Chapter 2
Rural Electrification and Rural Development

Paul Cook

Abstract Recent interest in rural electrification has emphasised the importance of linking its development with productive uses for energy and poverty reduction. This has been viewed as necessary to increase the pace of rural electrification and reduce its concentration on a relatively small number of developing countries. Despite this emphasis, progress in electrifying remote rural areas has been slow. In part this has been attributed to the emphasis on cost recovery and a reliance on the private sector to deliver electricity widely. This chapter reviews the literature on the role and relation of infrastructure, particularly infrastructure in rural areas, to economic growth and development. It reviews the focus on poverty reduction by the major international development agencies and examines the arguments for increasing rural incomes. It critically reviews the economic and social issues underlying the development of rural electrification, drawing on the experience with both grid and off-grid applications in developing countries and assesses the impact of electrification on the ability to generate income in rural areas. Conclusions are drawn in relation to the beneficiaries of rural electrification, the constraints that are faced in stimulating economic activity that will contribute to making rural electrification more feasible and affordable and to the importance of complementary services and appropriate institutions to support rural electrification.

This chapter is a revised version of the paper Infrastructure, rural electrification and development by the author that was published in Energy for Sustainable Development, 15(3):304–13.

P. Cook (✉)
Centre on Regulation and Competition, University of Manchester, Manchester, UK
e-mail: paul.cook@manchester.ac.uk

S. Bhattacharyya (ed.), *Rural Electrification Through Decentralised Off-grid Systems in Developing Countries*, Green Energy and Technology,
DOI: 10.1007/978-1-4471-4673-5_2,

2.1 Introduction

The recent literature on rural electrification has emphasised the importance of linking its development with productive uses for energy. This has been viewed as necessary to increase the pace of rural electrification and reduce its concentration on a relatively small group of developing countries. The slowness to extend electricity to rural areas in a wide range of developing countries through grid extension, stand-alone and mini-grid approaches has resulted in a substantial proportion of the world's population still without access to electricity. It is estimated that worldwide more than 1.4 billion people did not have access to electricity. Regionally, South Asia and Sub-Saharan Africa are amongst the poorest served, with only 48.4 and 11.9 % respectively of their rural populations having access to electricity (see IEA 2009). The disappointing progress towards providing sufficient rural electricity has been partly attributed to the insistence on cost recovery, particularly where projects are privately financed, and to the failure to raise the incomes of rural households and effectively design tariffs and adapt regulatory systems that can make electricity more affordable to poorer communities (Estache et al. 2001). The evidence for this conclusion can be seen in the World Bank's most recent ratings for the rural electrification projects it supports. Only 68 % of electrification projects supported since 1995 have been ranked satisfactory, which represents a drop from earlier periods, and is below the rated assessment for all World Bank projects in general (World Bank 2008).

The purpose of this chapter is to review the past and more recent literature on the role and relation of infrastructure, particularly rural infrastructure, to economic growth and development. It will examine some of the economic and social issues underlying the development of rural electrification, drawing on the experience with both grid based expansion and off-grid applications in developing countries.

The review will assess the impact that schemes for rural electrification have had on small business development and income generating activities and on access and affordability. Affordability is of course, related to household income and opportunities to earn income, as well as income or concessions provided through various types of policy interventions (e.g. implicit and explicit in the design of tariff and subsidisation policies). Affordability is also integrally affected by wider issues, such as participation in community-based initiatives and the availability of localised credit facilities to help develop and finance access and use of energy.

2.2 The Relation Between Infrastructure and Growth

Intuitively rural electrification is an important part of a country's infrastructure, although it has not always been the case that it has been given priority in a developing country's economic plans for infrastructure. The interest in the importance of infrastructure for growth and development has historically ebbed

and flowed, as has the debate over whether it ought to be provided by the public or private sector. Central to these issues has been the type of case that can be made for developing infrastructure. Should infrastructure to be developed primarily because the relationship to economic growth is a supportive one, acting as a prerequisite for growth? Or alternatively, does economic growth increase the demand for more infrastructural services? In contrast, can the development of infrastructure be viewed as a universal right, giving people access to essential services? Clearly, the case for this has been made more strongly in relation to water and health. A definitive answer to these age old questions has been difficult to find. Swings in political ideology at the national and international levels have played their part in explaining the fluctuating interest in issues relating to infrastructure. In recent years, there has been a belief that the differences in growth between the successful East Asian economies and other parts of the developing world can be explained by failure to invest sufficiently in infrastructure (Estache and Fay 2007).

Moreover, the concern for rural electrification has resurfaced in recent years with the heightened interest in infrastructure in relation to the part it can play in improving welfare and reducing poverty. Poverty is now officially recognised as the core issue of international development; notably, halving absolute poverty by 2015 is at the top of the list of the Millennium Development Goals (MDGs) (UN 2000), and the MDGs are recognised by most aid agencies, as well as by many NGOs, as constituting their leading priority. In part this is a return to a recognition that the relative importance of infrastructure may relate to a country's level or stage of development. In developing countries, even on economic grounds, it is now seen that there is an urgent need to expand infrastructural services as widely as possible to integrate dispersed populations in rural areas into the mainstream economy. The mainstream economy has typically been concentrated in urban areas where economic activities have been most vibrant. A contrast in experience can be witnessed in the industrialised countries, where increased attention on private ownership and the development of infrastructure have changed the pattern and level of service provision in rural areas, although welfare has not necessarily declined as a consequence. For example, the privatisation of railways has often resulted in a deterioration of services in rural areas, as provision has been rationalised on economic efficiency grounds, but alternatives and substitutes in the form of other methods of transport have often been more readily available. The relation between infrastructure and growth has been a debated arena for some time as both the quantity and quality of infrastructure affect growth.

Infrastructure affects growth through a number of channels both direct and indirect. The most evident direct link is through the productivity effect. This is often captured in a production function framework, where an increase in the quantity of infrastructure ought to raise the productivity of other factors. For example, giving enterprises access to electricity will spread to the development of other types of investment. This process can be applied to infrastructural investment in remote areas and result in an increase and diversified range of private investments in productive activities. Direct channels, therefore, concern the effects of

infrastructure on productivity in industry, agriculture as well as various types of services. The impact of investment in infrastructure on growth, output or firm costs will in turn also depend on the indirect channels. For example, on the number of users and, in the case of electricity, on the extent of the network as there will be network effects. Modeling the effect of infrastructure on growth will need to include these nonlinear effects and capture the effects of network externalities which will be reflected in the size of the network, the institutional development associated with network development and the degree of competition or factors that affect the quality of the service provided.

Agenor and Moreno-Dodson (2006) point to improvements in the stock of infrastructure reducing private capital adjustment costs through lowering the logistic cost of such investments and by allowing the substitution of palliative investments in machinery. Here infrastructure services can be made more reliable to reduce a firm's necessity to invest in substitutes to hedge against potential service disruptions, therefore freeing up resources for more productive things. In rural areas this may relate to the effect on labour productivity due to reductions in the time commuting, fetching, carrying and organising work. Developing infrastructure can also contribute to improving health and education which increases labour productivity in both the short and longer terms. An interesting characteristic of infrastructure investment is its spatial dimension. It involves choices concerning the selection of rival locations for equipment and processes and connections for energy, since it is an input for firms and household's consumption and investment decisions. The location of infrastructure will affect patterns of behaviour such as the decision to migrate and locate a business. The contrast between urban and rural areas is often portrayed as one between leading and lagging regions. Rural populations market most of their goods in urban concentrations. In this respect the most promising research from a spatial dimension has been developed from the approaches combining new growth theory with new economic geography (Krugman 1995).

Literature in this arena suggests that infrastructure will interact with physical characteristics to affect the comparative advantage of a region. Investing in electricity to help disadvantaged regions could change characteristics in order that these areas could integrate with more prosperous parts of the economy. Evidence from the transport sector can be used to illustrate the point. Improved infrastructure in a poorer area may remove a natural trade barrier that was protecting a local industry and lead to a higher concentration of employment in a more successful region. In this way access to electricity in an underdeveloped area could lead to the inward migration of new enterprises moving to lower cost regions. This effect is likely to be reinforced if complementary types of infrastructure and related services are also being developed, which will further contribute to lowering costs. This point is developed in more detail later in the paper in relation to rural electrification.

Numerous studies and reviews of the relation between infrastructure and economic growth have been undertaken. Recent examples include Straub and Vellutini (2006) and Straub (2008). Calderon and Serven (2004) point out that increases in the quantity and quality of infrastructure raise growth but the effects

can take a long time and can be costly. Whilst these reviews find both positive and negative effects on growth, there appears to be consensus that infrastructure matters more for growth in lower income countries (Romp and deHaan 2005). Fewer studies explore the relationship between infrastructure and growth in Africa and most are hampered by the low quality of data and the concentration on the role of human capital (Estache and Fay 2007). More recently, Escribano et al. (2010) has extended the analysis by using total factor productivity in African manufacturing to examine the relationship with infrastructure. They find although infrastructure (including electricity) has a low impact on total factor productivity in the higher income countries in the region, the poor quality of electricity provision does have adverse effects in poorer countries. Earlier Esfahani and Ramirez (2003) came to similar conclusions, estimating that poor economic performance in Sub-Saharan Africa was due to under investment in electricity and telecommunications. Some of the blame for the poor performance of low income economies has been linked to the adverse effects on infrastructure investment resulting from the pursuit of economic liberalisation and forms of structural adjustment policies in the 1980s, which called for smaller government and reduced public expenditure (Cook 1988). Most capital expenditure in low income developing countries was aid financed in the 1980s since indebtedness caused the cessation of external private capital inflows. Some of the external financing supplied by the only lenders at the time, the World Bank and the IMF, was diverted to support recurrent rather than capital costs, as the effects on operating and maintenance of previous capital expenditure was becoming increasingly recognised (the so-called recurrent cost problem). Inevitably, this limited the growth of infrastructure in a wide range of low income developing countries. Although private investment in infrastructure, principally through privatisation did not significantly develop until the mid-1990s, after the World Bank concluded in its Bureaucrats in Business Report (1995) that utility privatisation had not proceeded as anticipated, the results have nevertheless been disappointing. A recent study by Cook and Uchida (2008) showed that although the performance of privatised utilities may have improved immediately after privatisation in developing countries, this was not the case later. Even 10 years after privatization there have been significant declines in investment and rising indebtedness has been used to cover operation and maintenance costs of privatised electricity utilities in many developing countries.

2.3 Electricity and Growth

Electricity infrastructure as consumption and an intermediate good is linked to growth in income and therefore causality between income and infrastructure may be in both directions. Changes in income lead to changes in the demand for electricity and electricity generation. The causality between electricity and economic growth has preoccupied energy economists for a number of years. Four types of causal relationship between electricity and economic growth have been

postulated in the recent literature (Ozturk 2010). These consist of no relationship, which implies that a policy directed at each is irrelevant for the other. If the relationship is one where economic growth leads to the growth in demand for electricity then policies directed towards conserving energy may have little effect on economic growth. If on the other hand electricity consumption leads to economic growth, then conserving energy may adversely affect economic growth. The most plausible relationship is likely to be in two directions and in this case the relation between policies towards promoting growth, energy use and conservation are likely to be more complex. The differences are, however, increasingly relevant as the ideas for sustainable development continue to penetrate thinking about future growth paths for developing countries. The initial relationship between energy consumption and economic growth was explored by Kraft and Kraft (1978) in the US. Since then, numerous studies in this field have used single country bi-variate and multi-variate models (which have included variables such as fixed capital formation, labour force etc.) to examine the relationship (see Ozturk 2010 for a recent review). The results from the majority of studies examined on causality are mixed.

A recent study by Huang et al. (2008) has grouped countries by income to investigate the relationship between energy consumption and growth. They use panel data for 82 countries between 1972 and 2002. They find a bi-directional (feedback) relationship between energy consumption and economic growth. In lower income countries there did not appear to be a causal relationship between energy consumption and economic growth, with the implication that setting parameters for energy policy would be less clear cut since increases in energy consumption would not lead to growth. In middle income countries (lower and upper) economic growth leads positively to energy consumption and negatively in higher income countries. This implies that high income countries have already undertaken conservation policies to protect the environment.

With the relation postulated for middle income developing countries there is the additional question posed in the literature of whether the benefits resulting from economic growth from energy consumption outweigh the cost imposed on the environment through pollution. This appears in the so-called inverted U relation between the level of economic development and pollution (Grossman and Krueger 1995). In low income countries there are not many industrial units to pollute. As an economy grows, pollution increases as it attracts higher polluting industries. Eventually, the pollution problem becomes the main concern and there may be a tendency to produce lower polluting products (although firms can export their pollution by relocating to lower income countries).

The inconclusive nature of the empirical results on the causality between electricity consumption or use and economic growth may be due to statistical inconsistencies, inappropriate methodologies for measuring the relationship and differences in comparative country contexts. A major shortcoming of many of the studies is that they have merely extended the range of years investigated and have not introduced significantly different methods. Most data span 30–40 years and using unit root and Johansen co-integration tests with insufficient data points

provides low statistical testing power (Huang et al. 2008). Although inconsistent results on the association and the direction of the link exist, the more important question for development comes down to the importance of electricity (or energy) in relation to other factors of production, such as capital and labour. Even where this has been examined the results continue to be mixed. Recently, Wolde-Rufael (2009) has shown that in 11 out of 17 countries studied in Africa energy contributes to economic growth but not as much as capital and labour. It ought to be noted that transport costs also generally form a higher proportion of a firm's total costs than energy. Studies at the country level, however, do find more in favour of a relationship running from electricity consumption to economic growth (Ozturk 2010). This implies that a policy to halt or slow down electricity capacity growth will adversely affect economic growth.

It has also been argued that many studies are flawed in terms of causality or attributing impact because electricity is put into areas with the greatest potential for growth. Further, results can be distorted because a developed country puts more effort into creating energy efficiency and introducing protective regulation for the environment and the economy, whilst a developing country is more likely to put more resources into production rather than energy efficiency and environmental protection.

2.4 Rural Electrification Policies in Developing Countries

The policy emphasis towards rural electrification has fluctuated over time and has been influenced by the World Bank. In the 1970s the World Bank thought investment in rural electrification was worthwhile [reflecting the received wisdom over the previous 20 years that rural electrification would act as a catalyst for rural development (Hirschman 1970)] but would be loss-making (World Bank 1975). It was thought that the high up-front investment costs and perceived low demand in rural compared to urban areas would constrain rapid development in this direction and that developments in health and water were of higher priority. Despite the spurt to rural electrification projects in the 1980s in, for example, Malaysia and Bangladesh, an Independent Evaluation Group (IEG) found disappointing results in terms of low economic returns, low cost recovery (between 10 and 15 %) and little evidence of an impact on industrial development (IEG 1994). This finding was also reflected in wider reappraisals of its effects which began in the 1980s (Barnes 1988; Foley 1992; Pearce and Webb 1987; Kirubi et al. 2008).

The World Bank's approach to energy in the 1990 s turned towards the promotion of utilities in the private sector. The implications for the electricity sector were spelt out in World Bank (1993a). This represented a reversal of earlier policy where the World Bank had argued, particularly for poorer countries, that privatisation of utility sectors was too difficult due political reluctance and the lack of

willing buyers and investors (Cook 1999). In the early 1990s the World Bank also attempted to balance efficiency with an emphasis on sustainable development with little real success (World Bank 1993b). The subsequent shift by the World Bank and other international development institutions after 1995 towards a strategy based on poverty had a more significant implication for rural electrification programmes and the ways in which they were perceived.

The link between energy and poverty was clearly laid out in a number of the World Bank's reports (World Bank 1996). By 2008 the World Bank could claim that the economic case for investment in rural electrification is proven and that the benefits to rural households are above the average long run supply costs, indicating that cost recovery tariff levels are achievable (World Bank 2008). The World Bank's coverage of rural electricity is still low in South Asia and Sub Saharan Africa and it acknowledges that it supports few projects in the countries where access to electricity is poor and rural electrification is limited, although new energy projects have recently commenced in Ethiopia, Uganda and Tanzania. The motives for supporting projects are evenly matched between those that aim to improve welfare (60 % have this component and it includes poverty reduction), those to increase electricity supply (72 % have this component) and those to foster institutional development (75 % have this component). Most poverty reduction objectives are associated with multi-sector projects. Institutional development mainly relates to utilities and private sector development and includes training and operational support as for example provided in Senegal and some grid and off-grid regulation projects in Peru.

Most World Bank support for off-grid projects appear to be linked to renewable energy schemes and is usually a component of a larger project, as is the case in at least 28 out of the 33 off-grid projects that involve the World Bank. Many of these are considered pilot projects which attract co-funding from the Global Environment Facility (See Sovacool 2010 for a recent review of support mechanisms for renewable electricity). The World Bank uses several criteria to support electrification projects. These include cost effectiveness to connect, distance to a grid, affordability and population density. Sometimes a wider more socially-oriented criterion is used in a minority of projects (usually multisectoral projects) and has been used to support projects in deprived regions of NE Brazil and in Chile, Honduras and Vietnam.

According to the World Bank, projects furthest from a grid are likely to involve off-grid solutions, where there are small communities. In this way a kind of pecking order is used which favours grid over off-grid support. Financial considerations are also used to determine the merit order. This is the case because the World Bank's favoured model for delivering even off-grid electricity is through the private sector, as in Nicaragua and Laos. However, as the example of Cuba shows the real value of supplying a locality with off-grid technology lies in its ability to draw on local resources and help develop local potential (Cherni and Hill 2009).

As far as an overall assessment is concerned it is evident that the private sector has not developed electrification in rural areas on the scale envisaged with privatisation and the variety of approaches pursued to increase private participation in

infrastructure. This is largely the case whether consideration is given to investment in rural electrification through privatised utilities, forms of public–private partnerships, increased use of subsidisation, through for example output-based aid and more overtly through development assistance.

The deficit has to a very limited extent been filled by the growth of local micro and small scale private providers and community-based cooperatives, who have become more prominent and have to some extent compensated for the failings of large scale privatisation and publicly-owned monopolies, either through stand-alone or mini-grid systems (Ellegard et al. 2004; Sebitosi et al. 2006; Moner-Girona 2009; Yadoo and Cruickshank 2010). In addition, there is evidence that larger scale private firms resort to generating their own electricity in response to the insecurity in network supply. For example, Steinbuks and Foster (2010) find significant evidence of own generation of electricity in Africa. They examined 25 countries. Self-generation accounts for 6 % of installed capacity in Sub-Saharan Africa, or 12 % in lower income countries in the region.

Own generation is high despite power sector reforms. The marginal costs of own generation are high and emergency backup does not appear to fully explain why there are so many own generators, although power failures, when they occur, do put strains on smaller enterprises, for example in Nigeria (Adenikinju 2005) and Uganda (Reinikka and Svensson 2002) and on enterprises in the informal sector. If smaller enterprises generate electricity they tend to install less than 5 MW thermal generators. Again, although maintenance levels are generally low, essential parts are sometimes difficult to acquire. Reinikka and Svensson (2002) also suggest that the costs of own generation outweigh the benefits. The decisions to generate own electricity result from many factors and the benefits are difficult to measure. They include elements such as lost sales due to power failures and where backup is needed to meet export demand. Since own generation of power is costly there could be opportunities to sell power at full cost. The extent of this is largely unknown and whether or not excess power could be sold to grid to improve national power supply is uncertain. For small firms it is believed that own generation imposes relatively low fixed costs but higher variable costs. For larger firms, the reverse is the case, with firms facing relatively high fixed costs and increasing variable costs, indicating that there could be scope for large firms to sell to small firms.

2.5 The Focus on Poverty

Despite the heightened interest in poverty reduction through the targets established in the MDGs, the objectives are not new: poverty reduction has been a major policy focus in development circles for at least two decades. Unsurprisingly, there is an immense literature on poverty going back to the 1960s, and the intention here is to draw out some of the main analytical perspectives as a framework for an understanding of the linkage to specific economic reforms held to have a pro-poor

orientation (see Minogue 2004). Whilst this is a contested literature, there is general agreement that poverty in some way constitutes deprivation; that it has absolute and relative dimensions; and that it is complex and multifaceted, with no linear set of relations of cause and effect (Addison et al. 2008; Hulme and Shepherd 2003; Grinspun 2001; World Bank 2000; UNDP 1997).

Traditionally, poverty has been understood through its connection with inadequate levels of income and consumption, identified either in terms of inadequacy of food availability and consumption, insufficient fulfillment of basic needs or inadequate levels of income to meet basic needs. The minimum requirements, which were originally considered solely in terms of calorie-intake or food requirements, are now considered in terms of basic needs, which take into account both food and non-food requirements for the minimally acceptable fulfillment of human needs (UNDP 1997). Based on this concept of basic human needs, poverty is considered a deprivation of the minimum necessary level of material requirements including food, as well as basic health, education and essential services required in order to prevent people from falling into poverty.

The concept of entitlement distinguishes between availability and accessibility, because the simple availability of goods and services in society at large does not necessarily ensure everyone's access to them. People need to have an established command over those goods and services in order to benefit from them; in other words, they must have entitlement to the minimum necessary goods and services necessary to meet basic needs (Sen 1981). For example, entitlement to command food may be secured through ownership of land that produces food or by securing employment that generates income to buy food (Dreze and Sen 1989). Entitlement failure, where a person's livelihood system fails to provide access to an adequate bundle of necessities, can arise when unemployment, production and price shocks and other problems increase the vulnerability of particular individuals (Grinspun 2001).

Sen argues that it is inadequate and misleading to regard the poor as a homogeneous category. In reality particular classes and occupational groups have different endowments, being governed by rather different entitlement relations (Sen 1981). The concept of capabilities is used by Sen to explain why entitlement failures occur. People may not have certain capabilities, such as education, to access entitlements, which may prevent them from responding to employment and income earning opportunities (Sen 1999). Whilst individual capabilities are not necessarily sufficient to ensure entitlements (e.g. an educated person may not get a good job if an economy suffers from an economic downturn), basic capabilities are necessary pre-requisites for entitlements.

Inequality is also as important as absolute poverty. With inequality the main conceptual focus is on the distribution of income within a society rather than the levels of deprivation experienced at the individual level. But poverty and inequality are closely linked and poverty reduction has to take place within a broader context of distributional dynamics. Recent research indicates that the more equal the distributions of productive assets (e.g. land) the higher is economic growth (World Bank 2000). This concept applies not only to differences in

countries but to intra regional analysis, and provides justification for developing backward rural areas.

Current approaches to poverty also emphasise the need to involve the poor in the identification of their issues, through participation processes and mechanisms, as well as in the consideration of what types of poverty reduction interventions could be appropriate and effective (Chambers 1997). Two main strategies have emerged from the literature for policy interventions to reduce poverty. Livelihood promotion aims to raise productivity to bring people out of poverty. Livelihood protection aims to prevent a decline in welfare and uses direct transfers and other means to safeguard and protect the vulnerable. Livelihood protection, therefore, focuses on ensuring the minimum level of entitlements. Although these two concepts are useful to distinguish the goals and means of differing poverty reduction policies, it is important to note that they are closely related. Effective livelihood protection makes livelihood promotion more likely, since a household will have the confidence to take on more risky, higher-return economic activities in order to raise income (Matin and Hulme 2003).

2.6 Poverty, Rural Development and Income Generation

The more positive view of the role of rural electrification and its relation to poverty reduction has interesting implications for rural development strategies as a whole. Most people living in poverty are in rural areas living below the poverty line (70 % in rural as opposed to 30 % in urban areas). Earlier thinking was that rural poverty could be alleviated by raising agricultural productivity (Johnston and Mellor 1962). Underpinning this notion was agriculture as a labour-based activity suitable for income earning possibilities in a labour abundant and capital scarce developing economy (Hayami and Ruttan 1971).

Following these ideas a technological revolution in the form of the Green Revolution gave impetus to the idea that agricultural growth could be stimulated, particularly through increasing the efficiency of yields and involving smaller farming units. This created a view that income could be increased with rising equity and that economic growth could be linked to agricultural change through backward (supply inputs to farmers) and forward (marketing and processing of agricultural outputs and consumption linkages, that is expenditure by farmers on non-farm consumption goods) linkages (Ellis 2006). With these developments, infrastructure could contribute to improving agricultural productivity and reduce rural poverty (Van de Walle 2002; Renkow et al. 2004). This view was reinforced by the associated rise in non-farm activities in rural areas (Freeman and Norcliffe 1981).

However, there are sceptical views of the agriculturally centred approach which emphasise that growth and poverty reduction may come more from the links with industry and services than from agriculture (Harriss 1987; Hart 1993). Work by

Bernstein et al. (1992) and Ellis (2000) have questioned the agriculture-centred approach to rural poverty reduction. They point to the importance of non-farm sources of income for rural households through studying livelihood patterns. The livelihood approach emerged in the 1970s and provides the link between assets and the options that people have to pursue alternative activities that give income. The belief that farming alone can provide a sufficient means of survival in rural areas is replaced by a livelihood approach that emphasises a process by which households construct a diverse portfolio of activities and social support capabilities for survival and to improve standards of living. Moreover, it is evident that incomes of farm households also depend on income from migratory flows of labour to urban areas (income remittances). Interestingly, it has been found that the rural poor are more dependent on agriculture than the better-off rural population, who are less dependent on agriculture (Ellis and Freeman 2004). The better-off farmers are also able to use non-farm income to acquire inputs to raise productivity of farms. Part of the explanation for the emphasis on non-farm income is linked to the deteriorating terms of trade between agricultural and industrial goods prices. In many instances then this has led to less reliance on agriculture in rural areas with increasing rural to urban migrations, particularly of males and women remaining in agriculture.

Livelihood research would therefore suggest that rural poverty reduction depends on the scope for intersectoral mobility and adaptability (Ellis 2006), and that barriers to these need to be addressed (barriers include institutional factors such as land tenure systems that hamper exit; land tenure systems make land rental difficult without compromising ownership security). There are also social restrictions on the mobility of women (less the case in the Philippines). In this case poverty reduction could be served by encouraging urban and non-farm growth, although some attention would need to be given to raising farm productivity where this is low. Rural lighting, by improving possibilities for education, would help remove the bottleneck of failure to get an urban job by raising skills and increasing prospects of rural non-farm employment (Gibson and Olivia 2009). In practice, many households straddle rural and urban areas through migration and investment strategies, kinship ties and cultivation and livestock ownership (Satterthwaite and Tacoli 2002). Rural to rural migration is also important, which is often seasonal, and migrants search for work in road construction for example and contribute to building infrastructure (Rogaly 2006).

Water and livelihoods are also intimately connected because water is a constraint on food production. Around 80–90 % of all consumed water goes onto fields and only half of that touches crops through poor irrigation. In the water sector the shift to cost recovery has increased prices for those connected to the piped network, however, many of the poorest and those living in low income settlements have not been connected. Low income households can buy water from private vendors but this soaks up a high proportion of their income and may not be viable. Connection is also not tenable because connection charges are high and there is a need to pay bills on a regular basis. Income for the poorest is often uncertain and seasonal. This is a reminder that poor households may find

themselves constrained to make choices when allocating their low incomes between necessary and possibly mutually reinforcing public services such as water and energy; if they pay for one they may not have enough remaining income to pay for the other.

2.7 Impact of Electricity on Income Generating Activities

It is argued that electrification enables livelihoods in several ways. By stimulating employment and income generating activities, where people build assets such as the expansion of dairy milk production and achieve better cash flows. It also argued that electrification enables people to use surplus resources made possible through their entrepreneurship that contribute to the emergence of credit and savings schemes based on the newly available cash. Extra electric lighting and improved water from better pumping facilities are likely to reduce women's drudgery in fetching water and create opportunities to set up other businesses.

In general, one of the underlying dilemmas of rural enterprise in developing countries is that electric machinery potentially replaces labour that is comparatively cheap and the poorly educated fail to recognise the potential uses and benefits of motive power. In this situation the inclusion of complementary services including training becomes an important element for creating change. This is reaffirmed in the study by Peters et al. (2009) who examine the impact of developing rural electricity with complementary services as opposed to just financing hardware and civil works. Complementary services in their study refer to advocacy to take-up and use electricity. These services comprise sensitisation campaigns to raise awareness amongst households, enterprises and social institutions of both the advantages and disadvantages of electricity. With respect to commercial electricity users, complementary services can be broadened to cover business development services, consumer and micro-finance services and other infrastructure, telecommunications and transport (Kirubi et al. 2008; Brew-Hammond 2009; Mustonen 2010). Utilities could provide complementary services as is the case in Thailand. Kenya used this approach: the Kenya Power and Lighting Company (KPLC), a national utility, put 500 rural electrification schemes covering health, schools and community water in rural Kenya costing 30 million US$ (KPLC 2007). NGOs also contribute in this area. Bastakoti (2006) in a study of rural electrification in Nepal argues that complementary service systems and policy coordination are necessary preconditions for the effective use of electricity power in rural communities.

One of the difficulties in assessing the impact of electrification on opportunities for income generation is to separate the effects of existing connections to electricity and the stimulus provided by new connections. The literature does not always address this issue in a direct way. One study that makes a distinction is by Prasad and Dieden (2007).They indicate that growth in income generating

activities primarily resulted from businesses already connected to electricity. Prasad and Dieden used household survey data between 1995 and 2004 to examine the impact of electrification on the development of micro, small and medium sized enterprises and those in self employment amongst households. They estimated that between 40 and 53 % of the increase in enterprise activity was attributed to the extension of the electricity grid, indicating that enterprise growth was higher amongst those already connected. However, in the more remote rural areas the take up did appear to be stronger. It increased by more than 40 % amongst non-connected and only 10 % amongst the connected. Enterprises were mainly in the wholesale and retail sectors. The increase in cellular telephone technology was also a contributing factor to uptake.

However, the aim of targeting rural electrification towards income generating activities that will raise the demand for electricity and support cost recovery appears to be compatible with the recent shift in policy emphasis by the major International Development Institutions who favour rural electrification that impact on poverty alleviation and reduction. The discussion on livelihoods indicated that there were better prospects for developing off-farm activities in rural and remote areas than relying on agriculture, although in terms of asset building the greatest scope for developing enterprises might come from the better off in the farming community who has access to a variety of income sources. It was also apparent that the scope for generating economic activities in sparsely populated rural areas might be greatest when inward investment could migrate easily to low cost regions. Clearly, rural electrification would facilitate a response to the risks associated with this by making it easier to operate and repair various types of machinery.

This was reaffirmed by Kirubi et al. (2008) conducting fieldwork in Kenya. They reported that electricity enabled the use of electric power tools and equipment which resulted in an increase in productivity of enterprises studied. These ranged from retail shops, grain mills, petrol garages, welding and carpentry businesses. Enterprises could also support the further mechanisation of agriculture as welding facilities were more readily available. An important element of this study, however, was the link to other types of infrastructural development, including business support services. This finding is in keeping with studies of other infrastructure sectors. For example, Whittington et al. (2008) in the case of the water sector shows how important are post construction support.

It is, however, difficult to draw firm conclusions from the empirical studies and project evaluation reports that have attempted to access the impact that rural electrification has had on income generating activities. There are studies that provide a more negative view of the link with electricity. For example, Wamukonya and Davis's (2001) study in Namibia reported that electrification did not have a significant impact on the growth of income-generating activities in rural areas. They found that the share of households with home-based income generating activities was highest amongst households without electricity. In their study home-based activities included basket weaving, cake making and welding. Few home-based enterprises used electricity except for lighting. All the businesses that

used electricity started before electrification. The source of electricity, whether from grid or solar powered energy, did not influence the overall findings. Further, in a more narrowly focused study on the effects of lanterns for lighting, Adkins et al. (2010) examined the relation between electric lighting and income generation in Malawi. They looked at the innovative use of lanterns that use light-emitting diodes (LEDs) powered by batteries and charged by grid or small solar panels. These have emerged as a relatively cost effective alternative to kerosene and other fuel-based lighting technologies since they provide a brighter light for longer duration. They found little evidence of a clear connection with income generating activities. Lanterns were paid for in cash and not installment plans. The introduction of LED lanterns dramatically changed lighting patterns for buying households, decreased their reliance on traditional lighting sources and reduced their fuel outlays. Agoramoorthy and Hsu (2009) came to similar conclusions from their study in India. These studies do indicate that lanterns in comparison with other energy sources may still be unaffordable and possibly out of reach of the very poor. Some householders indicated that lanterns did provide opportunities to expand business opportunities by allowing more time to work at night when compared to fuel-based lighting sources. The extent of this is difficult to measure. Simply in terms of numbers, however, there are more studies that show rural electrification can contribute to the development of income earning activities. But even in the majority of these studies it is difficult to determine that electrification alone accounted for the positive result. Mapako and Prasad (2008) in their study of Zimbabwe adopted a different approach to examining basic indicators by focusing on end user perspectives. Rural electrification took place mainly as a result of extensions to the grid. Surveying 73 enterprises in Matebeland they concluded electrification increased the number and scope of small enterprises and increased employment. Respondents to their survey did not complain about higher tariffs but were more concerned with the reliability of supply. Hiremath et al. (2009) in a more recent study show the viability in India of small scale renewable energy technologies that can be implemented locally by communities and small producers. These permitted increases in activities such as sewing and handicrafts, where sewing machines were predominantly used by women to generate income. Agricultural work could also be extended to night times.

Other studies have sought to broaden the argument of the benefits of rural electrification beyond income generation. These have included the effects on poverty reduction (Fan and Chan-Kang 2002 in China for example), the quality of education, health, and gender equality. The World Bank's study (ESMAP 2003); in the Philippines found that access to electricity was correlated with educational achievement. Better illumination from solar electricity contributed to improved conditions for study. Access to electricity for television viewing also improves information and helps spread knowledge on health and family planning. Gustavsson (2007) shows in Zambia the educational benefits resulting from solar technology. The study did not suggest that school children's marks improved (this could not be measured) but more time was spent reading and studying. Health benefits were also likely to occur through less eye strain. Obviously, the benefits

for income generation through strengthening education are more likely to be revealed in the longer term. Kanagawa and Nakata (2008), using multiple regression analysis show that literacy rates above 6 years are explained by household electrification. Finally, Howells et al. (2005) examine the effects on the quality of life in rural Africa as a result of energy use. They argue that the benefit of electrification in reducing local pollution (cleaner energy) and allowing for special high value added services helps explain why the South African Government and Eskom (the public electricity utility) have engaged in electrification programmes for poor areas and support a subsidy for an initial volume of electricity for poorer consumers.

2.8 The Impact on Access and Affordability

According to the World Development Indicators (2007) access to electricity is lowest in low income countries and, as a percentage of population, is lower than access to other infrastructure services such as telecommunications, water and sanitation. Whilst access to electricity is undoubtedly the major problem facing electricity reform programmes in developing countries, much progress at an individual country level has been achieved. In recent years, for example, electrification levels have more than doubled in South Africa from 34 to 70 % between 1994 and 2001 and from 20 to 42 % in Zimbabwe between 1980 and 2001 (Davidson and Mwakasonda 2004). In these countries off-grid electricity programmes were used to reach the poor, particularly for lighting. Questions have been raised concerning whether or not this use of electricity is the highest priority for the poorest communities (Davidson and Sokona 2002). It has been argued that designing energy reform programmes for the poor ought to address household cooking and water heating needs over lighting. This would reduce the heavy dependence on traditional fuels such as wood, dung, candles and kerosene that are predominantly used by the poor (Louw et al. 2008); although even here the value to lighting cannot be under estimated, in terms of providing opportunities for the poor to raise their capabilities through the extra hours of studying that can be undertaken and the additional illuminated time it provides to engage in simple income earning activities.

Even where electricity is made available to a poor community the take up has been affected by a wide range of factors. Various models have indicated that the demand for electricity is income inelastic, as households view electricity as a basic good. This assumption is implicit in most individual country's electricity planning, for example in South Africa, and in the energy policies of international development agencies such as the World Bank. It is also apparent that cross price elasticities of substitute energy services are inelastic and that various fuels are substitutes for each other. However, it has not always been the case that the poor have switched to more sophisticated forms of energy when these have become available (Howells et al. 2010). In practice, most households continue to use a

combination of fuels at any one time, some of which may be advanced and others more traditional. In any event, household fuel choices are likely to be related to the size and diversity of household incomes, and other factors such as education and distance and availability of natural resources come into play (Heltberg 2004). The cost and availability of electric appliances, such as cooking stoves, has often been a prohibiting factor in the take up of electricity. If appliance costs were to be subsidized then indications are that the demand for electricity take up and use would increase amongst the poor. However, whether or not the cost for this is borne by cross subsidisation by higher income and higher consumption households has to be carefully considered as price sensitivity amongst higher income groups could lead them to switch to other fuels, with a consequent fall in the demand for electricity.

The experience from projects has shown that where electricity becomes available the take up is variable. Sometimes it takes between 1 and 3 years for households to start using electricity, and there are still high percentages that do not connect. So a distinction can be made regarding the type of policy that ought to be used to improve connection where electricity has arrived, and towards expanding electricity to areas where it does not presently exist. The World Bank report that the emphasis is on the latter in Indonesia. This situation exists, despite the fact that once a community is electrified, the marginal cost of electrifying additional households is low. Marginal costs fall as more households become connected. It is therefore argued that if tariff levels are sufficient to cover operating and maintenance costs then little is lost by providing connections. However, in terms of affordability it may mean looking more critically at discriminatory tariffs to capture the poor that go beyond the cross subsidisation of commercial and non-commercial users (as in Cambodia) and rural and urban users.

The World Bank confirms that in their experience connection rates are low for the poor even when electricity becomes available. This has mainly been attributed to the relatively high cost of connection. They cite the example of Laos, where 30 % of the population cannot afford the $100 connection charge. They also reiterate that even though off-grid schemes can be delivered to a community at lower cost than an electric grid can be extended to an area, it is sometimes still the case that the price of off-grid electricity is higher than to those households that are buying electricity from a grid elsewhere. It is obvious that cost continues to be a barrier to accessing off-grid electricity for poorer households. But even for the better off, costs can be formidable in many countries in Africa. For example, for a solar heating scheme in Namibia a household needs $2,500 per year.

The World Bank in their projects has also looked at the issue of late connectors, as in Laos, but has largely attempted to deal with the issue through loans rather than subsidies. These are being tried in Ethiopia and Thailand. It is apparent that the use of subsidies are more common in relation to off-grid projects, particularly to meet the upfront equipment installation costs, since operating costs are negligible in the case of solar energy and these systems only require limited maintenance. This circumstance may represent a problem for low skilled poor communities and may

correspondingly provide opportunities for unscrupulous businesses to exploit the situation by introducing high dealer and maintenance costs.

In general the World Bank favours the use of partial subsidies schemes that retain an incentive element. They also prefer the use of extended credit and possible micro credit institutions but these do not exist in all areas. Community based schemes assist in getting people together to pay and work (for example in Kenya) but may be more difficult to organise in the more remote areas of a country. It is likely that subsidies have gone to the better off and there is some evidence that the poor pay more per kilowatt hour for electricity than higher level consumers (Angel-Urdinola and Wodon 2007).

These circumstances can be attributed to design flaws in tariffs. Tariffs are often skewed against the poor because they represent a higher risk category i.e. they have a greater tendency to default and have to be disconnected at a cost. These categories of the poor are also more likely to tap into or grab electricity illegally. Part of the problem here is tariffs are not always made clear to the poor, whose education may be low, and they have not previously been used to paying regular bills. It has also been argued that subsidies for electricity, especially where a free element is provided, can have distorting effects through encouraging poor households to cook with electricity rather than using potentially cheaper alternatives such as liquefied petroleum gas (Howells et al. 2006).

A useful study on many of the issues discussed so far is provided by Prasad (2008), who compares the impact of energy reform in Botswana, Ghana, Senegal and Honduras. Prasad gives two examples of successful energy reform to increase access and affordability. In Botswana the electricity that was delivered resulted in a method of payment adjustment to make it affordable to the poor. This led to a fivefold rise in rural connections between 1996 and 2003. In the most recent phase of reform potential customers formed groups of 4 or more to share the cost of extending the grid to their premises. A 5 % payment was required before connection work began. The balance of 95 % was provided by a loan from the Botswana Power Corporation (BPC), paid with interest spread over 18, 60 and 180 months according to customer preferences. Full cost recovery was insisted on to sustain the reform programme. The government paid for the grid extension. It was reckoned that 80 % of the beneficiaries would not be connected without the scheme. Groupings also increased affordability. Low income households could afford loans because BPC did not require income guarantees and security. Sometimes lower interest rates than commercial loans were applied. However, low income households on irregular incomes continued to encounter affordability problems. In Senegal households got subsidies for butane gas for cooking. The scheme also subsidised small stoves and gas cylinders. This led to a reduction in the use of charcoal and wood and helped with deforestation. The exit of the subsidy did depress growth in demand. 85 % of Senegalese households across all income ranges tend to use gas for cooking compared to 23 % of the lowest income group in Botswana. Motives for reform did vary between the two countries and there has been some deforestation in Senegal. In Botswana poverty alleviation and deforestation was secondary. In both countries the poorest of the poor remained

excluded despite government intentions. The poorer were also the first to revert to wood when the subsidy was reduced to 20 % in Senegal.

Typically subsidies for rural electrification tariffs are based on estimates of household spending for lighting and light electricity use. This was the case in Argentina (Covarrubias and Reiche 2000). In the absence of willingness to pay analysis, household expenditure on kerosene, bottled gas and dry batteries was used as an indicator of the upper limit of electricity tariffs and affordability. This determined the baseline cost the rural poor could pay. If the actual cost of electricity provision was higher, then the difference ought to be subsidised. But surveys show that willingness to pay, even if estimated in this way, can be lower than a household's capacity to pay. In practice households generally want to pay less than they previously paid for kerosene when switching to electricity or any other new energy source. Obviously, there are advantages which they may not recognize such as convenience of use and less pollution in the household.

Problems remain in relation to the knowledge poor communities have over the benefits of electricity and in convincing them that these will eventually contribute to improving welfare. The poor may continue to be reluctant to adopt newer processes when they perceive meeting regular monthly payments will be difficult, since their income flows vary in time and are often seasonal.

2.9 Impact on Income Distribution

There is a group of studies that analyse the distributional impact of infrastructure reform. Amongst them are Adam and Bevan (2004), Bricefio-Garmendia and Klytchnikova (2006) and Boccanfso et al. (2009). Bricefio-Garmendia and Klytchnikova use household data to show that the access gaps for infrastructure between the poorest and richest 20 % in various countries are systematically strongest in poorer countries. Access to electricity is 9.7 % for the poorest 20 % of the population compared to 68.7 % for the richest 20 %. Access for middle income countries was higher in both extremes of the income spectrum, reaching 80 % amongst the poorest 20 % of the population and almost 100 % for the highest income category. It is apparent, however, that access rates for the poor are much higher for water and sanitation than for electricity, although they are low for telephones. Presumably this results from the greater priority given to water and sanitation over energy and telecommunications because they are identified more clearly as universal basic needs and also have significant health and public health implications. Balisacan et al. (2002a, b), using data from the Philippines 1985–1997, argue that the rich benefit more than poorer segments of the population from access to electricity. Balisacan et al. (2002a, b) in examining Indonesia in 1990 showed that a 10 % improvement in access to electricity raised income to the poor by only 2 %.

Access to electricity will affect market production and the demand and supply for labour and may lead to a change in the nature of enterprises that can operate in these rural areas. According to Dinkelman (2009) there is a net labour supply

effect in South Africa as labour is freed up with the arrival of electricity. The effect on women is greatest. The female employment response is driven by the middle-poor and second -richest communities that initially rely on wood for cooking and are able to respond more when new electricity services become available. The effects are larger for women in their 30 and 40 s and there is evidence to suggest that this is related to women having fewer child-care responsibilities at these ages.

Dinkelman also looks at the potential spillover effects from electrification. If firms create jobs for people living in neighbouring areas, then there are said to be positive spillover effects. If, however, people move out of a non-electrified area towards an electrified area to get a job, then there is a negative spillover. Dinkelman suggests there are no strong spillover effects between communities. Electrification was driven by household targets and capacity was too small to stimulate even mid-sized enterprises or services. The lack of evidence for spill-overs, therefore, supports the claim that electrification increased employment primarily through a labour supply rather than a labour demand channel. Why might middle-quintiles in particular have larger employment effects? It appears these communities contain households that experienced the largest changes in home production technology when electricity arrived. Middle poor areas are initially less likely to be using electricity than richer areas and are anyway more reliant on wood for cooking. Women who have additional home-production responsibilities are less likely to be able to respond to the new access to electricity, even though their productivity at home may be substantially enhanced by the use of electricity i.e. child care.

2.10 Conclusions

In what ways has infrastructure development or reform failed the poor? It is apparent that many of the benefits from rural electrification have gone to the non-poor (both access and subsidises). Rural electrification schemes have not so far provided universal access and have been unaffordable for most poor people. The question of addressing access for the poor has been raised many times and the solution has often been portrayed as simple. As argued by Estache and Fay, it essentially involves three aspects. First, instruments are required to ensure service operators provide access (a service obligation). Second, instruments are required to reduce connection costs (through tariff design or direct subsidies built into payment plans to favour the poor). Third, instruments are required to increase the range of suppliers (to give choice to users to opt to choose lower quality service providers). The achievements of these have often been difficult and slow (Bhattacharya (2007) on South Asia) and our understanding of the issues that act as constraints to the above is incomplete.

Both connection charges and electricity charges continue to represent serious constraints for the poor and more innovative discount or subsidy schemes for connection and improved tariffs, that are compatible with poor people's incomes

and resources, are required. Our review has also indicated that whilst the more extensive use of subsidies cannot be ruled out, caution is needed in relation to the distributional effects of certain types of subsidies. For example, whilst income elasticities do not rule out cross-subsidisation as a way of providing affordable services to lower income households, high income groups could be over-burdened, and as a result may alter the quantity of electricity they consume. For example, it could lead to a decrease in demand (where gas is available for instance) to middle and high income households (as indicated in Louw et al. 2008), if greater price sensitivity exists amongst higher income groups who could switch to other fuel sources. Our review has also shown that, if appliance costs are subsidised, then electricity take up and use would increase for the poor.

Our review has indicated that the earlier emphasis on cost recovery and reliance on the private sector to delivery electricity widely was misplaced. More recently, the World Bank, drawing on the experience with the 120 electrification projects it has supported since 1995, has moved away from a pure cost recovery approach to provide lessons that are more in keeping with meeting the needs of the poor, particularly in rural areas. These include firstly, justifying subsidises for capital as long as income covers operating and maintenance costs. The example of Kenya's experience with community led rural micro-grids that have the potential to cover a substantial proportion of the operating costs from internal revenue derived from the sale of electricity and other charges linked to SMEs, demonstrates the alternatives that are available.

Secondly, rural electrification programmes must be implemented with complementary infrastructure, including educational initiatives that influence change. As seen in our review this enables the users of electricity to put energy to productive uses. These aspects are not normally part of rural electrification programmes provided by private or state-owned utilities. Even enterprise development programmes have not, as a rule, been designed to promote end-users of electricity (Cook 2006). There are, of course, some examples such the Nepalese Enterprise Development Programme between 1993 and 1998 that did, but these have often been short-lived.

Thirdly, an autonomous and effective implementing agency is needed to ensure that plans for electrification can be delivered. Although it has been argued that the precise institutional structure for these agencies is less relevant, as different structures exist in different countries (Barnes and Foley 2004 citing examples of a separate rural electricity authority in Bangladesh, rural cooperatives in Cost Rica and branches of government in a wide range of countries), it is apparent that not all types of institutions are effective. An ingredient that works in many spheres of local development is to involve the community closest to the targeted beneficiaries that can leverage local skills and resources and overcome local resistances.

References

Adam C, Bevan D (2004) Aid and the supply side: public investment, export performance and Dutch disease in low income countries. Department of Economics Working Paper 201, Oxford University: Oxford.

Addison, T., Hulme, D., Kanbur, R. (2008). Poverty dynamics: Measurement and understanding from an interdisciplinary perspective. BWPI Working Paper 19. Manchester: Brooks World Poverty Institute, University of Manchester.

Adenikinju, A. (2005). Analysis of the cost of infrastructure in a developing economy: The case of the electricity sector in Nigeria. African Economic Research Consortium Research Paper 148, Nairobi.

Adkins, E., Eapen, S., Kaluwile, F., Nair, G., & Modi, V. (2010). Off-grid services for the poor: Introducing LED lighting in the millennium villages project in Malawi. *Energy Policy, 38*, 1087–1097.

Agenor, P., Moreno-Dodson, B. (2006). Public infrastructure and growth: New channels and policy implications. Policy Research Working Paper Series 4064. Washington: World Bank.

Agoramoorthy, G., & Hsu, M. (2009). Lighting the lives of the impoverished in India's rural and tribal dry lands. *Human Ecology, 37*(4), 513–517.

Angel-Urdinola, D., & Wodon, Q. (2007). Do utility subsidies reach the poor? Framework and evidence for Cape Verde, Sao Tome, and Rwanda. *Economics Bulletin, 9*(4), 1–9.

Balisacan, A., Banerjee, A., Cole, S., Pernia, E. (2002a). Probing beneath cross-national averages: Poverty, inequality and growth in the Philippines. ERD Working Paper Series no 7. Manila: Asian Development Bank.

Balisacan, A., Pernia, E., & Asra, A. (2002b). *Revisiting growth and poverty reduction in Indonesia: What do sub-national data show? ERD Working Paper Series no 25*. Manila: Asian Development Bank.

Barnes, D. (1988). *Electric power for rural growth: how electricity affects rural life in developing countries*. Boulder: Westview Press.

Barnes, D., Foley G. (2004). Rural electrification in the developing world: a summary of lessons from successful programs. Joint UNDP/World Bank Energy Sector Management Assistance Programme (ESMAP), Washington: World Bank.

Bastakoti, B. (2006). The electricity-livelihood nexus: Some highlights from the andhikhola hydroelectric and rural electrification centre (AHREC). *Energy Sustain Development, 10*(3), 26–35.

Bernstein, H., Crow, B., & Johnson, H. (1992). *Rural livelihoods: Crises and responses*. Oxford: Oxford University Press.

Bhattacharya, S. (2007). Power sector reform in South Asia: Why slow and limited so far? *Energy Policy, 35*, 317–332.

Boccanfso, D., Estache, A., & Savard, L. (2009). A macro–micro analysis of the effects of electricity reform in Senegal on poverty and distribution. *Journal Development Study, 45*(3), 351–368.

Brew-Hammond, A. (2009). Energy access in Africa: Challenges ahead. Energy Policy, 1–11.

Bricefio-Garmendia, C., & Klytchnikova, I. (2006). *Infrastructure and poverty: What data are available for impact evaluation*. Washington DC: World Bank.

Calderon C, Serven L (2004) The effects of infrastructure development on growth and income distribution. World Bank Policy Research Working Paper 3400. Washington: World Bank.

Chambers, R. (1997). *Whose reality counts? Putting the last first*. London: Intermediate Technology Development Group.

Cherni, J., & Hill, Y. (2009). Energy and policy providing for sustainable rural livelihoods in remote locations—The case of Cuba. *Geoforum, 40*, 645–654.

Cook, P. (1988). Liberalizacion y politica de desarrollo industrial en los paises menos dessarrollados. *El Trimestre Economico, LV, 1*, 3–40.

Cook, P. (1999). Privatisation and utility regulation in developing countries: The lessons so far. *Annals Public Cooperative Economics, 70*(4), 549–587.
Cook, P. (2006). Private sector development strategy in developing countries. In G. Hodge (Ed.), *Privatization and market development*. Cheltenham: Edward Elgar.
Cook, P., & Uchida, Y. (2008). The performance of privatised enterprises in developing countries. *Journal Development Study, 44*(9), 1342–1353.
Covarrubias, A., & Reiche, K. (2000). *A case study on exclusive concessions for rural off-grid service in Argentina*. Washington: World Bank.
Davidson, O., & Mwakasonda, S. (2004). Electricity access for the poor: A study of South Africa and Zimbabwe. *Energy Sustain Development, 8*(4), 26–40.
Davidson, O., Sokona, Y. (2002). A new sustainable energy path for African development: think bigger, act faster. Cape Town: Energy and Development Research Centre, University of Cape Town.
Dinkelman, T. (2009). The effects of rural electrification on employment: New evidence from South Africa, mimeo: Princeton University.
Dreze, J., & Sen, A. (1989). *Hunger and public action*. Oxford: Oxford University Press.
Ellegard, A., Arvidson, A., Nordstrom, M., Kalumiana, O., Mwanza, C. (2004). Rural people pay for solar: Experiences from the Zambia PV-ESCO project. Renew Energy, 29, 1251–1263.
Ellis, F. (2000). *Rural livelihoods and diversity in developing countries*. Oxford: Oxford University Press.
Ellis, F. (2006). Rural poverty reduction. In D. Clark (Ed.), *The Elgar companion to development studies*. Cheltenham: Edward Elgar.
Ellis, F., & Freeman, H. (2004). Rural livelihoods and poverty reduction strategies in four African countries. *Journal Development Study, 40*(4), 1–30.
Escribano, A., Guasch, J., Pena, J. (2010). Assessing the impact of infrastructure quality on firm productivity in Africa. Policy Research Working Paper 5191. Washington DC: World Bank.
Esfahani, H., & Ramirez, M. (2003). Institutions, infrastructure and economic growth. *Journal of Development Economics, 70*, 443–477.
ESMAP. (2003). Rural electrification and development in the Philippines: Measuring the social and economic benefits. Energy Sector Management Assistance Programme, 255/03. Washington DC: World Bank.
Estache, A., Fay, M. (2007). Current debates on infrastructure policy. Policy Research Working Paper 4410. Washington DC: World Bank.
Estache, A., Gomez-Lobo, A., & Leipziger, D. (2001). Utilities privatisation and the poor: Lessons and evidence from Latin America. *World Development, 29*(7), 1179–1198.
Fan, S,. Chan-Kang, C. (2002). Growth, inequality, poverty reduction in Rural China. Research Report 125. Washington DC: IFPRI.
Foley, G. (1992). Rural electrification in the developing world. *Energy Policy, 20*, 145–152.
Freeman, D., & Norcliffe, G. (1981). The rural nonfarm sector and the development process in Kenya. In G. Norcliffe & T. Pinfold (Eds.), *Planning African development*. London: Croom Helm.
Gibson, J., & Olivia, S. (2009). The effect of infrastructure access and quality on non-farm enterprises in Rural Indonesia. *World Development, 38*(5), 717–726.
Grinspun, D. (2001). *Choices for the poor: Lessons from national poverty strategy*. New York: United Nations Development Programme.
Grossman, G., Krueger, A. (1995). Economic growth and the environment. Q J, 10(2), 353–377.
Gustavsson, M. (2007). Educational benefits from solar technology—Access to solar electric services and changes in children's study routines, experiences from Eastern Province Zambia. *Energy Policy, 35*, 1292–1299.
Harriss, B. (1987). Regional growth linkages with agriculture. *Journal Development Study, 23*(2), 275–289.
Hart, G. (1993). Regional growth linkages in the era of liberalisation: A critique of the new agrarian optimism. World Employment Programme Research Working Paper no 37. Geneva: International Labour Office.

Hayami, Y., & Ruttan, V. (1971). *Agricultural development: An international perspective*. Baltimore: John Hopkins University Press.
Heltberg, R. (2004). Fuel switching: evidence from eight developing countries. *Energy Economics, 26*, 869–887.
Hiremath, R., Kumar, B., Balachandra, P., Ravindranath, N., & Raghunandan, B. (2009). Decentralised renewable energy: Scope, relevance and applications in the Indian context. *Energy Sustain Development, 13*, 4–10.
Hirschman, A. (1970). *Development prospects observed*. Washington DC: Brookings Institution.
Howells, M., Alfstad, T., Victor, D., Goldstein, G., & Remme, U. (2005). A model of household energy services in a low-income rural African village. *Energy Policy, 33*, 1833–1851.
Howells, M., Victor, D., Gaunt, T., Elias, R., & Alstad, T. (2006). Beyond free electricity: The costs of electric cooking in poor households and a market-friendly alternative. *Energy Policy, 34*, 3351–3358.
Howells, M., Jonsson, S., Kack, E., Lloyd, P., Bennett, K., Leiman, T., et al. (2010). Calabashes for kilowatthours: Rural energy and market failure. *Energy Policy, 38*(6), 2729–2738.
Huang BN, Hwang M, Yang C (2008) Causal relationship between energy consumption and GDP growth revisited: a dynamic panel data approach. Ecol Econ, 41–54.
Hulme, D., & Shepherd, A. (2003). Conceptualising chronic poverty. *World Development, 31*(3), 403–423.
IEA. (2009). *World energy outlook*. Paris: International Energy Agency.
IEG. (1994). *Evaluation results independent evaluation group*. Washington DC: World Bank.
Johnston, B., & Mellor, J. (1962). The role of agriculture in economic development. *American Economic Review, 51*(4), 566–593.
Kanagawa, M., & Nakata, T. (2008). Assessment of access to electricity and the socio-economic impacts in rural areas of developing countries. *Energy Policy, 36*, 2016–2029.
Kirubi, C., Jacobson, A., Kammen, D., & Mills, A. (2008). Community-based electric micro-grids can contribute to rural development: Evidence from Kenya. *World Development, 37*(7), 1208–1221.
KPLC (2007) Kenya power and lighting company annual report and accounts 2006–2007; Nairobi.
Kraft, J., & Kraft, A. (1978). On the relationship between energy and GNP. *Journal Energy Development, 3*, 401–403.
Krugman, P. (1995). *Development, geography and economic theory*. Cambridge, MA: MIT Press.
Mapako, M., & Prasad, G. (2008). *Rural electrification in Zimbabwe reduces poverty by targeting income-generating activities*. South Africa: Energy Research Centre, University of Cape Town, Cape Town.
Louw, K., Conradie, B., Howells, M., & Dekenah, M. (2008). Determinants of electricity demand for newly electrified low-income African households. *Energy Policy, 36*, 2812–2818.
Matin, I., & Hulme, D. (2003). Programs for the poorest: Learning from the IVGVD program in Bangladesh. *World Development, 31*(3), 647–665.
Minogue, M. (2004). *What connects regulatory governance to poverty? Centre on Regulation and Competition*. Manchester: University of Manchester.
Moner-Girona, M. (2009). A new tailored scheme for the support of renewable energies in developing countries. *Energy Policy, 37*, 2037–2041.
Mustonen, S. (2010). Rural energy survey and scenario analysis of village energy consumption: a case study of Lao People's Democratic Republic. *Energy Policy, 38*(2), 1040–1048.
Ozturk, I. (2010). A literature survey on energy-growth nexus. *Energy Policy, 38*, 340–349.
Pearce, D., Webb, M. (1987). Rural electrification in developing countries: A reappraisal. Energy Policy, 329–338.
Peters, J., Harsdorff, M., & Ziegler, F. (2009). Rural electrification: Accelerating impacts with complementary services. *Energy Sustain Development, 13*, 38–42.
Prasad, G. (2008). Energy sector reform, energy transitions and the poor. *Energy Policy, 36*, 2806–2811.

Prasad, G., & Dieden, S. (2007). *Does access to electricity enable the uptake of small and medium enterprises in South Africa*. South Africa: Domestic Use of Energy Conference.
Reinikka, R., & Svensson, J. (2002). Coping with poor public capital. *Journal of Development Economics, 69*(1), 51–69.
Renkow, M., Hallstrom, D., & Karanja, D. (2004). Rural infrastructure, transaction costs and market participation. *Journal of Development Economics, 73*, 349–367.
Rogaly, B. (2006). Migration for rural work. In D. Clark (Ed.), *The Elgar companion to development studies*. Cheltenham: Edward Elgar.
Romp, W., de Haan, J. (2005). Public capital and economic growth: A critical survey. European Investment Bank Papers, 10(1), Luxemburg.
Satterthwaite, D., & Tacoli, C. (2002). Seeking an understanding of poverty that recognises rural–urban differences and rural–urban linkages. In C. Radodi & T. Lloyd-Jones (Eds.), *Urban livelihoods: A people-centred approach to reducing poverty*. London: Earthscan.
Sebitosi, A., Pillay, P., & Khan, M. (2006). An analysis of off grid electrical systems in Rural Sub- Saharan Africa. *Energy Conservation Management, 47*, 1113–1123.
Sen, A. (1981). Poverty and famines: An essay on entitlement and deprivation. New York: Oxford University Press.
Sen, A. (1999). Development as freedom. Oxford: Oxford University Press.
Sovacool, B. (2010). A comparative analysis of renewable electricity support mechanisms for Southeast Asia. *Energy, 35*(4), 1779–1793.
Steinbuks, J., & Foster, V. (2010). When do firms generate? Evidence on in-house electricity supply in Africa. *Energy Economics, 32*(3), 505–514.
Straub, S. (2008). Infrastructure and growth in developing countries: Recent advances and research challenges. Policy Research Working Paper Series 4460. Washington DC: World Bank.
Straub, S., Vellutini, C. (2006). Assessment of the effect of infrastructure on economic growth in the East Asia and Pacific Region, mimeo, Washington DC: World Bank.
UN. (2000). Millennium declaration and millennium development goals. United Nations, New York.
UNDP. (1997). *Human development report*. New York: United Nations Development Programme.
Van de Walle, D. (2002). Choosing rural investments to reduce poverty. World Development, 30(4), 575–589.
Wamukonya, N. (2001), Davis M. Socio-economic impacts of rural electrification in Namibia: Comparisons between grid, solar and unelectrified households. Energy Sustain Development, 5(3), 5–13.
Whittington, D., Davis, J., Prokopy, L., Komives, K., Thorsten, R., Lukacs, H., et al. (2008) How well is the demand-driven, community management model for rural water supply systems doing? Evidence from Bolivia, Peru and Ghana. BWPI Working Paper 22 Brooks World Poverty Institute, University of Manchester; Manchester.
Wolde-Rufael, Y. (2009). Energy consumption and economic growth: The experience of African countries revisited. *Energy Economics, 31*(2), 217–224.
World Bank. (1975). Rural electrification. Policy paper no PUB-517. Washington DC: World Bank.
World Bank. (1993). *Energy efficiency and conservation in the developing world. Policy paper*. Washington DC: World Bank.
World Bank. (1993b). The World Bank's role in the electric power sector: Policies for effective institutional, regulatory and fuel reform. Working Paper. Washington DC: World Bank.
World Bank. (1995). Bureaucrats in business. Washington DC: World Bank.
World Bank. (1996). Rural energy and development, improving energy supplies for two billion people. Washington DC: World Bank.
World Bank. (2000). *Attacking poverty, world development report 2000/2001*. Oxford: Oxford University Press.
World Bank. (2007). World bank development indicators. Washington DC: World Bank.

World Bank. (2008). *The welfare impact of rural electrification: A reassessment of the costs and benefits. An IEG Impact Evaluation*. Washington DC: World Bank.
Yadoo, A., & Cruickshank, H. (2010). The value of cooperatives in rural electrification. *Energy Policy, 38*(6), 2941–2947.

http://www.springer.com/978-1-4471-4672-8

Rural Electrification Through Decentralised Off-grid Systems in Developing Countries

Bhattacharyya, S. (Ed.)
2013, XII, 300 p., Hardcover
ISBN: 978-1-4471-4672-8