance on traditional fuels. Less time is available for productive activities if fuelwood must be collected. Costs associated with expensive energy sources imply lower expenditures on other necessities. In addition, negative impacts are found on human health, from smoke produced by traditional biomass stoves, on the environment, from inefficient energy production, and in the form of inferior energy services, as in the case of light from kerosene not being sufficient for pupils’ homework in the evening.

From the perspective of energy fuel use, development has for a long time been modelled as the ascent of a “rural energy ladder” (Barnes and Floor, 1996). In general, such an ascent follows a movement away from the utilization of human, animal and biofuel power to a mix of traditional and modern fuels.[5] Empirical studies raise objections to the model’s disregard of commonly observed multiple fuel uses and the persevering adherence to established, traditional techniques even in the face of modern alternatives (e.g. Masera, Saatkamp, and Mammen (2000)). Nevertheless, the approach serves to delineate two overriding problems in the energy sectors of developing countries. Firstly, there is a widespread production and use of traditional energy sources, which poses economic, environmental and health problems. Secondly, the access to modern energy sources, such as electricity, petroleum or gas products, is very unevenly distributed. Consequently, energy strategies for developing countries would have two objectives; to make the production and use of traditional fuels more sustainable and to enhance a social transition to clean, modern fuels.

In the pursuit of the social transition, Barnes and Floor (1996) stress the roles of demand and local participation as driving forces. The authors accordingly attribute considerable importance to the creation of enabling conditions for income growth, the reduction of costs and increased access to modern fuels, while prices should in general reflect true scarcities rather than being subsidized. The authors furthermore point to two features of successful energy interventions. Firstly, incentives for the development of agriculture and related industries should be present. Secondly, modern energy provision should relate to social and economic infrastructures, such as water supply, health interventions, education, and road works, which make energy provision more meaningful.

[5] Currently and in terms of the main end-uses of energy in developing countries, wood is the preferred fuel for cooking and (where needed) space heating. In certain cases, agricultural residue or dung, kerosene, coal or biogas may be alternatives for cooking and coal for heating. For lighting, those lacking electricity commonly use candles or kerosene. Wealthier households use electricity if it is available, since it is more convenient and the quality of lighting is higher. Tools and appliances are run where electricity (or storage cells) is available.

In this view, energy provision is not a substitute for other development programmes but a *contributing factor* in development. The successful delivery of energy services is thus strongly related to the knowledge and understanding of local needs. Consequently, energy's impact to development should be assessed in the capacity of a contributing factor. The implied yardstick of such assessment is the extent to which interventions contribute to meeting local needs.

2.4 Energy and development — aggregated micro effects with multiplier effects and increasing returns

Theoretical models of economy-wide increasing returns from energy services are reviewed by Toman and Jemelkova (2003). Such effects obviously have a bearing on the traditional economies-of-scale notion in the early stages of industrial development. However, it also brings into light the importance of (aggregated) small-scale impacts from energy provision in rural development, with enhanced production capacity as associated with better education, less drudgery and better health, as well as more home-business opportunities.

The authors refer to two theoretical approaches within which energy availability contributes to the expansion of economic activity with multiplier effects. Firstly, if energy availability increases incomes, this would raise consumption from the baseline level, which increases production and incomes by the classic, Keynesian multiplier effect from increasing demand. Secondly, it is argued that energy input in itself, as well as the time-savings it may give rise to, yields increasing returns to scale in industrial production at early development stages. The authors proceed to discuss multiplier effects from other, non-energy inputs and illustrate how investments in energy provision yield disproportionate returns at different stages of economic development.

Some specific links through which small-scale impacts may accumulate to generate multiplier effects are:

- reallocation of household time, especially by women, into education or income-generating activities
- greater flexibility in time allocation as activities extend into the dark hours of the day
- health-related benefits from e.g. reduced indoor air pollution, access to clean water, and refrigeration
- enhanced productivity in education
- economies of scale in industrial activities
- utilization of more efficient capital stock with modern technology;
- decreased transportation and communication costs, which yield improved access to information and markets

These channels represent both supply and demand side effects, as well as a mix of opportunities that could arise with improved energy services. The authors stress however, the importance of tracking demand-side benefits of energy availability, since the effects reside not only with improvement in quality of life, but with increased production possibilities of the entire economy. The authors conclude with an encouragement of empirical studies into both the extent of multiplier effects of energy provision and into the causal linkages between energy and development, especially in countries at early stages of development (Toman and Jemelkova, 2003).

3 Empirical substantiation of links between energy and development

Two events have, perhaps more than anything, contributed to putting energy on the poverty alleviation and development agenda. Those events are the United Nations Conference on Environment and Development (UNCED) in 1992 and the World Summit for Sustainable Development (WSSD) ten years later. Especially the World Summit motivated international NGOs, donor organizations and various branches of the United Nations to prepare documents, which state the institutions' respective stances on energy's role in development and in the alleviation of poverty (UNDP (1992), ESMAP (2000)).

Many of these documents propose and illustrate important roles for energy in improving Third World livelihoods through facilitated water access, health and education services, as well as through the enhancement of agriculture and preservation of biodiversity. With the widespread adoption of the Millennium Development Goals (MDGs), several documents of similar kind also prescribe crucial links between energy services and the accomplishment of those goals (Modi, McDade, Lallement, and Saghir (2005), DFID (2002b), UN-Energy (2005)). Over time, documents like these have come to reflect an increasing realization, as pronounced in DIFID (2002b), that energy in a developing country context needs to be understood as not primarily being about technology provision, but of understanding the impact of energy on the livelihood opportunities of the poor and how the poor value and use energy.

Yet, in many such documents it is not clear whether proposed links between energy and development have been substantiated or are simply hypothesized. However, quite a few studies do exist, which present evidence of a number of development impacts, although the specific causal relationships are rarely disclosed. Below we therefore discuss documents of the type mentioned above, as well as papers published in scientific journals, working or project papers, that all refer to the Millennium Development Goals. In section 3.2, we briefly review results from a household survey designed to analyze impacts from rural electrification in the Philippines. In section 3.3 we take a closer look at results presented in previous literature studies.

3.1 Studies linking energy to the Millennium Development Goals

In this section we present studies with substantiated impacts on the MDGs, separated for each of the goals. In order of appearance the boxes list interventions with evidence of impacts that contribute to: (i) the achievement of universal primary education; (ii) the reduction of extreme poverty and hunger; (iii) gender equality and empowerment of women; (iv) reduction of child mortality, improvement of maternal health and the combat of HIV/Aids, malaria, and other diseases; and (v) environmental sustainability. In summary, there is a fairly rich literature of findings, claiming to provide evidence of impacts on MDGs pertaining to poverty, gender inequality and health issues. Fewer studies, however, present impacts on education and environmental impacts. The relative magnitudes of evidence should perhaps not be read as energy provision being of less importance in the latter cases. The lesser amounts of evidence may also relate to the greater difficulty in monitoring progress towards those goals.

The findings in Box 3.1 can be summarized as examples of how modern energy (i) allows the uptake of novel and/or additional income-generating activities; (ii) promotes greater efficiency in the production of prevailing activities; and or (iii) frees up time from unpaid tasks into income-generating activities. Some studies point to income generated for those producing or running equipment used in the project. While these incomes would be observed, they may not, however, affect the majority of the targeted groups.

Intervention/project	**Evidence**
Manufacturing, distributing and using improved Upesi cook stoves in Kenya.	Cash savings among users and income generated for stove producers and distributors. Saved health expenditures among users (Njenga, 2001)).
Production and use of biomass briquettes in Malawi.	Increased income for briquette producers and time saved from not having to collect firewood (Mabona, 2001).
Provision, production and use of battery operated lamps in Bangladesh.	Increased income from extended business hours and increased quality of life through better lighting (Khan, 2001).
Improved shea butter production process with motorized plate mills in Ghana.	Daily production capacity increased by 200 percent (Mensah, 2001).
Improved fish smoking with an LPG-fired oven in Ghana.	Reduced fuel expenditure (Mensah, 2001).
Operation and use of multifunctional platforms in Mali.	Increased production or value added from manual work. Increased income from larger production volume. Increased trade opportunities (Burn and Coche, 2001). Reduced time spent milling cereal and de-husking rice. Increased production and consumption of food (Anderson *et al*, 2005). Reduced working hours for women. Reduced risk of family members foregoing evening meals. Time and released for productive agricultural or other income-generating activities. Alleviation of seasonal financial stress through diversification into non-farming income-generating activities. Cash received by MFP operators(Brew-Hammond and Crole-Rees, 2004).
Rural micro hydro projects in Nepal.	Income generated by participants through productive activities using electricity, including setting up micro-enterprises (Rana-Deuba, 2001).
Using and distributing solar PV system, including loan programme in Uganda.	Improved efficiency and quality work in income-generating activities (Sengendo, 2001)).
Geothermal power project in Kenya.	Increased tourism, businesses, income and improved infrastructure (Mariita, 2002).
Rural electrification programme in Brazil.	Most income indicators showed positive correlation with access to electricity in 1991 but the correlations were considerably weaker in 2000 (Berg *et al*, 2005).
Installation of biogas digesters for cooking and water heating in rural China	Among families with biogas digesters, per-capita energy consumption is 25 percent lower and consumption of fuel (stalk and straws) is almost 50 percent lower, than among those without (REN21, 2005).

Box 3.1 Interventions with evidence of impacts on MDG 1 – reduction of extreme poverty and hunger

Several of the seven studies referred to in Box 3.2 point to the beneficial impacts on children's home study conditions of having access to electrical light. Other studies point to the freed up time for children who are employed in income-generating activities as well as increased expenditure on school fees from income generated thanks to modern energy.

Intervention/project	**Evidence**
Manufacturing, distributing and using improved Upesi cook stoves in Kenya.	Increased income helped to pay children's school fees and reduced children's dropout rates (Njenga, 2001).
Provision, production and use of battery operated lamps in Bangladesh.	Increased hours of studying at home for children and adults. Families with school age children show significant interest in purchasing lamps (Khan, 2001).
Operation and use of multifunctional platforms in Mali.	Lower drop-out rates among school children. Greater proportion of children entering secondary school (Anderson, Fracchia, Lang and Porcaro, 2005). Reduced employment of children (especially girls) for domestic activities thus increases school attendance and performances (Brew-Hammond and Crole-Rees, 2004)).
Rural micro hydro projects in Nepal.	Electricity improved children's studying conditions (Rana-Deuba, 2001).
Rural electrification programme in Brazil and the Philippines.	Literacy rate and gross enrolment ratio show a positive correlation with access to electricity (Berg, Díaz-Wionczek, Gelman, Granof, and Porcaro (2005), Blanchard, Porcaro, Shigeoka, and Yokota (2005)).

Box 3.2 Evidence of impacts on MDG 2 – achieve universal primary education.

Box 3.3 presents the studies that demonstrate impacts on gender inequality through energy interventions. Considering that energy is in many cases a substitute for human labour, and that women in developing countries are burdened with a disproportionate share of that labour (World Bank, 2004), one should perhaps not be surprised by the multitude of findings pertaining to this MDG. However, while some impacts pertain to reduced drudgery or time saved among women, other impacts such as reduction of reduction in of indoor air pollution, which results in diseases to which women are more exposed, increased income, social status, and school participation among girls appear. A component of several projects was also to equip women with skills for running businesses.

In addition to the reduction in diseases from indoor air pollution, a number of health related impacts from energy provision are recorded in Box 3.4.

Intervention/project	**Evidence**
Use of improved cook stoves in Kenya.	Reduction in risk of getting acute lower respiratory infections (ALRI) and acute respiratory infections (ARI) in adult females (Ezzati and Kammen, 2002).
Manufacturing, distributing and using improved Upesi cook stoves in Kenya.	Women who participated in the programme generated income to support their families. The use of improved stoves reduced ARI and conjunctivitis in mothers by 65-67 percent. Time savings for women of approximately ten hours per months from the use of improved stoves (Njenga, 2001).
Production and use of biomass briquettes in Malawi.	Women who were trained for briquette production were also trained in entrepreneurship, and business management skills. Increased income by women lead to greater support from husbands. Decisions on how to spend the additional income at the household level rest with the women. Women became able to mix and interact socially more freely (Mabona, 2001).
Provision, production and use of battery operated lamps in Bangladesh.	New opportunity for women to earn a living. Women who participated gained more control over their time through the allocation of time to project activities and to housework (Khan, 2001).
Improved shea butter production process with motorized plate mills in Ghana.	Female workers' arduousness was reduced through the use if motorized plate mills (Mensah, 2001).
Operation and use of multifunctional platforms in Mali.	In addition to being trained to run the machinery, MFP operators (generally women) were taught how to keep records, manage bank accounts, and perform general maintenance. Operators developed functional literacy and numeracy. Women gained more time for rest or other housework. Women earned income from previously unpaid manual work since MFPs allowed for larger production volumes (Burn and Coche, 2001). Increased girl-to-boy ratios in primary school. Increased proportion of girls entering secondary education (Anderson *et al*, 2005). Reduced working hours for women by two to six hours per day. Cash received by MFP operators (usually women). Reduced risk of family members foregoing evening meals reduced the social tension within the household. Reduced employment of children (especially girls) for domestic activities thus increases school attendance and performances. Women were trained by the project to read and count (Brew-Hammond and Crole-Rees, 2004).
Rural micro hydro projects in Nepal.	Livelihoods of women and their families were vastly improved as a result of income-generating activities. Attitudes towards women changed in areas and in ethnic groups where the status of women traditionally was very low. Women in the community organizations are emerging as leaders and decision makers inside the programs, in the community and finally in their households. Women have reduced drudgery household tasks and increased productive and community roles (Rana-Deuba, 2001).

Box 3.3 Evidence of impacts on MDG 3 – promote gender equality and empower women.

Intervention	Evidence
Use of improved stoves in Guatemala	Reduced acute lower respiratory infections (ALRI) in young children as well as improved respiratory and cardiovascular health in women (Smith-Sivertsen *et al*, 2004) .
Use of improved cook stoves, fuel switch from wood to charcoal and change of cooking location, in Kenya.	Reduction in ALRI and ARI in infants, adult females and adult males (Ezzati and Kammen, 2002).
Manufacturing, distributing and using improved Upesi cook stoves in Kenya.	Reduced ARI and conjunctivitis both in children under five and in mothers (Njenga , 2001).
Improved shea butter production process with motorized plate mills in Ghana.	Reduced exposure to smoke through the switch to motorized plate mills (Mensah, 2001).
Operation and use of multifunctional platforms in Mali.	Improved drinking water quality (Burn and Coche, (2001), Anderson *et al*, 2005). Increased income by women improved children's health. Increased food security improves health and both work and study capacity (Brew-Hammond and Crole-Rees, 2004).
Geothermal power project in Kenya.	Better nutrition has improved health in participants. Provision of a health centre by the project. Improved water supply as the community members extract water from two water tanks provided by the project (Mariita, 2002).
Rural electrification in the Philippines.	Health indicators (birth assisted by doctor/nurse) show a positive correlation with access to electricity (UNDP, 2005).
Installation of solar PV panels in rural clinics in Burma	An estimated 54 000–90 000 people have benefited from the eighteen illuminated clinics since August 2003. The solar systems allow medics to address night time emergencies, have proper lighting for medical procedures, and use electric medical devices and laptop computers (REN21, 2005).
Installation of solar PV panels in rural clinics in Cuba. The clinics which were equipped with various types of medical equipment and radiotelephones.	The health situation has improved greatly. The average birth rates have decreased from 5–6 children per woman to 2–3 which has also reduced the infant mortality rate (REN21, 2005).
Provision of solar PV to pumps in the Dominican Republic and Honduras.	The project has provided clean water, to communities otherwise dependent on distant, contaminated surface water sources. Costs worked out at $.004 per litre, compared to the $.007 per litre charged for water delivered by private truck (REN21, 2005).

Box 3.4 Evidence of impacts on MDGs 4 to 7 – reduced child mortality, improved maternal health and combat of HIV/Aids, malaria and other diseases.

An indirect impact from increased income among women seems to be improved child health. Projects that improve food security and nutritional intake also boost health in target groups. In several cases, the electrification and simultaneous provision of equipment to rural health clinics are associated with improved health conditions. Although possibly quite costly, some programs of the latter type have been large and thus affected great numbers of people. Finally, in Box 3.5 below, reduced indoor air pollution appear, juxtaposed to reduced greenhouse gas emission and reduced deforestation, as impacts on the MDG for environmental sustainability.

Intervention/project	**Evidence**
Use of improved cook stoves in China.	Reduced indoor air pollution (TSP and CO) and GHG emissions (Edwards, Smith, Zhang, and Ma, 2004).
Production and use of biomass briquettes in Malawi.	Reduced deforestation and the utilization of waste reduced environmental burdens of the city (Mabona, 2001).
Provision, production and use of battery operated lamps in Bangladesh.	Reductions in indoor air pollution and in fire hazards (Khan, 2001).
Using and distributing solar PV system, including loan programme in Uganda.	Reduced deforestation and emissions of GHG. Use of solar lanterns helped to improve indoor air quality (Sengendo, 2001).

Box 3.5 Evidence of impacts on MDG 8 – ensure environmental sustainability

3.2 Rural Electrification and Development in the Philippines

Possibly the most data-intensive investigation so far of development impacts from energy provision is presented in ESMAP (2002a). The study is built on survey data from questionnaire-based interviews with 500 households in each of four provinces in the Philippines. The survey covered attitudes as well as quantitative measurements, and the authors identify both quantitative and qualitative benefits so as to present a fuller picture of how electrification affects rural households and areas. The benefits which the study sets out to investigate, i.e. goods and services into which electricity is assumed to be a key input, are: education, health, entertainment and communication, comfort and protection, convenience, and productivity in home businesses and agriculture. We return to home businesses and benefits in terms of comfort and protection in a later section and in the next chapter respectively.

With respect to education, attitudes among both electrified and non-electrified households were measured with several questions. These respondents expressed strong favour of electrification as important in children's education, in the children's studying at night, as well as in facilitating reading in the home at night. Still, many households claimed that television takes away study time from children and thus is a negative impact from electrification. Multivariate analyses showed that having access to electricity reduced the probability of children studying at night, when controlling for covariates of electrification, such as parents' education, earnings, and aspirations for the children, as well as children's employment status and the building materials of the home. However, once at study, children in electrified homes read for a longer time. Also adults in electrified homes tended to read more, with similar controls in multivariate analysis.

Electricity was assumed to affect health in (at least) two ways; in reducing the use of kerosene or diesel for lighting and in providing pumped water, which would be of better quality than that from springs, lakes or river. Households agreed strongly on these notions. Impacts on health were measured by numbers of days per annum missed from school or work because of illness. While the evidence was weak, children in homes with running water were on average absent four days less per year than children in households with other water sources. However, the use of LPG for cooking or boiling water or did not give rise to significant differences in health as compared to that of children in homes where other fuels were used. (Electrified homes probably didn't use electricity for cooking or boiling water.) Among adults, men tended to miss work more often than women, but the type of burning fuel used again had no significant impact. There was however evidence that adults in non-electrified homes reported higher incidences of coughing and shortness of breath.

In the area of entertainment and leisure, four fifths of the sampled households agreed that television was a significant source of entertainment. Not very surprisingly this perception was especially strong in areas with high levels of electrification. Roughly half the households found it difficult to obtain news and 90 percent thought that TV was a great source of news and information. While subject to considerable geographic variation and associated traditions, electricity in some instances also turned out to positively affect households' decisions to receive guests in their homes after dark. Among the determinants of time spent listening to radio or watching TV, electricity had positive impacts as did, for radio listening, education and the number of toddlers in the household. Higher labour wages were associated with less time spent watching television, while increasing non-labour income was associated with the opposite. Larger families also tended to watch more TV.

In conclusion, rural electrification appears as an important component of the social infrastructure that facilitates development, especially as linked to education. The evidence showed that households not only perceive electricity as important for children's home study conditions, but both children and adults spend more time reading when provided with electricity access. Also the flow of information from the ether media is improved with electricity.

The study concluded that the most important finding rests in the linkage between electricity and improved education, as reflected in longer time spent studying and reading among children and adults, improved educational attainments, as well as higher returns to education in electrified households. Evidence of other benefits pointed towards improved flows of information and entertainment to electrified households and less time spent on collecting fuelwood or fetching water. However, the authors were unable to identify health benefits of electrification, as no significant relationship was found between the presence of electricity service and number of sick days reported by adults, as well as in school children.

3.3 Evidence cited in previous literature studies

Although a number of accounts of case studies can be found in the existing literature on welfare impacts from energy interventions, the hard empirical evidence that captures the direction of links between energy and poverty alleviation is rather limited. Before turning to case studies, the focus turns to four reviewed literature surveys that cover work on impacts from energy interventions in developing countries. While compiled for individually different purposes that also differ somewhat from ours, all four studies indicate the potential for modern energy as a driver of poverty alleviation (Meadows, Riley, Rao and Harris (2003), Toman and Jemelkova (2003), Martinot, Chaurey, Lew, Moreira and Wamukonya (2002); Cabraal, Barnes, and Agarwal (2005)).

One important general feature of the perceived benefits from energy interventions in all case studies is that benefits appear to be highly context specific. This notion can be exemplified by results from three different studies that are accounted for by Martinot *et al* (2002). In the first, little evidence was found that Solar Home Systems had an impact on poverty alleviation (GTZ, 2000). Rather it was found that households did not buy such systems in order to reduce energy costs, but for the purposes of longer TV viewing and better lighting quality. However, in the second study from Inner Mongolia, improved energy access through small-scale wind turbines led to household investments in various types of equipment, substantially increased incomes, time saved for women, as well as TV and radio allowing households to access language instruction, information about weather, commodity prices and new farming methods (Richter and Meunier, 1997). The third study, from Bangladesh, showed that community solar-powered cell phones, produced up to $200/month in revenue for the local village operators (Urmee and Wimmer (1999), Barua (2000)). The financial benefits on behalf of the villagers from learning about commodity prices, exchange rates, market trends, and from verifying cash deliveries made by relatives clearly exceeded the per minute connection charges.

Furthermore, while lack of access to modern energy is often characterized as a barrier to development, consensus seems to exist that removing this barrier alone, does not necessarily result in socio-economic development. In previous literature studies emphasis is often made of the role of energy in concert with other interventions.[6] Thus, modern energy should be viewed as one of a set of critical enabling factors that individually and/or jointly contribute to the creation of an environment conductive to development. Hence, the assessment of the significance of modern energy relative to that of other enabling factors, for specific types of development outcomes in particular circumstances, is perceived as critically important. Further, all four literature surveys highlight the shortage of experience and published articles that analyze welfare improvements from the provision and use of modern - particularly renewable - energy in developing countries. Agreement exists on the need for better data, a clearer picture is needed of the needs among beneficiaries and the modern energy services that can meet those needs efficiently and effectively. The field thus deserves much greater attention from donors, development agencies, and governments (Meadows *et al* (2003), Toman and Jemelkova (2003), Martinot *et al* (2002), Cabraal *et al* (2005)).

[6] An example from Cabraal *et al* (2005): In Cuba, clinic electrification resulted in significant health improvements in local communities. However, owing to the remoteness of clinics, doctors had no way to communicate with ambulances or hospitals. Radio communications were added to each clinic. Of the 170 clinics, 130 have radiotelephones, allowing them to communicate with hospitals in the larger towns. The radiotelephones have already saved numerous lives and have been used for many purposes, including during hurricanes and floods to request ambulance or helicopter assistance; to inform relatives of the condition of a patient in a hospital; to inform hospitals about the status of vaccination campaigns; to ask for specific medicines needed by the clinic; and to solicit help from medical specialists. Importantly, the communications equipment adds only slightly to the cost of the total PV system.

Providing education without electricity is not going to have as much impact as providing education with electricity. Similarly, providing electricity by itself without schools or other educational facilities will not have as much impact as having both of them present in a community. This is supported by a study in Peru that found the bundling, or joint provision, of services was very important in creating positive impacts and increasing returns. To illustrate, the study found, in an analysis of identical households, that those households with access to basic services such as electricity and water "had a significantly higher growth rate of per capita consumption than households that did not have such access" (World Bank, 1999).

3.3.1 Productive uses of energy for rural development

One of the richest recent surveys of relevant literature by far is that of Cabraal *et al* (2005). The authors make a strong case for the revision of the concept of "productive uses of energy", into a concept which also appreciates energy's productive role in achieving development objectives, such as the MDGs. More than half of the world's population and more than seventy percent of the world's poor are found in rural areas and an equal fraction is women (World Bank, 2004; Cabraal *et al*, 2005). As will be contended, rural poverty may be alleviated through improved energy provision in a variety of ways. In the context of rural development, however, Cabraal *et al* (2005) argue that energy has traditionally been looked at as having two converse uses; residential (or consumptive) and productive. In the former case, the uses of energy were expected to improve quality of life or rural living standards, whereas productive uses were expected to increase productivity, enhance economic growth, boost employment, and thereby stem up migration of the rural poor to urban areas.

Customarily perceived productive uses would refer to electricity principally used for farm machinery such as water pumps, fodder choppers, threshers, grinders, and dryers in agriculture-based industries. However, Cabraal *et al* (2005) argue that a revised notion of productive use should also take into account the impacts of improved energy services on income, education, health, and gender issues. The proposed revision is motivated by research which documents several crucial productivity-enhancing contributions from modern energy services. In summary, firstly, lighting improves productivity and extends business hours for rural non-farm businesses.[7] Secondly, electricity in rural homes has been shown to accumulate and protect human capital by increasing education levels and reducing both morbidity and mortality, for example from indoor air pollution or kerosene accidents.[8] [9] Hence, since educated and healthy individuals will be equipped with greater income generation potential than those comparatively unhealthy and uneducated, the above uses should be considered productive.

Further, currently perceived "consumptive" uses of energy may in fact not be so. Cabraal *et al* (2005) quote a recent study in Bangladesh, which found that women in households with electricity were better informed about gender equality and women's empowerment related issues. Almost two thirds of the women in electrified households cited television – the viewing of which is traditionally considered a consumptive use – as their chief source of information.[10]

Cabraal *et al* (2005) proceed to build their case on empirical substantiation in each of the four areas of poverty, education health and gender equality/women's empowerment, only some of which is specified below. With respect to income generation, the aforementioned "traditionally perceived" productive uses have been shown to raise rural incomes in Sachs (2005). The authors also point to research that shows other beneficial impacts on income from modern fuels. If replaced by modern energy, dung of substantial monetary value could rather be used as fertilizer to increase income in India (IEA (2002); Njie (1995)). Through access to improved stoves and modern cooking fuels, the rural poor can reallocate time to income-

[7] Cabraal *et al* (2005) refer to Siddhi (2000), Kumar and Hotchkiss (1988), and World Bank (1996a).

[8] For education impacts Cabraal *et al* (2005) refer to ESMAP (2002a) and Dahlin (2002).

[9] For impacts on indoor air pollution and kerosene accidents Cabraal *et al* (2005) refer respectively to Desai, Mehta and Smith (2004); Sunday Observer, Sri Lanka (2001).

[10] Cabraal *et al* (2005) refer to White (2002)

generating activities, which would otherwise have been spent on collecting fuelwood, dung, and water (Barnes, Fitzgerald and Peskin (2002), ISDOUS (2003)).

The same time saved, for example by improved stoves and modern cooking fuels, has been shown to increase the amount of time spent in school by children, primarily girls (World Bank, 2003; Kammen, 1995; Barnes, Openshaw, Smith, and van der Plas, 1994). Numerous studies also show the benefits for education of children's ability to do their homework by electrical light at night, rather than by candles or kerosene. Electric lights in schools and homes permit evening study and classes. These greatly encourage adult education because adults are busy during the day (ESMAP, 2002a).Also distance learning facilities rely on energy to run radio and television sets (Estrada and Brown, 2003; Calderoni 1998). [11]

One plausible field of health improvement, also discussed in Cabraal *et al* (2005), in which distance learning can have an impact, is that of combating AIDS and other diseases. Other health areas in which modern energy service has proven effective is that of exposure to biomass smoke, which is a significant cause of health problems such as acute respiratory infections, chronic obstructive lung diseases, lung cancer, and pregnancy-related outcomes (Bruce, Perez-Padilla and Albalak (2002), Ezzati, Saleh and Kammen (2000)). Indoor air pollution is estimated to kill 2 million women and children every year: about 500,000 deaths of women and children in India, about the same in China, and the other million in other developing countries. (Ramani and Heijndermans (2003), ESMAP (2002b)). A study in Guatemala referred to by Cabraal *et al* (2005) shows that average exposure levels to particulates are three and a half to four times as high, per 24 hours and cubic metre, in households that cook over an open fire as compared to those that use an improved "plancha" stove or LPG (World Bank, 2005).

Rural health clinics in the developing world cater to fight diseases and promote health in rural communities. Cabraal *et al* (2005) identify a number of conceivable positive impacts if such clinics have access to electricity, modern fuels, clean water, or telecommunications.[12] Evidence is provided from *inter alia* studies in Ghana, Cuba and Bangladesh. In the first case, a rural primary health facility evolved into a district hospital from the introduction and expansion of primarily PV systems and LPG for heat and sterilization (World Bank, 1996b). In Cuba a similar intervention is reported to have increased the quality of life and decreased the regional infant mortality rate (Stone, 1998). One of the most striking impacts on health from electrification originates in the study from Bangladesh. Comparing electrified and non-electrified households in electrified villages, the results indicate that the infant mortality rate in households with electricity is 25% less than the national average and 35% less than the national rural average. Estimates were that if access to electricity is expanded to 100% of rural households, on average 101 infant deaths could be avoided per day (Barkat, 2003).

Apart from having direct impacts on health, energy services also provide indirect impacts on improving health by increasing literacy. Evidence referred to by Cabraal

---

[11] While the evidence of correlation between electricity and education is strong, the authors alert the reader to difficulties in attributing causality. On the one hand electricity appears related to improvement in school attendance, literacy, and level of education. On the other, educated households may be more prone to adopt electricity, which would yield the same picture.

[12] Among the many impacts recorded by Cabraal *et al (*2005) from provision of electricity, heat, and kerosene or liquefied petroleum gas (LPG) to rural health clinics are: cleaner and safer environments, power for operating lights, water pumping and heating, sanitation, sterilization of medical equipment, medical refrigerators, other laboratory equipment, and telecommunications equipment.

et al (2005) show for instance that the higher the female literacy rate, the lower is the maternal mortality rate (Grant, 1991). Since it is women and girls who spend the greatest amount of time and effort cooking and collecting water, fuelwood, and other biomass resources, these groups are likely to benefit more than others from modern energy services (World Bank, 2004). A number of impacts in the field of gender equality and women's empowerment are mentioned by Cabraal *et al* (2005). Some of these are the increase women's sense of safety due to the provision of public lighting, which encourages evening community and commercial activities; clean cooking fuels, which as we have seen above, reduce indoor air pollution and the associated morbidity and mortality of women; and electricity and fuels for lighting, refrigeration, entertainment, and a host of other purposes with which women develop small enterprises and increase their income and social power (Barnes and Sen 2004). In addition to alleviating drudgery, the saved time can improve women's or girls' educational achievement, health, economic opportunities, as well as women's power, status and involvement in community activities (IDSUOS (2003), UNDP (2001), Manapol, Weingart, Lilley, and Walt (2004)).

Finally, it should be stressed that a revised understanding of productive uses of energy is not only a semantic issue, but also has important policy implications. In recognition of the sector's potential impact on income, education, health and women's empowerment, the implicit recommendation is that scarce public resources be guided into energy investments, which may lead to the achievement of nationally or internationally defined poverty alleviation goals.

3.3.2 Evidence of impacts on micro-enterprises

In this section we look at impacts from modern energy provision on non-agricultural SME activities in developing countries. Despite this focus, the significant role played by the agricultural sector in this context must be acknowledged. Firstly, it is enormously important as the generator of income for consumers in most developing countries. Secondly, the sector provides many backward and forward linkages with opportunities for small scale entrepreneurs.

The role of agricultural conditions in the context of Kenyan SME activities is analyzed by (Kirubi, 2007). In the study, two settlements are compared, one of which was equipped with diesel-driven mini-grid, Mpeketoni, while the other village, Witu 1, is located closer to markets and main roads with cheaper and superior energy provision from the national grid. Both settlements had also received similar assistance from the German Assisted Settlement Programme (GASP) in the fields of road clearance, water supplies, schools and health facilities. Evidence of the benefits arising to carpentry and tailoring enterprises Mpeketoni after the provision of diesel generator are derived from access to modern tools, that increased per-worker productivity increased volumes of daily sales and gross revenues. Also agricultural activities and small scale agro-processing businesses benefited from electricity. However, none of these developments were observed in Witu 1. The prime limiting factor is the low levels of agricultural activity and diversity there due to the settlement's location in a semi-arid region. Hence, neither the better roads nor the cheaper electricity could outweigh the agricultural disadvantage (Kirubi, 2007).

Other researchers have arrived at similar results and suggest that access to electricity encourages the modernization of existing rural enterprises, but only exerts modest stimulus for the growth of new enterprises (Rogerson, 1997). It has also been suggested that "energy becomes a relevant input to income generation only when a certain economic capacity beyond sheer subsistence is reached" (Nyabeze, 2001).

These findings thus suggest that necessary, contextual pre-conditions for energy provision to contribute to the development of micro-enterprises.

Meadows *et al* (2003) have reviewed a number of case studies that assess the role of modern energy in stimulating micro-enterprises in developing countries. While causal relationships are not presented in detail, evidence from a variety of countries does, however, attest to a development-enhancing potential of energy with micro-hydropower contributing to small businesses development in Nepal, security lighting enabling small enterprises to run also in the evening in poor urban areas of South Africa, and reports of power-theft for business purposes by non-metered users in India (Rana-Deuba (2001), Xavier Institute of Management (1997), Habtetsion *et al*, (2002)).

The Grameen Phone initiative has promoted business activities through the installation of solar systems in rural villages in Bangladesh. These installations have not only created thousands of small mobile phone charging enterprises. It has also stimulated other entrepreneurial activities that use the systems, among which are found workshops that repair radios and TVs, operators of solar powered computers, lamp rental agencies, and retail businesses (Bayer et al 1999, Barua, 1998). Energy supply also provides opportunities for micro service-enterprises. Examples of such enterprises are the import, wholesale and retail businesses of PV systems in Kenya, local wiring and electrical repair businesses, retail sale of pre-paid electricity, service businesses for rural PV systems, and battery charging for domestic (Dunnett (1999), Hankins (2000), Barney, Ota, Pandey and Puranik (2001), Cunningham (1996), D'Addario (2000), Anderson et al (1999))

The ESMAP (2002a) study of rural electrification in the Philippines also captured information relating electricity access to home business activities. Compared to the usage of other fuels, access to electricity was shown to reduce the amount of time spent on non-market home production. For market production, it turned out that the (one-quarter) fraction of electrified households that ran home businesses was almost two-thirds larger than the corresponding fraction among non-electrified households. Households with access also ran a larger variety of businesses, which suggests that electricity makes a wider range of enterprise alternatives feasible. Electrified households also spent more time on business activities, whether they used electricity in the business or not, but somewhat less so in the latter case. It should also be noted that the survey was conducted during a two year spell of little rain, attributed to the El Niño effect, with considerable, negative consequences for the performance of the agricultural sector (ESMAP, 2002a).

From the results above it does appear as if electrification indeed has the capacity to stimulate enterprise formation. However, the interpretation of results would benefit from the provision of greater detail on the context in which enterprise studies are undertaken.

4 Quantifying consumer benefits from modern energy – data requirements and applications

For the assessment and quantification of demand-side benefits from access to modern energy access, one would need at least two types of understanding. Firstly some insight is required into how the poor *currently* obtain and use energy services. Secondly, one would wish to understand their demand for *better* energy services, including their willingness to pay for them. However, data collection on these issues has traditionally been weak and several aspects of energy use in developing countries make the collection very difficult. Despite these difficulties, recent years have seen an increase in the collection of such information, which in some instances can make the estimation of fairly sophisticated quantitative measures possible. In this chapter we start by briefly reviewing some of the complications associated with the collection of energy demand side data in developing countries. In the light of those difficulties, in Section 4.2 we turn to characteristics of an "ideal" data set, for the computation of a broad set of indicators meant to quantify energy issues of relevance to poor households. In Section 4.3 we compare those characteristics to what is generally available in a typical household surveys. Section 4.4 reviews a survey-data based method for the assessment of households' willingness to pay for modern energy services, which is intended to quantify also their "intangible" socio-economic benefits.

4.1 Challenges in data collection and characteristics of an ideal data set

Households in developing countries are found in highly diversified contexts with respect to the availability and costs of energy sources. They also differ in mix and levels of fuels consumption, in end-uses, in technologies, and in energy-related preferences, traditions and behaviours. Further, the traditional fuels, which dominate the supply side, are either collected or traded outside the formal, monetized economy or bought and sold in a large number of small markets. The latter applies to a very high extent also to petroleum fuels (Leach and Gowen, 1987).

Further complexity is added to the situation by the interrelatedness of the arrangements for production, exchange and – not least – uses of biomass materials, which encompass a wide range of purposes other than merely energy use. Energy impacts on livelihoods must thus be considered within this total context. It follows, firstly, that most household energy use in developing countries is not recorded by supply agencies and must be captured through household surveys or participatory methods. Secondly, energy supply and demand patterns would often be specific to regions, districts, settlements within districts, and to households within settlements. For data to be representative of these differences, the data collection must be highly disaggregated, both spatially and socially. The generalization from a few detailed surveys in specific places would be misleading unless the survey sites are known to be representative. The collection of representative data is therefore costly and highly time consuming, especially if comparable data were to be collected over time so as to capture trends (Leach and Gowen, 1987).

4.2 Quantitative welfare indicators and data requirements

An approach for the measurement of direct welfare impacts on poor households from energy sector interventions has been proposed by Foster (2000). Below we will briefly review those indicators, before we turn to the data requirements. Applying three different perspectives on human welfare—basic needs, monetary, and non-monetary (Lok-Dessallien (1999)), Foster (2000) proposes nine different indicators. The method requires data on households' energy use and information that allows the distinction of poor and non-poor households. Ideally, the indicators should consider the full range of energy sources used by a household. Also, when calculating the shares of the various sources in total household energy consumption, the sources' efficiency factors[13] should be taken into account so as to yield energy consumed rather purchased. In order to provide information of how households have been affected, the indicators should be measured both before and after the intervention.

4.2.2 Basic needs inspired indicators

The most basic indicator of access is *coverage rate*, which should be applied for all different energy services, not only for electricity infrastructure. Access to sources such as traditional biomass or modern commercial fuels, may be subject to constraints in the local environment or in distribution networks (Barnes and Qian 1992). One may also wish to sum up the number of energy sources available (but not necessarily used) to households.

The benefit, for example, of being connected to the grid obviously depends on how much of the time the service is available. A useful complement to the coverage indicator is therefore the *reliability index*, reflecting the share of time that individual households are able to access energy from a particular source. An aggregated version of this index can be computed as the sum of scores for all sources weighted by their share of the household's total effective consumption.

An alternative means of measuring reliability is the *consumption concentration index* computed as the summed squares of shares of different energy sources in total effective energy consumption. However, fuel diversity could as well indicate fuel sources' cost-effectiveness rather than reliability problems.

4.2.3 Monetary indicators

A common monetary indicator of welfare is energy *expenditures' share of household income* (or expenditure), a large value of which is typically interpreted as energy requirements being unacceptably costly. However, a large share of energy expenditure could reflect high consumption, high per-unit energy prices, or a very low income. The policy implications from each explanation would be very different.

Alternatively, a measure could be computed to reflect the extent to which households can afford subsistence energy requirements. Such requirement would need to be defined exogenously, taking contextual circumstances and household size into account. Two implied affordability indexes are then, firstly, the *share of households which can afford the subsistence level* or, alternatively, the *ratio of each household's effective per capita energy consumption to the subsistence threshold*.

By tracking fuel costs and fuel subsidies over time it is possible to estimate the impacts of pricing policies on the poor. In doing so, two additional indicators can be used. The *average fuel cost per effective unit of energy consumption* is the total household energy expenditure divided by total effective energy consumption, whereas the *average subsidy per effective unit of energy consumption* is computed by weighting the per-unit subsidy of each fuel by its share in each household's total effective energy consumption.

High capital costs of appliances may be an obstacle to - typically credit constrained - poor households' from taking advantage of fuels with lower per-unit prices. If one adds the amortized capital costs of durables to the average fuel cost per effective unit of energy consumption, one would arrive at the *average total cost per effective unit of energy consumption*.

[13] Or more strictly "the efficiency factors associated with energy conversion from the various sources".

4.2.4 Non-monetary indicators

As mentioned previously in this study, evidence exists that energy interventions may have beneficial health and education impacts. This has shown to be the case where the use of modern fuels reduces exposure to indoor air pollution, and where access to electric light facilitates evening studies among school children. Two types of indicators may be applied to measure these impacts. The *exposure levels* would measure , for example, indoor air pollutants inhaled or hours spent reading. Further downstream are the *consequences of these exposures*, which would capture the incidence of respiratory illnesses in poor communities or the rate of grade completion among school age children. As will be returned to in a later chapter, with the distance downstream from the energy intervention, the consequences becomes more difficult to attribute to energy, since other factors may also affect health and educational attainment.

4.2.5 Data – requirements and availability

While conceptually reasonably uncomplicated, many of the proposed indicators are rather data intensive. Ten basic pieces of information are required to calculate all the indicators on access and affordability (the health and education indicators are more complex):

- Household access by fuel
- Efficiency factors
- Reliability of access by fuel
- Household expenditure by fuel
- Unit cost by fuel
- Unit subsidy by fuel
- Capital cost of household energy use
- Per capita subsistence threshold
- Household size
- Household income *or* expenditure (for poverty definition)

For the above purposes, the ideal data set would have three characteristics (Gomez-Lobo, Foster, and Halpern 1999). It should contain:

- data on both energy-related behaviour and income or consumption of households
- information that allows the computation of index values both immediately before an energy intervention and some time after, for the same households
- identical data for a control group of households that has not been affected by the intervention

In the view of Foster (2000) the most critical input for these indicators is the effective household consumption for each of the fuels. These indicators could be inferred from data on households' expenditures on different fuels. However, the same approach would not capture consumption of non-purchased fuels such as traditional biomass fuels, which would be especially relevant to the poorest households. Such information can only be obtained through special surveys. Thus, the low availability of appropriate data and the high data collection costs may be significant obstacles to using this approach.

Occasionally one may be able to obtain sufficient information by relying on existing household survey data supplemented by external price and efficiency parameters. Household surveys that capture detailed expenditure information are becoming increasingly common. However, this kind of information is till lacking for many countries, where special energy sector surveys would be needed. A serious limitation of resorting to existing household surveys is that they would rarely have been timed with regard to energy interventions. Even so, studies that follow the same households over time are very uncommon in developing countries, which makes information about the same households before and after an intervention very rare.

Nevertheless, an increasing number of countries undertake cross-section (once-off) household surveys, inspired by the design of Living Standards Measurement Study (LSMS) surveys. LSMS surveys were initiated the World Bank in 1980s and have been applied in a large number of developing countries, with questionnaires that sometimes probe into access to utility services, such as water, electricity, and telephony. The surveys have therefore commonly been used, not only for assessing living standards and poverty, but also in the design of policies and programmes for public service delivery.

For the purpose of a cross-country analysis, Komives, Whittington, and Wu (2000) used Living Standards Measurement Study (LSMS) survey data that included service coverage, choice of cooking fuel, and energy expenditures. Their analysis includes comparisons of coverage, fuel use for cooking and lighting, and monthly electricity expenditures, in categories defined by urban or rural location and for various income or expenditure groups. While the LSMS type surveys in some instances offer a good deal of relevant information, there are also considerable gaps. Data is not commonly collected each year and only in rare cases do they encompass information about infrastructure services available to households or on the quality of the service. Household expenditures on such services would be covered but not use levels or unit prices.

4.3 Benefit-evaluation techniques applied to survey data

The ESMAP (2002a) study set out to apply established techniques for the assessment of intangible socio-economic benefits in the untried area of rural electrification. Using data from a specially designed household survey, various benefits were quantified, as differences between pre- and post-electrification costs of satisfying certain consumer demands for selected energy services. A full appreciation of the applied techniques requires more than a basic knowledge of economic theory. Here we therefore refrain from all but a brief overview of the approach.

The ESMAP study argues that private benefits from electrification should be estimated by the "consumer surplus" in the demand for electricity services. In order to compute the surplus one needs an estimate of consumers' "willingness to pay". For an individual consumer, the willingness to pay corresponds to the highest price she is prepared to pay for a unit of a good (or service). Somewhat simplistically, the individual consumer's surplus constitutes the difference between her willingness to pay and the price actually charged. A positive individual surplus for a given good implies that the consumer "saves" money, in not having to oblige to the willingness to pay, which can be spent on other goods or services. The latter expenditures are thought to further increase the consumer's welfare. If the price charged for electricity meets the cost of providing it, a positive total consumer surplus (across all non-electrified customers) contributes to the justification of investing in the programme. Seeing that electricity can generate many different services, the consumer surpluses in all services should be added to generate the total consumer surplus, preferably as predicted over the lifetime of the investment.

The main challenge to the above approach lies in the estimation of the willingness to pay, as it is not readily observed. Since such estimates crucially affect analyses upon which decisions are made about whether to proceed or not with rural electrification project or not, the issue is of more than academic interest. Below we shall illustrate the difference between benefit estimation methods previously used by the World Bank and the above approach, with application to households' demand for lighting, before and after electrification.

With the previous method, one component of the quantified value of benefits from electrification was the predicted revenues to the electricity company. Hence, the value of the benefit from a unit of electricity for the customer is thought to be reflected by what it cost. Added to that component would be the costs saved in generating the consumed energy by alternative means. By the new approach, if demand for a lumen[14] does not change with electrification, the lighting benefit is estimated by the increased consumer surplus resulting from the lower (post-electrification) per-lumen price. However, if the price per lumen has decreased, previously non-electrified households may demand more (or less!) lumen than they did before. If so, the latter consideration must be built into the computation of consumer surpluses. The key point here is that changes in lumen consumption can only be accessed through the survey the light consumption among both connected and non-connected households. Hence, the more sophisticated approach becomes feasible only with household survey data.

The general "new" approach can be summarized in four steps:

i. Determine a measure for each of the final outputs from electrification (in the ESMAP case, in the areas of education, health, entertainment and communication, comfort and protection, convenience, and productivity in home businesses and agriculture)

ii. Observe the differences in final outputs between electrified and non-electrified households.

iii. Estimate the effect of electrification of the final outputs (in terms of amounts of benefits experienced).

iv. Estimate households' willingness to pay for increments in final outputs resulting from electrification.

In the example above, the "output" is lighting and the "metric" is lumen (say, per month). The "effect of electrification" is the usage of cheaper lumen. The amounts of light consumed, by different means, between electrified and non-electrified households, are observed. The willingness to pay is at minimum assessed as the cost saved in consuming the pre-electrification amount of lumen at the post-electrification price. (If lumen consumption increases with electrification, straightforward geometrics can prove that one-half of the price difference times the difference in consumption levels should be added.)

In the above case the willingness to pay is estimated from in energy expenditures for lighting among connected and unconnected households. In the study, analogous approaches are applied to radio and television use, returns to electricity-access induced effects on education among adults, time saved in household chores, and improved productivity for home businesses. We will not review all the computations here, but a second illustration is taken from the time saved in household chores. If a newly electrified household uses an electrified water pump rather than fetching water by foot (the effect), it needs to allocate less time (the metric) to fetching water. The

[14] The **lumen** (symbol: lm) is the SI unit of luminous flux, a measure of the perceived power of light.

difference in time spent on collecting water (the output) can be compared between households with and without electricity access. The willingness to pay for the water pumping service could be estimated by value of the observed time difference. Proxies for the time value could be the cost of hiring someone to fetch the water for such an amount of time or, alternatively, by the revenue earned were the time saved allocated to income-generating activities. Finally, it should be mentioned that the by far largest estimated benefit in the study was from increases in future earnings, which result from longer and higher-quality education in electrified households.

In addition to discussing and taking a multitude of other considerations into account, the authors also suggest several areas for methodological improvement, which are not reviewed here. Most potential recipients of electrification as well as previous qualitative investigations associate large benefits with electrification programs. The ESMAP (2002a) study however addresses the much more complex assessment of whether such benefits, quantified in monetary terms, are comparable to the costs of electrification. The total cost of the above quantification exercise is probably infinitesimal in comparison to total electrification costs. However, at the authors' upper estimate of $100,000 the approach is not feasible to the DEA project.

5 Impact assessments and evaluation of energy interventions

According to the OECD Development Assistance Committee's "Glossary of key terms in evaluation and results based management", an *evaluation* is defined as "The systematic and objective assessment of an on-going or completed project, programme or policy, its design, implementation and results." In close accordance with the DEA project objectives, the aim of an evaluation is to "determine the relevance and fulfilments of objectives, development efficiency, effectiveness, impact and sustainability". Information provided from an evaluation should furthermore be credible, useful and enable the incorporation of lessons learnt into the relevant decision–making processes (DAC-OECD, 2002).[15]

Over the last decade or so, donors have increasingly attempted to assess the impact of their programs, so as to ensure that their funds have been well spent. A methodological shift away from more costly large-scale exercises discussed in the previous chapter, with science-like sample surveys and statistical analyses, is discussed by Hulme (2000). Based on the increasing use of multi-method "impact assessment" studies and participatory methodologies, the same study provides lessons for future impact assessments from the field of microfinance programs. An international group of experts, assembled by the Global Village Energy Partnership (GVEP), is already taking some of the lessons into account for the compilation of a "short-guide to Monitoring and Evaluation in Energy Projects".[16] The GVEP guide also draws on previous evaluations of energy interventions and on guidelines produced by the German "Gesellschaft für Technische Zusammenarbeit" (GTZ) and

[15] Distinctions are made between intervention *inter alia ex-ante* and *ex-post* evaluations. Evaluations are undertaken of development *programmes* as well as of *projects* (which may or may not be part of or sum up to programmes). Evaluations may be conducted by someone *external* or *internal* of the implementing organizations. The *credibility* of an evaluation depends largely on its extent of *independence of political or organizational pressure* from those responsible for the design and implementation of the intervention (DAC-OECD (2002)).

[16] The short-guide is available in English and French from http://www.gvep.org/gvep_c.aspx?id=146

the Imp-Act Consortium of the Institute of Development Studies (IDS). The latter are respectively designed for studies of technical cooperation projects and microfinance interventions.

In the light of the guidelines already in existence and that under production, this chapter will provide a brief account of the underlying concepts, theoretical frameworks and broader considerations in evaluation studies. In doing so, we draw closely on the structure and content of Hulme (2000) with supplemental detail from other work. As a first step we present the "result" and "impact" chains for *theoretical modelling*. The two chains could be interpreted as attributing differing precise meanings to "impact". That difference could in turn suggest a deeper methodological compartmentalization between "results monitoring" and "impact assessment". This is however, not the case. In order to avoid such misunderstandings, the first section also introduces the reader to the most central concepts and definitions.

While analytically non-trivial, the theoretical modelling with chains is however, one of several components to a conceptual framework for evaluation. That framework, in turn, is not the sole determinant of the study's final design, including data collection and analysis methods, which also depends on the precise scope and objectives, the context and the available resources, and ambitions to affect policy and practice. Section 5.2 therefore comments on other considerations that go into the design of impact assessment studies. Section 5.3 presents criteria for the effectiveness of impact assessments in light of the many different factors that affects its design. The same section proposes four broad methodological that meet various common requirements for impact assessments. The final Section 5.4.introduces some of the operational aspects of the GVEP short-guide as an application of many of the considerations of the earlier sections in this chapter.

5.1 Theoretical modelling and terminology

The theoretical evaluation model known as the *impact chain* illustrates the overall objective of an evaluation, whether large or small-scale. This model will be introduced in the first subsection below, in which we shall attribute "impact" its intuitive, everyday meaning, similar to "effect", and consider *impact assessment* as synonymous of project evaluation. Another commonly applied modelling tool is the *results chain* which illustrates a causal sequence to achieve desired objectives of a development intervention. (As we will be made increasingly more explicit, the issue causality in impact assessment is not a minor one. However, for the illustration of modelling techniques, the different notions of causality will be momentarily sidestepped.) The model places the intervention and its effects in a broader context of influences, which allows the "impact" concept to take on a more profound meaning. Since the elements of the results chain also form the basis for many other evaluation concepts, an intervening subsection between the two models introduces some of the key concepts in evaluation.

5.1.1 The "impact chain"

Behind virtually all development interventions lies an assumption that the effort will induce changes in human actions towards the achievement of some desired outcome. The impact-chain model refers jointly to individuals, enterprises, households, populations, or policymakers as "agents", who in turn may or may not have been subject to – or experienced – the intervention in question. It is furthermore assumed that some variable, key characteristic of the agents, their behaviour, or their circumstances exists, that can be related to the intervention's desired outcome. In the case of an intervention to improve water access, such a characteristic could be, for instance, per village incidences of dehydration among infants. The objective of impact assessments is to capture difference in the values of those key characteristics between the outcomes on agents that *have* experienced the intervention and those that have *not*. The impact chain is illustrated in Figure 5.1 (Hulme, 2000).

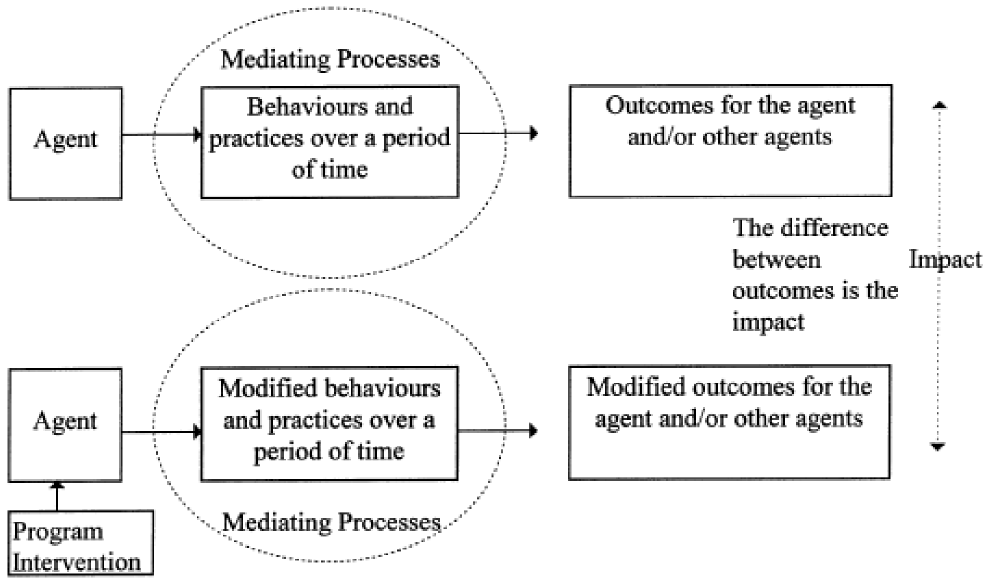


Figure 5.1 The impact chain [source Hulme(2000)]

The previous chapters have contained several examples showing that the link(s) between energy and development or poverty reduction are many and complex. Establishing causation within the general setting of household energy use in developing countries is thus not a straightforward task. In Chapter 4 the consequences of exposure to energy-induced improvements in living standards were mentioned. It was mentioned that such consequences become more difficult to attribute to energy, the further downstream from the energy intervention they are found, since other factors may also come into play. For instance, in the fields of health status or educational attainments, energy access may have considerable consequences. But across time and space, variations in, for example, vaccine availability or teaching aptitudes affect results. The same phenomenon is depicted in the figure and will be revisited in connection with the results chain below. Here, all long-term changes in agents' behaviours or practices, induced by the intervention, are thought to be affected by specific characteristics of the agent and his or her specific economic, physical, social and political context. The processes by which the agents' characteristics and contexts affect the intervention outcomes are termed "mediating processes". Given the complexity of the user-side of energy in a third world context, it follows that the final results of these processes are very difficult to predict (Hulme, 2000).

It is worthwhile to consider also that variations in contexts may affect both the agents that *have* experienced the intervention and those that have *not*. Hence, without a record of such changes, the impact attributable to the intervention may become biased. An intuitive example of the latter would be that good rainfall (context) can have affected both sets of agents' incomes (impacts). Increased incomes could be due to altered crop diversification (behaviour), which in turn may result *also* from improved access to price information via media operated by electricity. The operation of media may finally be facilitated for instance by a solar home systems programme (intervention). As we shall see, the more complex conceptualization of the results chain allows links of causality to disperse in different directions, whereby an "*effect*" from an intervention can be a *cause* of further effects.

5.1.2 The elements of the results chain and key evaluation concepts

A results chain can be thought of as a set of hypotheses of the linkages between an energy intervention and its possible impacts. The chain makes our assumptions about those linkages explicit and is suitably visualized with its strategic elements as a set of arrows arranged in a direction of causality from left to right. By deconstructing the chain into several levels and gathering proof of the linkages between each level the investigator can assess the plausibility of a proposed link between energy interventions and observed social, economic and environmental changes (GTZ, 2004). The results chain thus stipulates the necessary causal sequence to achieve desired objectives of a development intervention. It begins with *inputs*, moving through the other "strategic elements", *activities* and *outputs*, and culminates in *outcomes*, *impacts*, and *feedback*. In some agencies, *reach* is part of the results chain"[17] (Hulme (2000), DAC-OECD (2002)). As related to a development intervention, the strategic elements are individually defined as:

- Inputs: the financial, human, and material resources used
- Activities: actions taken - or work performed for the mobilization of resources - in order to produce specific outputs
- Outputs: resultant products, capital goods and services, as well as resultant changes relevant to the achievement of outcomes.
- Outcome: The likely or achieved *short-term and medium-term effects* of an intervention's outputs. Not a strategic element itself, an *effect is* a "change intended or unintended due directly or indirectly to an intervention"
- Impacts: produced *long-term effects* that may be positive and/or negative, primary and secondary, direct or indirect, intended or unintended.
- Feedback: *transmission* of findings generated through the evaluation process to parties for whom it is relevant and useful so as to facilitate learning (for instance, collection and dissemination of findings, conclusions, recommendations and lessons from experience).
- Reach: beneficiaries and other stakeholders

Furthermore, outputs, outcomes, and impact are referred to as *results* which give rise to the related term *results monitoring*. Such monitoring signifies "a continuing function that uses systematic collection of data on specified *indicators* to provide […] indications of the extent of progress and achievement of objectives and progress in the use of allocated funds". An *indicator* is defined as a "quantitative or qualitative factor or variable that provides a simple and reliable means to measure achievement, to reflect the changes connected to an intervention, or to help assess the performance of a development actor" (DAC-OECD (2002)). Hence, as related to the illustration using the impact chain in the previous subsection, an indicator would be a measurable key characteristic of the agents, their behaviour, or their

[17] The inverse of this chain is the *results framework* which is a "programme logic that explains how the development objective is to be achieved, including causal relationships and underlying assumptions." Associated with the results framework is the *logical framework*, "a management tool used to improve the design of interventions, most often at the project level. It involves identifying (inputs, outputs, outcomes, impact) and their causal relationships, indicators, and the assumptions or risks that may influence success and failure. It thus facilitates planning, execution and evaluation of a development intervention."

circumstances, that can be related to the intervention's desired outcome. One operational objective of the assessment is thus to capture differences in indicator values between agents that have experienced the intervention and those that have not.

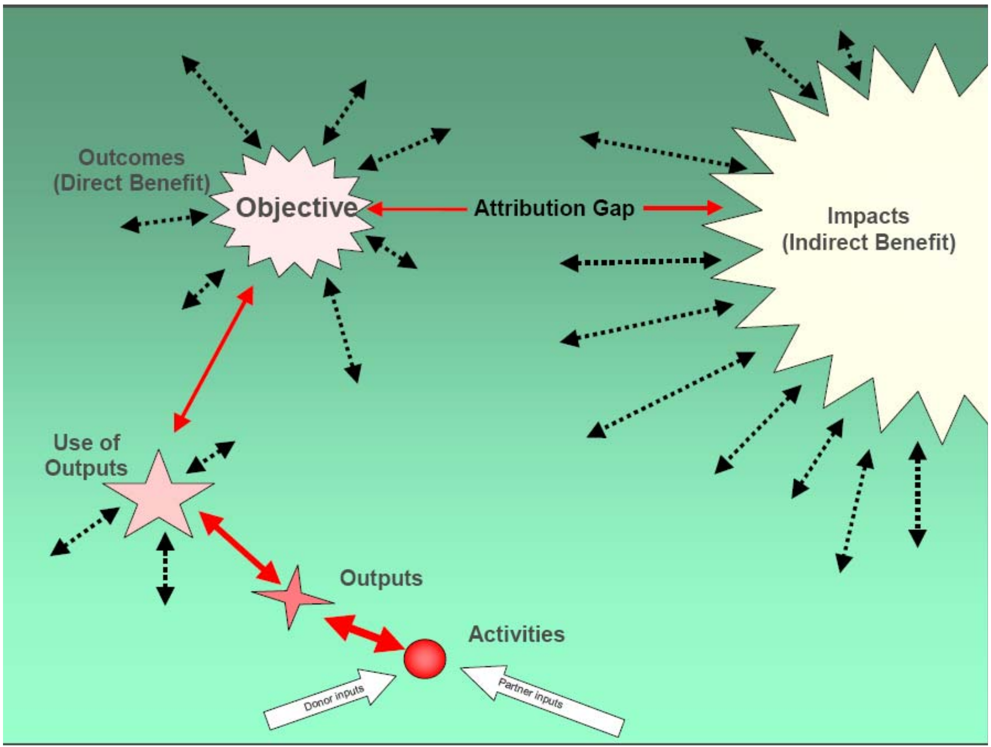


Figure 5.2 The results chain "Use of Outputs" as an element between Outputs and Outcomes [source GTZ (2004)].

5.1.3 Modelling causality in energy interventions and the attribution gap

Figure 5.2 shows the links in the results chain depicted in a complex "real-world" context. As can be seen, causality in the context of the results chain should not be confused with a linear sequence of causes and effects. Attribution of results to the energy intervention up to the level of outputs and use of outputs is relatively easy in most cases. From an empirical perspective, if a causal relationship between outputs and observed development changes can be demonstrated, the project can make a credible claim to development as a direct benefit (GTZ, 2004).

The attribution problem is further illustrated through Figure 5.3. In an above subsection it was discussed how, in reality, causality could disperse in different directions and that an effect from an intervention can be a cause of further effects. This is illustrated in Figure 5.3. Input in the form of a diesel engine, brought by an energy project, yields shaft power for the extraction of water as output. The pumped water is an output. The pumped water serves as one of several inputs into an agricultural project, which could yield higher incomes. A parallel health project aimed at reducing dysentery also utilizes the pumped water as an input, with pipes and education to promote the use of potable water. In combination, the three interventions may bring about development impacts in the form of improved living standards (GVEP (2007)). However, the figure does not illustrate contextual influences such as

- ground water levels and diesel availability on the water output

- weather on agricultural production
- access to agricultural markets and prevailing prices on farm income
- spare or replacement parts and repair skills for water pipes

Each of these four influences form part of the context of the separate projects and may seriously complicate the attribution of development impacts to the diesel engine.

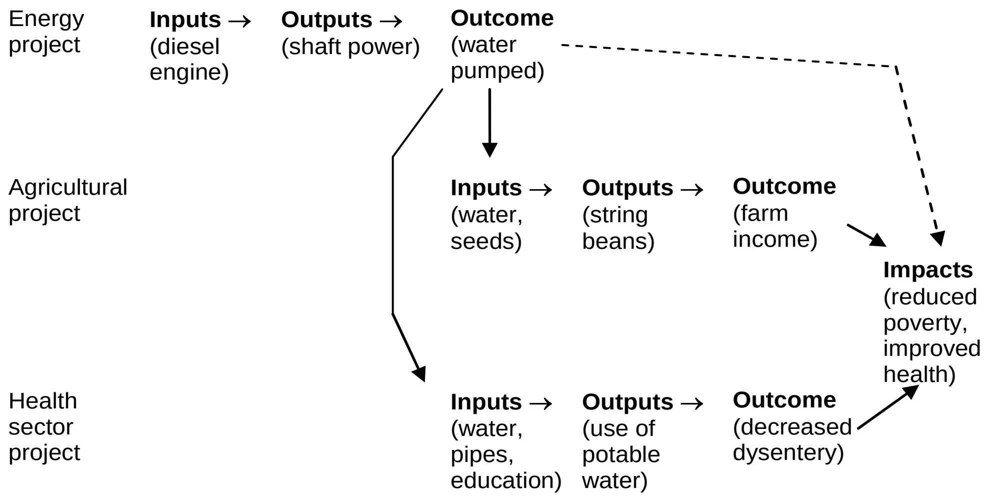


Figure 5.3 Results chains in interaction - outcome from an energy project as input into other interventions

5.2 Considerations in the design of an impact assessment study

Quite naturally, all studies whether based on quantitative and/or qualitative methods must pursue rigor. While all impact assessment share a general, underlying conceptual framework, the design of such a study, must also address the following questions:

- What are the objectives of the assessment?
- How is the information to be used and by whom?
- What level of reliability is required?
- How complex is the program, what type of programme is it, what is already known about it?
- What resources (money, human and time) are available?

Hence, there are several parameters that define the sphere within which an impact assessment's pursuit of rigor takes place. Spelled out in some more detail these parameters encompass:

- the objectives
- notions of (meaningful) causality attribution
- data collection methods

- cost and financial resources at hand
- the human resources available and respondent motivation and representation
- ambitions of influence on policy and practice

In line with the DEA project's ambition it will be assumed that an impact assessment will have the objectives both to *prove impacts* and to *improve future interventions*. Each of the other parameters will be introduced below, after a brief account of the underlying general framework of an impact assessment.

5.2.1 The elements of a conceptual framework

Most large-scale impact assessment exercises with long timer horizons are built around an explicitly identified conceptual framework at their heart (Khandker, 1998; Sebstad, Neill, Barnes and Chen, 1995; Schuler and Hashemi, 1994). On the other hand, smaller scale exercises are usually more of a common-sense type. Hulme (2000) lists three main elements to a conceptual framework:

- a model of the impact chain
- the specification of the level/unit for impact assessment
- the specification of the types of impact that are to be assessed

Based on a model of the impact (and/or results) chain, the choice of unit(s) or level(s) for assessment is made. The selection commonly involves one or several of: the *household*, the *enterprise* or the *institutional environment* in which the agents operate. With respect to the type of impact looked for, the number of (indicator) variables that can be identified is almost infinite. Two general criteria for the selection of such variables are that they must be *defined with precision* and must be *measurable*.

Two classes of indicators are the *economic* and the *social*. The former encompasses changes in income, levels and patterns of expenditure, consumption and assets (an advantage of which is that they do not fluctuate as much as other economic indicators) (Barnes, 1996).The social indicators encompass, for example, educational status, health service access, nutritional intake levels, anthropometry, contraceptive use, control over resources, involvement in household and community decision-making, levels of participation in community and/or social networks, as well as electoral participation. Another useful distinction in this context is that of "domains of change" and "`markers of change", examples of which would be respectively household income and amount of income, number of income sources or seasonality of income (Sebstad et al. (1995), Hulme (2000)).

Finally, often the exact indicators used will be affected by the choice of methodology. This raises problems especially in the case of multi-method approaches where it may be difficult to maintain a single definition of an indicator across all methods applied. Further, as a rule, impact assessors should always seek to keep the number indicators to a manageable number rather than attempt a comprehensive approach which may have adverse effects on both the data quality and on study relevance.

5.2.2 Notions of causality

At the core of impact assessment lies the attribution of specific effects to specific causes, where the cause is the intervention and its results the effects. Hulme (2000) draws out three paradigms for the demonstration of attribution. These are separable for analytical purposes, although practice often involves some mix of these approaches.

The first strand is the conventional, scientific method, originating in the natural sciences, in which a judgment is formed about a particular stimulus causing an observed effect. Rigorous controls of the ("mediating processes") in the environment are not feasible in the social science. That problem is often circumvented by the use of control groups, as discussed in the previous chapter. However, serious problems arise if the allocation of agents in the control and experimental is systematically affected by traits in the agents themselves (sample selection bias). Hence, it is *inter alia* required that a group is identified which matches the treatment group in terms of its economical, physical, and social environment. The common assumption of one-way causality between the intervention and agents furthermore poses a risk of misspecification of causal relationships. Again, such problems can be overcome by econometric methods, but are data/cost and skills intensive (Hulme (2000)).

The second paradigm has its roots in the humanities and focuses on making a reasoned argument supported by theory and specific pieces of evidence. Commonly the bulk of data generated by such an approach is "qualitative", although at later stages of analysis such work often quantifies some data. Its main features are an inductive approach, a focus on key informants, recording by notes or image, and the data analyst is usually directly (and heavily) involved in data collection. One merit of the approach is its recognition that there are usually different, possibly conflicting accounts of what has been achieved by a programme. However, such analyses from typically often fail to demonstrate a causal link, as they are not able to generate a "without programme" control group. Hence, the validity of this kind of study has to be judged by the reader on the basis of factors such as logical consistency of arguments, degree of triangulation of source, quality of methodology as well as the consistency, strength and quality of the evidence. Combinations of the "scientific" and "humanities" approaches are also becoming more common for the assessment of the validity of findings (Hulme (2000)).

The third and most recent approach to the field is that of participatory learning and action (PLA). This line of argument can be thought of as a reaction to the scientific method which, in the adherents of this view, fails to capture the complexity and diversity of livelihood generation in developing countries. The PLA method perceives causality as multidirectional and takes the form of complex webs rather than arrows. It also addresses the power relationships inherent to the scientific method which reinforces status quo and impedes development by empowering professionals, policy-makers and elites. According to the method, a first step in empowering the poor would be to let them take the lead in problem identification and analysis and knowledge creation. Conditional upon local people becoming enabled to identify their own indicators, establish participatory baselines, monitor change, and evaluate causality, two beneficial results will arise. Firstly, the impact assessments would be better. Secondly, the intended beneficiaries would be empowered through the research process itself. Evidence, which shows that well-conducted, participatory methods can be more reliable than conventional surveys, is found in Mayoux (1997) and Chambers (1997) (Hulme (2000)).

5.2.3 Data collection methods

For the assessment of intervention impacts, the investigator would apply an *impact assessment tool*, defined as "a mechanism of obtaining the answer to certain questions or revealing certain information about impact that we are looking for". Impact assessments are not fundamentally different from other research, in the sense that it is the search for answers to research questions, which determine the appropriate mix of research methods or tools. It follows thus, that the extent to which an investigator adheres to one of the paradigms in the previous subsection will affect the choice of data collection methods. The key issue in selecting methodologies or tools is however, to approach research with flexibility and with a good grounding in the issues to be investigated (Simanowitz, 2001).

With the introduction of participatory approaches the range of available data collection and knowledge creation methods for impact assessment studies has increased. Each of the methods of sample surveys, participant-observation and PLA has a different pattern of strengths and weaknesses. (A more detailed account of impact assessment tools is found in Simanovitz (2001) and Rai (2005) provides a fuller account of participatory approaches for impact studies of energy programmes.) The data that can be collected is however, often very limited. It is therefore important to first undertake qualitative research so as to determine which indicators provide the most accurate reflection of the type of impact information that one wishes to gather. The tools selection process therefore also involves a close look at the kind of data a particular approach will produce and to consider how that data should be processed and analyzed. A common mistake is to select indicators based on an insufficient understanding of the processes one seeks to assess. The starting point in any impact assessment should therefore be analysis (Simanovitz, 2001).

As indicated above, the key methodological concern is the *mix* and *combination* of methods most appropriate for the study at hand, rather than the choice of one, unique method. This choice is obviously subject to considerations of resources available and the context at hand. Nonetheless, a trend at least within microfinance assessment, appears to be towards efforts to combine the advantages of representativity, quantification, and attribution in sample survey approaches, with the humanities' or participatory approaches' abilities to uncover processes, capture the diversity of perceptions, views of minorities and unexpected impacts (Hulme, 2000). At one extreme end of the range of methodological mixes one could find an ambition to prove impact for policy or major investment purposes. An example at the opposite extreme could be to independently corroborate the impact and strengthen implementation aspects of a small-scale programme. In the first case the mix would probably entail a large scale, longitudinal sample survey, supplemented by triangulation from the other methods. In the latter case, a mix of rapid appraisal and small-scale survey would likely suffice (Hulme, 2000).

5.2.4 Financial considerations

Drawing on verbal reports, Hulme (2000) provides the following guidelines for study costs. Impact assessments which utilize the scientific approach method to prove impact may cost in the range of US$500,000 to US$5 million, depending on the number of sites studied. On the other end, high quality, rapid appraisals of impact on individual sites, by qualified investigators can yield useful findings for improvement purposes at costs in the interval between US$5,000 and US$10,000. Some useful points of observation from the author's scan of the microfinance literature are:

- The costs of studies intended to produce authoritative evidence exceed what most agencies can afford and the timescales involved would render results that are historical rather of operational relevance.
- The notion that qualitative and participatory methods are cheap appears somewhat misguided
- The validity of findings from most studies would be best served by triangulation of sources and the utilization of a mix of survey, qualitative and participatory techniques. Attempts to achieve a representative sample survey on a limited budget are likely to have a negative effect on data quality and sample representativity.
- Project monitoring by programme staff make high-quality impact assessment feasible at moderate costs, since the need for primary data collection is relatively low.

5.2.5 Human resources – staff and respondents

In developing countries the recruitment of qualified personnel for interviewing, collating, analyzing and write up impact assessments is a core challenge. Different studies often compete for the people, which puts these individuals under great strain and is not met by an increasing supply of qualified individuals. Efforts to build impact assessment capacity in developing countries are therefore strongly supported by Hulme (2000).

On the respondent side, the issue of how to persuade respondents to spare the time for an interview, and provide accurate and honest answers, is an important one. Different strategies are needed for programme beneficiary and control group respondents. As a rule of thumb many researchers suggest that interviews should be concluded within one hour and that one and a half hours should be seen as the absolute maximum for an interview.

Beneficiaries usually accept that being part of a programme comes with “answering questions”. The quality of the data still depends on the respondents’ understanding of why they are being interviewed and their being given the opportunity to ask questions before the interview. In dealing with control groups, motivation may become an issue, especially if longitudinal data is collect. Even if a first interview has some novelty and amusement value, the provision of some reward to interviewees should be considered to promote data quality and for ethical reasons. Finally, participatory and rapid appraisal methods often stimulate respondents by their inherent social interaction. However, in conducting PLA exercises, care must be taken to observe who has turned up and who has *not* come to the meeting. Additional focus groups or interviews of non-attendees are often required (Mosse (1994), Mayoux (1997)).

5.2.6 Affecting policy and practice with impact assessments

A very limited influence on subsequent decision-making is a problem inherited by impact assessment studies from the evaluation studies of previous days. Hulme (2000) proposes the following ways to address this problem:

1. Impact assessors need to devote more time to the use of their studies and device dissemination strategies aimed at decision-makers, with short, user-friendly documentations combined with appealing presentations and strategic cups of coffee

2. Considerable thought must be put in to the timing of findings. Impacts on policy and practice decrease with the length of time between data collection and findings presentation. The Global Development Network has examined characteristics of research that successfully energy policy in five African countries (Karekezi et al. 2006). Among the important factors were timing – policy is most receptive to research input at early stages of formulation – and relevance to broader policy issues, such as macroeconomic or poverty reduction strategies. While beyond the scope for this survey, the Overseas Development Institute has undertaken considerable on Research and Policy in Development (RAPID) (ODI 2007), with thematic foci on how policy-makers can best use research, how researchers can best use their findings in order to influence policy; and how to improve the interaction between researchers and policy-makers.

3. The people often best positioned to affect the performance of interventions are programme managers. The influence of impact assessments on this category of stakeholders is likely to increase with their sense of co-ownership of findings. The latter can be enhanced through paying careful attention and incorporating their ideas into the design of impact assessment studies.

5.3 Effective impact assessment

Drawing on Little (1997), Hulme (2002) considers impact assessment ``...as much an art as a science...". The scientific facets of impact assessments pertain to standards of measurement, sampling, and analytical technique, thus the fields in which statisticians and econometricians specialize. With respect to the “art” aspect, there are three dimensions to any given impact assessment exercise;

1. the judgments about its design with respect to resources at hand, objectives and setting
2. the *process of arriving* at the most appropriate blend of assessment methods
3. the evaluators’ insight into the ways in which results may influence policymakers and intervention managers

Quite naturally, all studies whether based on quantitative and/or qualitative methods must pursue rigor. However, the first point in the list above states parameters under which that rigor must pursued. Hulme (2000) defines a measure of *effectiveness* of an impact assessment on how well it “achieves a fit” between its objectives, resources and context. The author groups approaches that are likely to fit common clusters of these parameters, ranging from impact monitoring and validation, via “simple” and “moderate” approaches to more complex ones.

5.3.2 Impact monitoring and validation

An alternative to an impact assessment study is to rather to strengthen the internal impact monitoring capacities of the implementing body. Quality control of this information can be achieved by using external monitors for validation purposes. One advantage of this approach is the increased likelihood that findings will be used due to the involvement of programme staff in the assessment of achievements. Often the approach would involve the collection of readily available data by pre-existing internal monitoring and research units, supplemented with easily accessible data on services users, their purposes and opinions, through focus groups, short interviews and rapid appraisal.

5.3.3 A simple approach

The central methodological feature of this approach is the use of a variety of methods, usually involving a small-scale survey supplemented with information on a comparison group that could be rapidly identified. In the absence of a baseline study, recall methodology would be utilized. The ambition with this approach would be to provide timely information at relatively low cost about programme impacts directed to programme managers and "country-based" donor staff. Reliability is moderate, at best, and the major objective is to evaluate the current understanding of impacts and contribute to improvements in the operation.

5.3.4 A moderate approach

The moderate approach involves considerably higher costs and reliability in terms of statistical inference rather than triangulation, with longer delivery time. Focus is both on proving impact and improving programs, with policy-makers and senior programme managers as audience. A significant survey with at least two visits and an adequate control group would constitute the core of the methodological mix. Rapid appraisal techniques, participant observation and case studies would be used for context assessments and crosschecking materials

5.3.5 A complex approach

This approach aspires to high levels of reliability with regard to causality attribution and the focus is exclusively on the impact proving orientation, through the application of statistical and econometric data analysis. Delivery time of findings would be twice as long as for the moderate approach, with four to six years after its launch. A very carefully constructed, large-scale sample survey, capturing all key characteristics of the client population, with a rigorously selected control group would constitute the heart of the methodology. The number of households visited would be in the vicinity of one thousand, with at least three visits to each over two years. A set of related studies on institutional performance would be conducted .The budget this kind of approaches would typically exceed a million dollars, with considerable data collection, processing, and analysis costs.

5.4 The GVEP guide – an adaptation to energy interventions

As mentioned, the GVEP short guide is based on a conceptual framework which is similar to what has been discussed above. It also many of the same considerations in the design and implementation of assessment studies as discussed here. The GVEP short guide emphasizes that the specific tools used for assessment studies monitoring and evaluation[18] of interventions - indicators, data collection procedures, analytical methods - must be adapted to specific local conditions and stakeholder needs (GVEP, 2007). The guide spells out a number of challenges and difficulties specific to the assessment of energy projects, as compared to intervention in the fields of for instance water, agriculture, health or education projects;

- Energy does not directly feed, house, or clothe people, but energy services are rather inputs into the production of food, clothing or health services. Consequently, *the results chain from energy to improvement in people's lives is often longer and more complex* than for other projects.

---

[18] The GVEP guide aims at "Monitoring and Evaluation" of energy projects, but does not make the same explicit distinction between "evaluation" and "impact assessment" studies as Hulme (2000). "Monitoring" is conveniently interpreted as repeated "evaluation", which in turn constitutes a broad category of studies, that includes "impact assessments".

- Energy services often affect several aspects of livelihoods generation, as is the case where electricity may be used to pump water, refrigerate vaccines and to weld metals. Hence, assessments of energy interventions face the challenge of *capturing and measuring improvements in more than one area*.
- The positive impacts of energy access may only materialize several years after the project ends. This requires that energy intervention assessments *may need to extend in time beyond the project life cycle*.
- In order to generate positive effects, energy often requires many other inputs. In the case of income-generating activities other inputs would be appropriate raw materials, markets, skills, and transportation must also be available. Thus, in order to identify and specify impact attributable to energy, the *impacts attributable to other factors that have been present must also by somehow be estimated*.

Given these specificities, the design of an evaluation of an energy project can be very challenging. To very briefly describe the guide, it proposes some ideas and methods to aid evaluation teams in meeting this challenge. The Guide has two parts. The first is general methodological section, which describes a ten-step process to define a project specific assessment scheme. The second part contains detailed suggestions for how the general methodology can be applied to specific projects. The suggestions are organized in four modules designed for different technologies and a separate module institutional support projects.

6 Conclusions

With the intention to find guidance for the DEA project's empirical investigation into micro-level links between energy and socio-economic development, this review has commented on recent literature. Households are the most common units consumption and very often for production in developing countries. Perhaps for those reasons, consensus among analysts seems to be that households are often the ultimate beneficiaries of energy interventions. Plausibly, development impacts are greatest where the energy services provided by interventions match needs and capacities on the user-side to incorporate those services into the generation of livelihoods. However, if one lesson from this study should be emphasized, it is the highly diversified contexts in which households in developing countries find themselves with respect to energy issues. The diversity appears in the availability and costs of energy sources and takes the shape of differences in the mix and levels of fuels consumption and in end-uses. Households also differ in ability and willingness to invest in new technologies, as well as in energy-related preferences, traditions and behaviours. It follows that energy supply and demand patterns would be specific to regions, districts, settlements within districts, and to households within settlements. Energy impacts on livelihoods must thus be considered within this total context.

From a theoretical perspective, the flexibility of the Sustainable Livelihoods Approach allows the incorporation of many of the above considerations. However, the variation in supply and demand patterns across space and social groupings requires highly context specific modelling. This study has also commented on impacts from a wide variety of types of energy interventions, which conceivably would have differing impacts even if undertaken on the same geographical location. From an empirical perspective the situation becomes further demanding by the lack of records of most household energy use in developing countries. The data must therefore be captured by investigators themselves and for data to be representative of the differences across space and social structures, the collection must me highly disaggregated.

An investigator is thus faced by a complexity and variation on the demand side combined with very differing impacts from different types of interventions on the supply side. On the positive side, the situation has yielded both a corresponding variety of empirical findings as well as a high degree of stimulating theoretical hypothesizing related to the links between energy and development. From an operational point of view, the theoretical complexity, variation in findings, and the multitude hypotheses suggest a need for specificity in the design of empirical assessments. The development impacts of an intervention must be approached as dependent on the specific technology of the intervention, the context in which it occurs, and the user-needs it addresses.

The growing multitude of findings in the field of micro-level impacts from energy interventions is encouraging. Two inter-related disappointments are however, firstly the limited extent to which the need for specificity in modelling is reflected in detailed accounts of theoretical models and empirical methods. Secondly, very few findings in this field have been published in peer-reviewed scientific journals. These disappointments are quite possibly linked to the prohibiting costs involved in the collection, processing and analysis of sufficient data, which are required for attempts to attribute causality to energy with some degree of scientific certainty, in the prevailing setting.

The conceptual framework of empirical impact assessment studies is influenced by the theoretical flexibility of the Sustainable Livelihoods Approach. The complexity and variability on the energy user side in development countries is incorporated into the framework by its recognition of context sensitive, “mediating processes”. These processes allow for agents’ characteristics and contexts to affect the long-term outcomes of intervention, which are transformed into more illusive “impacts” through the processes. The impact assessment approach also allows modelling of hypotheses specific both to interventions and contexts, through the elements of the “results chain”. Further appeal is found in the flexible methodological design of impact assessment studies. The use of multiple data collection and analysis methods is encouraged. The approach also recommends an adaptation of such methods to differing interventions, stakeholder groups and budgets. Further, an international group of experts has been developing a theoretical tool based on the impact assessment approach and specific to energy interventions. Seeing that this tool can be integrated and empirically assessed through the DEA project, the path of impact assessment studies appears well justified.

7 References

Anderson, T., Doig, A., Rees, Khennas, D. & S. (1999). “Rural Energy Services.” Intermediate Technology Publications, London.

Anderson, B., Fracchia, S., Lang, R. and Porcaro, J. (2005). “Mali country case study” in UNDP (2005).

Barkat, A. 2003. *Rural electrification and poverty reduction: case of Bangladesh*. Presented at NRECA International Conference “Sustainable Rural Electrification in Developing Countries: Is it Possible”, Arlington, VA

Barnes, C. (1996). *Assets and the impact of microenterprise finance programs*. Washington, DC: Management Systems International, cited in Hulme (2000)

Barnes, D.F and Floor, W. M. (1996). "Rural Energy in Developing Countries: A Challenge for Economic Development", *Annual Review of Energy and the Environment* 21.

Barnes, D.F., Fitzgerald K and Peskin, H.M. (2002)*. "The Benefits of Rural Electrification in India: Implications for Education, Household Lighting, and Irrigation", *Draft manuscript*, Washington, DC: World Bank

Barnes, D.F., Openshaw K, Smith K.R. and van der Plas, R. (1994)*. "What makes people cook with improved biomass stoves? A comparative international review of stove programs." *Techical Paper 242, Energy Series*, Washington, DC: World Bank

Barnes, D.F. and Qian, L. (1992). "Urban Interfuel Substitution, Energy Use and Equity in Developing Countries: Some Preliminary Results." *Industry and Energy Department Working Paper, Energy Series* 53, World Bank: Washington, D.C

Barnes, D.F. and Sen, M. (2004) *. "The impact of electrification on women's lives in rural India" *Energia News* 7:1

Barney, I, Ota, A.B., Pandey, B and Puranik, R. (2001). "Engaging Stakeholders: Lessons from three eastern India business case studies", *In Focus*, Report 1, Resource Centre for the Social Dimensions of Business Practice, cited in Meadows *et al* (2003).

Barua, D. (2000). "Mobilization of local entrepreneurship for delivery of rural services: experience of Grameen Shakti" Proceedings of Village Power Conference 2000, Washington, DC, National Renewable Energy Laboratory, cited in Martinot et al (2002).

Bebbington, A (1999). "Capitals and Capabilities: A Framework for Analyzing Peasant Viability, Rural Livelihoods and Poverty", *World Development* 27:12

Berg, M., Díaz-Wionczek, C., Gelman, T., Granof, L., and Porcaro, J. (2005) Brazil Country Case Study in UNDP (2005).

Brew-Hammond, A. and Crole-Rees, A. (2004) *Reducing Rural Poverty through Increased Access to Energy Services: A Review of the Multifunctional Platform Project in Mali*, NY: UNDP,.

Bruce N., Perez-Padilla R. and Albalak, R. (2002)*. "The health effects of indoor air pollution exposure in developing countries" *WHO Report WHO/SDE/OEH/02.05,* Geneva, Switzerland: WHO.

Burn, N., and Coche, L. (2001) "Multifunctional Platform For Village Power – Mali" in UNDP (2001).

Cabraal, R.A., Barnes, D.F., and Agarwaal, S.G. (2005). "Productive Uses Of Energy For Rural Development", *Annual Review of Energy and the Environment* 30.

Calderoni, J. (1998)* "Telesecundaria: using TV to bring education to rural Mexico" *Education and Technology Technical Notes Working Paper Series,* 3:2, Washington, DC: World Bank

Carney, D., Drinkwater, M., Rusinow, T., Neefjes, K., Wanmali S. and Singh, N. (1999) *Livelihoods Approaches Compared: A brief comparison of the livelihoods approaches of the UK Department for International Development, CARE, Oxfam*

* Cited in Cabraal et al (2005)

and the United Nations Development Programme). UK: DFID.

Chambers, R. (1987) "Sustainable livelihoods, environment and development: putting poor rural people first", *IDS Discussion Paper 240*, Brighton, UK, IDS

Chambers, R. (1997). *Whose reality counts? putting the first last*. London: IT Publications

Chambers, R and Conway, G. (1992) "Sustainable Rural Livelihoods: Practical Concepts for the 21st Century", *Institute of Development Studies Discussion Papers* 296.Cambridge, UK

Cherni, J. (2003) "Renewable energy technology and sustainable livelihoods", *DFID Energy Knowledge and Research Newsletter*, 17

Cherni, J. (2004) "Renewable Energy for Sustainable Rural Livelihoods", *Technical Report RESURL. Project KaR R8018*, Imperial College London.

Clancy, J.S., Skutsch, M. and Batchelor, S. (2003). *The Gender-Energy-Poverty Nexus: Finding the energy to address gender concerns in development*. DFID, London.

Cunningham, B.D. (1996). "ESKOM, a Case Study.", University of Virginia, cited in Meadows *et al* (2003).

DAC-OECD (2002). *Glossary of key terms in evaluation and results based management*

D'Addario, P.J. (2000). "Golden Genesis and the Teotonio Vilela Foundation." *Natural Resources Forum* 24: 4 , cited in Meadows *et al* (2003)

Dahlin, B. (2002)[*]. "The impact of education on economic growth: theory, findings, and policy implications", Duke University

Desai, M.A., Mehta, S. and Smith, K.R. (2004)[*]. "Indoor Smoke from Solid Fuels: Assessing the Environmental Burden of Disease", *WHO Environmental Burden Disease Series* 4, Geneva: WHO.

Devereux, S (2001). "Livelihood Insecurity and Social Protection: A Re-emerging Issue in Rural Development", *Development Policy Review, 19:4*

DFID (2000) *Sustainable Livelihoods Guidance Sheets*

DFID (2002a) *Energy*, Issue 14.

DFID (2002b)[*]. "The importance of increasing access to energy services", *Energy for the Poor: Underpinning the Millennium Development Goals*. London, DFID.

Dunnett, S. (1999). "Small wind generators for battery charging in Peru and Sri Lanka.", *Boiling Point* 43.

Eade, D. and Williams, S. (eds.) (1995). *Oxfam handbook for development and relief*, Oxford: Oxfam

Edwards, R.D., Smith, K.R., Zhang, J and Ma, Y. (2004) "Implications of changes in household stoves and fuel use in China", *Energy Policy* 32:3

Ellis, F. (2000) *Rural Livelihoods and Diversity in Developing Countries*, Oxford University Press

ESMAP (2000), *Energy Services for the World's Poor*, Washington, DC: World Bank

[*] Cited in Cabraal et al (2005)

ESMAP (2002a)* "Rural electrification and development in the Philippines: measuring the social and economic benefits". *ESMAP Report 255/02*, Washington, DC: World Bank

ESMAP (2002b)* "India, household energy, indoor air pollution, and health" *ESMAP Report 261/02*, Washington, DC: World Bank

Estrada, R. Q. and Brown, T. (2003).* "Telesecundaria: students and the meanings they attribute to elements of the pedagogical model.", Mexican Journal of Education. Research, 8:17

Ezzati, M., Saleh H., and Kammen, D.M. (2000).* "The contributions of emissions and spatial microenvironments to exposure to indoor air pollution from biomass combustion in Kenya.", *Environmental Health Perspectives* 108:9

Ezzati, M. and Kammen, D.M. (2002) "Evaluating the health benefits of transitions in household energy technologies in Kenya." Energy Policy 30:10.

Foster, V. (2002). "Measuring the impact of energy reform—practical options", Chapter 4 in DFID (2002b).

Gomez-Lobo, A., Foster, V., and Halpern, J. (1999). "Information and Modeling Issues Related to Water Subsidy Design." World Bank, Finance, cited in Foster (2002).

Grant, J.P. (1991).* The State of the World's Children, New York, NY: UNICEF

GTZ [Deutsche Gesellschaft für Technische Zusammenarbeit] (2000). "Financing of Solar Home Systems in Developing Countries", Eschborn, Germany, cited in Martinot et al (2002).

GTZ (2004). "Results-based Monitoring", Guidelines for Technical Cooperation Projects and Programmes, Unit 04 Corporate Development, OU 042 Internal Evaluation.

GVEP [Global Village Energy Partnership], *A Guide to Monitoring and Evaluation for Energy Projects*, Monitoring and Evaluation of Energy for Development [M&EED] Group.

Habtetsion, S. and Tsighe, Z. (2002). "The energy sector in Eritrea – Institutional and policy options for improving rural energy services." *Energy Policy* 30:11-12

Hulme, D. (2000) "Impact Assessment Methodologies for Microfinance: Theory, Experience and Better Practice", *World Development* 28.

IDSUOS [Institute for Development Studies, University of Sussex] (2003).* *Energy poverty and gender - A review of the evidence and case studies in rural China*, Washington, DC: World Bank

IEA [International Energy Agency] (2002).* "Energy and poverty", *World Energy Outlook*, Paris, International Energy Agency

Kammen, D.M. (1995).* "Cookstoves for the developing world", *Scientific American* 273

Karekezi, S., Kebede, B., Kimani, J. and Muthui, J. (2006) "The impact of research on national energy reform strategies in Eastern and Southern Africa" , Global Development Network (GDN) Bridging Research and Policy Project http://www.eerc.ru/details/download.aspx?file_id=10017

* Cited in Cabraal et al (2005)

Khan, H.J. (2001) ” Battery-Operated Lamps Produced by Rural Women – Bangladesh” in UNDP (2001)

Khandker, S.R. (1998). *Fighting poverty with microcredit: experience in Bangladesh*. Washington, DC: World Bank : Oxford University Press, cited in Hulme (2000).

Kirubi, C.G. (2007), “Does Rural Electrification Cause Rural Development”, forthcoming in *World Development*.

Komives, K., Whittington, D., and Wu, X. “Energy use around the world— evidence from household surveys”, Annex to Chapter 2 in DFID (2002b).

Kumar, S.K. and Hotchkiss, D. (1988).* “Consequences of deforestation for women’s time allocation, agricultural production, and nutrition in hill areas of Nepal.” *IFPRI, Research Report 69*,Washington, DC

Leach, G. and Gowen, M (1987). “Household Energy Handbook - An Interim Guide and Reference Manual”, *World Bank Technical Paper 67*. Washington, D.C.

Little, P. (1997). *Assessing the impact of microfinance programs on incomes and assets,* mimeo, Washington, DC: Consultative Group to Assist the Poorest (CGAP), cited in Hulme (2000)

Lok-Dessallien, R (1999). “Review of Poverty Concepts and Indicators.” United Nations Development Programme, New York, cited in Foster (2002).

Lucas R. (1993).* “Making a miracle.” *Econometrica 61*

Mabona, M. (2001) “Ndirande Nkhuni Biomass Briquette Programme – Malawi” in UNDP (2001).

Manapol P., Weingart J., Lilley A. and Walt, R. (2004).* “Bioenergy conversion for sustainable rural enterprise in the Philippines” *Paper presented at World Renewable. Energy Congress VIII*, Denver, CO.

Mariita, N. (2002) “The impact of large-scale renewable energy development on the poor: environmental and socio-economic impact of a geothermal power plant on a poor rural community in Kenya” *Energy Policy* 30:11-12

Martinot, E., Chaurey, A., Lew, D., Moreira, J.R. and Wamukonya, N. (2002). “Renewable Energy Markets In Developing Countries”, *Annual Review of Energy and the Environment* 27.

Massera, O.R., Saatkamp, B.D. and Kammen, D.M. (2000). “From Linear Fuel Switching to Multiple Cooking Strategies: A Critique and Alternative to the Energy Ladder Model”, *World Development* 28:12

Mayoux, L. (1997). “Impact assessment and women’s empowerment in microfinance programmes: issues for a participatory action and learning approach”, mimeo, Washington, DC: Consultative Group to Assist the Poorest (CGAP).

Meadows, K., Riley, C., Rao, G., and Harris, P. (2003). “Modern Energy: Impacts on Micro-enterprises: A Literature Review into the Linkages Between Modern Energy and Micro-Enterprise” *DFID Project Report R8145*.

Mensah, S.A. (2001) “Energy For Rural Women’s Enterprises – Ghana” IN undp (2001).

Modi, V., McDade, S., Lallement, D. and Saghir, J. (2005). *Energy Services for the Millennium Development Goals*, ESMAP, UNDP, UN Millennium Project and World Bank, NY

Mosse, D. (1994).”Authority gender and knowledge: theoretical reflections on the practice of participatory rural appraisal", *Development and Change* 25:3, cited in Hulme (2000).

Muleguetta, D., Dunnet, J., Khennas, S. and Rai, K. (2006). *Energy for rural livelihoods. A framework for sustainable decision making*, ITDG.

Nakajima, C. (1970). "Subsistence and Commercial Family Farms: Some Theoretical Models of Subjective Equilibrium" in *Subsistence Agriculture and Economic Development*, London: Frank Cass

Njenga, B.K. (2001), "Upesi Stoves Project – Kenya" in UNDP(2001).

Njie, N.-I. (1995).* "Energy's role in deforestation and land degradation", New Your: UNDP

Nyabeze, W.R. (2001). "Linking Productive Activities in Rural Areas to Energy Services – A Case for Micro-Hydro." Presentation at the EC Synergy Workshop, CSIR, Pretoria, South Africa.

ODI (2007) A large number of useful references on the "Research and Policy in Development" Programme may be found at http://www.odi.org.uk/RAPID/, Overseas Development Institute, London, 2007.

Ramani, K.V. and Heijndermans, E. (2003).* *Energy, Poverty, and Gender: A Synthesis*, Washington, DC: World Bank

Rana-Deuba, A., (2001) "Rural Micro-Hydro Development Programme – Nepal" in UNDP (2001)

REN21 [Renewable Energy Policy Network] (2005). "Energy for Development: The Potential Role of Renewable Energy in Meeting the Millennium Development Goals.", Washington, DC: Worldwatch Institute

REN21 (2005) "Energy For Development - The Potential Role Of Renewable Energy In Meeting The Millennium Development Goals".

Richter, M. and Meunier, B. (1997) Accelerating Rural Electrification in Inner Mongolia with the Use of Wind and Solar Energy. GTZ, Eschborn, Germany cited in Martinot *et al* (2001)

Rogerson, C.M. (1997) "Rural electrification and the SMME economy in South Africa." EDRC, University of Cape Town, cited in Meadows *et al* (2003).

Roe, E. (1998) *Policy analysis and formulation for SL*, New Yourk: UNDP

Sachs, J.D. (2005) *Investing in Development: A Practical Plan to Achieve the Millennium Development Goals*. London: Earthscan

Scoones, I. (1999), "Sustainable Rural Livelihoods: A Framework for Analysis" cited in Drinkwater and Rusinow (1999).

Schuler, S.R., & Hashemi, S.M. (1994). "Credit programs women's empowerment and contraceptive use in Rural Bangladesh", *Studies in Family Planning* 25:2, , cited in Hulme (2000).

Sebstad, J., Neill, C., Barnes, C., and Chen, G. (1995). Assessing the impacts of microenterprise interventions: a framework for analysis. Washington, DC: USAID, cited in Hulme (2000).

Sengendo, M.C. (2001) "Photovoltaic Project For Rural Electrification – Uganda" in UNDP (2001).

Siddhi, P. (2000). "Making solar affordable to the poor", *Paper presented at Village Power 2000*, Washington, DC: World Bank

* Cited in Cabraal et al (2005)

Simanowitz, A. (2001). "*A Review of Impact Assessment Tools*", Guideline for "Improving the Impact of Microfinance on Poverty, Action Research Programme" [Imp-Act], Institute of Development Studies, University of Sussex

Singh, I., Squire, L., and Strauss, J. (1986). *Agricultural household models: extensions and applications*. Baltimore, MD: John Hopkins University Press.

Smith-Sivertsen, T. et al (2004). "Reducing indoor air pollution with a randomised intervention design: A presentation of the Stove Intervention Study in the Guatemalan Highlands", *Norsk Epidemiologi* 14:2

Stone, L. (1998). Revolutionary health care PV-powered, *Home Power* 66

Sunday Observer (2001).* "No rise in bottle lamp accident victims", Sept. 23, Sri Lanka

Toman, M. and Jemelkova, B. (2003) "Energy and economic development: An assessment of the state of knowledge", *Energy Journal 24*

UN-Energy (2005). *The Energy Challenge for Achieving the Millennium Development Goals*, UN-Energy, NY

UNDP (1992) *World Energy Assessment*, New York: UNDP

UNDP (2001) "Generating Opportunities: Case studies on energy and women"., New York: UNDP

UNDP (2005) *Achieving the Millennium Development Goals: The role of energy services - case studies from Brazil, Mali and the Philippines*, New York: UNDP

Urmee, T. and Wimmer, N. (1999). "Transforming lives: microcredit promotes renewable energy in Bangladesh", *Renewable Energy World* 2:4, cited in Martinot et al (2002).

World Energy Assessment [WEA] (1992), New York: UNDP

White, R. (2002).* "GEF-FAO Workshop on Productive Uses of Renewable Energy: Experience, Strategies, and Project Development" *Workshop Synthesis Report,* Rome, Italy: FAO

World Bank, (1996a).* "The rural energy situation#, *Rural Energy and Development: Improving Energy Supplies for Two Billion People*, Washington, DC: World Bank

World Bank (1996b).* "Renewable energy-based electricity for rural social and economic development in Ghana", proposal to the Global Environmental Facility

World Bank. (1999).* "Poverty and Social Development in Peru 1944–1997", *World Bank Country Study, World Bank Report 19651*, Washington, DC: World Bank

World Bank. (2003).* *Infrastructure Services: The Building Blocks of Development*, Washington, DC: World Bank .

World Bank, (2004).* Energy Sector Management Assistant Programme: The Impact of Energy on Women's Lives in Rural India, p. 59. Washington, DC: World Bank.

World Bank. (2005).* Directions in Development: Environmental Health and Traditional Fuel Use in Guatemala. p. 6. Washington, DC: World Bank

Xavier Institute of Management (1997) *Socio-economic assessment of power sector in Orissa*, 1997, Bhubaneswar, cited in Meadows *et al* (2003).

* Cited in Cabraal et al (2005)