Utilising Electricity Access for Poverty Reduction

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Cover page photograph: Andrew Heath, Practical Action.

Executive Summary

The productive use of electricity can support sustained poverty reduction by enabling the creation and improvement of income generating activities. However, in order to realise these positive impacts, the level of electricity access must be sufficient and enabling conditions beyond the electricity supply itself must be in place.

The relationship between electricity access provision and poverty reduction has been unclear and policymakers are seeking answers to the following questions:

1. **What level of electricity access is required to enable and sustain poverty escape?**

2. **What constraints, despite increased access to electricity, mean that people are not able to use that electricity productively? How can they be removed?**

The research presented in this report has sought to explore these questions through a review of existing literature and case studies in Kenya and India which looked at the policy and regulatory regime in each country, and included stakeholder interviews and field research. The Literature Review and Case Study reports are included as annexes to this report.

Neither the literature review nor the field research demonstrated a clear, unambiguous, relationship between level of electricity access and poverty reduction.

While there is some evidence of positive relationships between level of electricity access and increases in enterprise revenues and profits, it has not been possible to identify any relationship between level of access and poverty reduction. Of the eight programmes studied, the three where the greatest increases in household income were seen included two grid extensions but also a solar lantern programme.

Instead, our research has reinforced messages from the literature regarding the importance of combining electricity access with other enabling factors to achieve poverty reduction. It would appear that electricity solutions which provide relatively low-level access may offer the greatest value in terms of poverty impact, while matching electricity access to the particular needs of communities and linking electricity access to markets, skills and finance is critical.

The research explored two variations on the causal chain that can link electricity access to productive uses and to poverty reduction. The first of these mechanisms concerns the improvements in enterprise performance (sales, productivity, profits, quality) that may result from electricity access for those enterprises. The second concerns the impact of electricity access as experienced by people, households and communities, which may increase the time, effort and application of skill that people are able to put in to productive activities.

No decisive link was found between the level of electricity access achieved by households and enterprises (as defined by the SE4ALL Global Tracking Framework) and the productive use or poverty indicators that were inferred from the proposed causal chains. The narrow range of access levels found in the communities studied for the field research limited the degree to which the impacts of different levels of access could be investigated. Improved electricity access was sometimes, but not always, found to result in the creation of new enterprises; however, the level of access did not seem to drive this impact. Contrary to the expectations derived from existing literature, the field research found that improved revenues and profits were often observed for existing enterprises that received improved electricity access, and the magnitude of the benefit did bear a loose relationship with the level of access. However, the case studies proved that sometimes even the most basic electricity access (solar lanterns) can have significant poverty reduction impacts when electricity access eases a limiting factor for a community (e.g. number of working hours) and other factors (markets, raw materials, skills) are favourable to productive use.

The findings relating to employment were inconsistent, with the literature reporting positive impacts but mixed indications generated by the field research, indicating a complex interaction between electricity access and other factors.

Both the literature review and the field research were inconclusive regarding impacts on household income. Some community pairs studied showed strong positive correlations between the household electricity access level and household income, whereas others showed no clear relationship or indicated negative correlations. Electricity access seems to have had a significant positive impact on the quality of education available to children of households surveyed during the field research, especially in India. Positive impacts in terms of healthcare appear to have been less widespread, although survey respondents widely agree that those improvements that have taken place can be attributed at least in part to improved electricity access.

From the evidence of the case studies examined in this study, it would appear to be the lower level, off-grid, energy access solutions which provide the greater value for money in terms of both access tier achieved and increase in beneficiary household incomes.

These sometimes contradictory and counter-intuitive findings affirm that the mechanisms by which electricity access enables poverty reduction are numerous and complex and are influenced by many other factors beyond electricity access.

An examination of the literature and a review of the regulatory and policy framework in the case study countries (including stakeholder consultations) found that the features of policy and regulation that are most critical in increasing use of electricity access for productive purposes by poor people are:

- Clear policy focus on provision of electricity for productive use (relative to basic household provision) and of off-grid electricity in the many contexts in which grid extension is not feasible
- Electricity access policies with explicit links to policies in other areas of livelihood creation and income generation, such as industrial and agricultural development.
- Regulation that encourages the provision of off-grid electricity access by non-governmental actors. In the case of mini-grids, tariff-setting, cross-

subsidisation and licensing regulations are key to bringing about new mini-grid investments. Furthermore, mini-grid developers need policies that protect them from uncertain grid extension plans.

With respect to the electricity supply itself, the poor service provided by on-grid and off-grid supplies alike emerged as a highly influential barrier. Most often, productive use and poverty impacts of electricity access were hampered by the low number of hours per day that electricity was available, poor reliability and quality and the high cost of electricity consumption. The capacity of the supply is also a frequent limiting factor for (potential) productive users. Despite this confirmation of the importance of not just electricity access, but good quality access, a direct connection between level of access and poverty impact could not be established.

Stakeholder interviews and research in communities which had received electricity access confirmed that socio-economic context and the presence of a number of critical enabling factors strongly affect the extent to which looked for benefits of electricity can be achieved. The most significant factors appear to be:

Costs and Access to Finance – both for electricity itself and for the wiring and equipment needed to use it productively, are strongly identified by all as factors driving (or preventing) its take up and use. Stakeholders in both countries saw the high cost of rural provision as being exacerbated by inequitable support regimes which favour grid over off-grid supply and fail to counterbalance the inbuilt cross-subsidy between urban and rural areas inherent in grid systems, with the effect that off-grid communities are competing on unequal terms with nearby grid-supplied communities.

Knowledge & Skills - Low skill levels and capacity act as a barrier to local people securing economic benefits through involvement in electricity provision. Knowledge of the benefits and possible productive uses of electricity is key in the take up of electricity access, and potential users also need the skills to operate and maintain electrical machinery. Finally, entrepreneurial skills are required to identify new opportunities created by electricity access, create new enterprises and find and access markets for the new products and services provided.

Access to Markets - In the absence of adequate access to external markets, demand in rural areas is often constrained and unable to absorb additional production, leading to market saturation with new and newly electrified enterprises simply competing with existing and un-electrified firms for the same overall “pool” of value. In the absence of access to wider markets, the availability of additional labour freed-up by electrification is likely to simply drive down wages and the prices of goods and services produced informally so that even those able to use additional time productively may well not see any increase in incomes.

The design of programmes, as well as policies, must give more attention to the productive use of electricity access, and ideally electricity access should be delivered as part of broader development initiatives that tackle infrastructure, skills and foster access to markets and finance.

Although the relationships between electricity access, productive uses and poverty outcomes identified in the literature are not straightforward, and impacts are highly specific to the country and context in which they are studied, some clear recommendations have emerged to increase the chances of the desired poverty reduction impacts resulting from policies and programmes relating to electricity access. By putting village-scale productive uses at the heart of electricity access provision, policymakers and programme developers can simultaneously improve the viability of electricity access projects and better ensure that the ultimate aims of poverty reduction and economic development are achieved.

Contents

ACRONYMS

CAFOD	Catholic Agency for Overseas Development
DfID	Department for International Development
ESMAP	Energy Sector Management Assistance Programme
GTF	Global Tracking Framework
ICT	Information and Communications Technology
IDS	Institute of Development Studies
IEA	International Energy Agency
IFC	International Finance Corporation
JNNSM	Jawaharlal Nehru National Solar Mission
kW, kWh	kilo Watt, kilo Watt hour
LaBL	Lighting a Billion Lives
NFE	Non-Farm Enterprise
NGO	Non-Governmental Organisation
PAC	Practical Action Consulting
REA	Rural Electrification Authority
RGGVY	Rajiv Gandhi Grameen Vidyutikaran Yojana
RISE	Readiness for Investment in Sustainable Energy
RVEP	Remote Village Electrification Programme
SE4All	Sustainable Energy For All
TERI	The Energy and Resources Institute
UNDP	United Nations Development Program
VAT	Value Added Tax
W, Wh	Watt, Watt hour
WB	World Bank

Note: although some authors define ‘mini-grids’ and ‘micro-grids’ separately, this report uses the term ‘mini-grids’ throughout to refer to all sizes of distribution systems up to 10 MW.

1. Introduction

Lack of access to electricity, for both households and enterprises, is seen as a major constraint to economic growth and increased welfare in developing countries. However, having good access to electricity requires more than just the existence of a physical connection or a source of electrical generation. Numerous *attributes* (such as duration, affordability, safety and convenience, among others), drive the extent to which people and enterprises can make use of electricity and so affect its ability to improve lives and livelihoods.

The productive use of electricity offers the potential for sustained poverty reduction through the creation and improvement of income generating activities. Energy is crucial for enterprises. It drives economic and social development by increasing productivity, incomes, and employment; reducing workloads and freeing up time for other activities; and facilitating the availability of higher-quality or lower-priced products through local production. For many applications, electricity is the optimal form in which energy can be used. Indeed for some applications, in particular lighting and ICT, electricity is the only viable energy source. Electricity is often the most affordable and convenient source of energy for higher power and dynamic loads such as drills and lathes, welding equipment, weaving machinery and refrigeration.

However, in poor communities the use of electricity is often limited to lighting, mobile charging and TV. These low-power applications are associated with important benefits for poor people, and can enable and enhance some types of productive activity, particularly services, but when people and businesses limit their use of electricity to lighting and electronics, the low and short-duration consumption levels both jeopardise the financial sustainability of electrification projects and limit the income generation potential of electricity access (Pueyo et al, 2013). On the other hand, productive activities in the primary and secondary sectors – those that involve manufacture or processing – often require a level of electricity access far beyond that which is needed for lighting and ICT/entertainment, most importantly in terms of capacity and the number of hours for which power is available.

Policymakers are concerned with maximising the productive uses of electricity in order to support sustained poverty reduction. However, most authors agree that whilst electricity is generally a necessary condition for increased income generation and poverty reduction, these outcomes are also conditional on a number of other factors. Policymakers aiming to maximise the poverty impact of electricity access are therefore interested in answering two questions:

1. **What level of electricity access is required to enable and sustain poverty escape?**

2. **What constraints, despite increased access to electricity, mean that people are not able to use that electricity productively? How can they be removed?**

This study has sought to respond to these questions through a literature review and two country case studies consisting of policy research, stakeholder consultations and field surveys. The full reports of the literature review and the case studies in India and Kenya are attached as annexes to this report, which synthesizes their findings to draw conclusions regarding the links between different levels of access to electricity and their impact on poverty reduction. Both parts of the work aimed at finding regularities between different levels of access and their poverty impact, bearing in mind that electricity is only one of the elements required for sustained poverty reduction. The study also seeks to investigate the constraints or enabling factors that prevent or promote productive uses of electricity and thus to recommend ways to make poverty reduction a more assured outcome of improved electricity access for poor people.

Accordingly, this report has added to the two principal research questions described above three supplementary questions:

1. What regulatory and policy measures will be most critical in increasing use of electricity access for productive purposes by poor people?
2. How programmes for electricity access can best be designed to incorporate measures which will allow constraints on productive uses to be overcome?
3. What technologies and on and off grid electricity systems can provide the levels of electricity access needed for productive use while achieving the greatest value for money?

Following this introductory chapter, Section 2 ‘Causal Links’ begins by mapping the routes through which electricity access is understood to enable poverty reduction.

Section 3 ‘Methodology’ outlines the methodology behind the various components of this study: the literature review and country case study research, consisting of a review of policy and regulatory frameworks, an electricity access provider stakeholder consultation and primary research in the form of field surveys. Finally, the chapter discusses the limitations of the research, the reliability of data and the level of confidence which can be placed on its findings.

Section 4 ‘Country Contexts’ positions the case study countries with respect to the geographical foci of the related literature. It goes on to describe in brief the electricity access situation in each case study country, with emphasis on the policy and regulatory features that promote or inhibit the provision of electricity access and the take up and productive use of that electricity.

Section 5 compares the levels of electricity access (as defined by the SE4ALL Global Tracking Framework) as indicated by the studies covered by the literature review with those found in the samples surveyed as part of this study and comments on the implications of the differences found.

Sections 6 and 7 consider the impacts of improved electricity access on productive uses and poverty outcomes respectively, synthesising evidence from the literature and the field research component of this study. Each impact is considered in turn, with conclusions being drawn with respect to the impact of electrification (considered as a binary variable) and the impact of different levels of electricity access.

Section 8 considers the factors that may enable or constrain the take up and productive use of electricity access. Some of these factors are aspects of the electricity supply itself, whereas others are features of the value chains and enabling environments which apply to rural enterprises. Evidence from the literature review and the field research is brought together to evaluate how influential each factor might be.

Section 9, Value for Money, draws on information regarding the costs of the programmes considered in India and Kenya to compare the value for money, in terms of electricity access level and impact on household incomes, of the different forms of access provision.

Finally, Section 10 brings together the evidence presented so far to develop broader conclusions about the relationship between electricity access, productive uses and poverty outcomes, while Section 11 sets out recommendations for policy makers and programme designers.

2. Causal Links between Electricity Access and Poverty Reduction

Although most literature agrees that electricity access is necessary for poverty reduction, the causal chains suggested for this dependence are various. This is to be expected given that researchers must deal with multi-factorial systems, with energy only one of a linked set of variables that determine poverty outcomes. The most frequently reported **causal chains** linking electricity access to poverty impacts are:

1. **the improved productivity or output of enterprises using electricity for their activities** (Barnes and Binswanger, 1986; Cecelski and Glatt, 1982; Grimm et al, 2013; Khandker et al, 2012; Khandker, 2009b; Kooijman-van Dijk and Clancy, 2010; Kooijman-van Dijk, 2012; Maleko, 2005; Meier et al, 2010; Mulder and Tembe, 2008; World Bank, 2008);

2. **the freeing up of time for paid work, which would increase labour supply** (Chowdhury, 2010; Dinkelman, 2008; Grimm et al, 2013; Khandker et al, 2012; Kooijman-van Dijk and Clancy, 2010; Sadanand, 2013; UNDP and ESMAP, 2004; UNDP and World Bank, 2002; Van de Walle et al, 2013).

The first causal chain describes the following process:

1. *Access to electricity is provided.*
2. *There is a demand for products or services that require electricity for their provision or whose production processes can be upgraded with electricity to increase output or productivity.*
3. *There are means to invest in electricity using devices.*
4. *Enterprises connect to and use electricity.*
5. *Income and revenues of enterprises increase as a result, with the potential to generate employment and provide an income for poor people.*

In the farm sector, some of the reported activities that could be upgraded with electricity include heating and lighting for hatcheries and poultry farms, milking machines and cooling for dairy farms, agro-processing equipment such as threshers, hullers, millers and crushers and pumpsets for irrigation. Non-farm activities that may benefit from electrification include tailoring, wood working, welding, hairdressing, beer brewing, retail sales and flour milling.

The second causal chain describes the following process:

1. *Electricity is provided.*
2. *Households connect to and use electricity.*
3. *Electricity extends evening working hours and reduces household drudgery.*
4. *More time is available to carry out paid work activities.*

5. *There are employment opportunities to absorb this additional labour supply as new enterprises are created or existing ones operate for longer hours or can produce thanks to electrification.*
6. *Labour income increases, with the potential to reduce poverty.*

Either or both of these causal chains may be active in a particular electrified community. Both chains imply possible positive feedback loops by which poverty reduction may enable further poverty reduction; the increased income for a household or an enterprise may enable it to invest in a better level of electricity access or better appliances that may promote further increases in income.

The significance of either of the causal chains in a particular community or population will depend to a high degree on pre-existing conditions and the strength and direction of other influences on economic activity (as discussed in greater detail in section 9.1). Therefore, the number, reach and magnitude of positive impacts that may result from improved electricity access will vary significantly between populations even when the features of the electricity services are identical.

The strength and influence of the causal chain also depends on to what degree the electricity supply meets the needs of the households or enterprises that use it. The relative importance of the different attributes of electricity access (capacity, duration/availability, reliability, quality, affordability, legality, health and safety and convenience) will depend on the context, but inadequacy across any of these attributes has the potential to inhibit the causal chains outlined above.

3. Methodology

3.1. Research Question

This study has sought to answer two principal questions:

1. **What level of electricity access is required to enable and sustain poverty escape?**

2. **What constraints, despite increased access to electricity, mean that people are not able to use that electricity productively? How can they be removed?**

Poverty is most frequently taken to refer to low income and consumption. However, some studies present wider perspectives of poverty as related to welfare and the different Millennium Development Goals or the sustainable livelihoods framework. This study has assessed the poverty impacts of electricity access in relation to education and health as well as indicators of financial poverty. Rather than attempting to employ any specific poverty boundary (such as a $1.25/day income level) against which "poverty escape" might be established the study has instead sought to gauge scale of poverty impact against these indicators.

3.2. Literature Review

The literature review component of the study focussed on the question:

"What level of electricity access is required to enable and sustain poverty reduction?"

The review employed a "Realist" approach, which synthesises research with an explanatory rather than judgemental focus to unpack the mechanism that links an intervention to its impacts (Pawson *et al,* 2005). The review began by elucidating a theory to break down the causal chain (described in Section 2). To support a structured and rigorous review, the overall question was broken down into two sub-questions:

1. **Under what circumstances do different levels of electricity access lead to productive uses?**
2. **Under what circumstances do productive uses enabled by electricity lead to income generation/poverty reduction?**

The search for the relevant literature was carried out across both peer-reviewed studies and grey literature, and included primary and empirical studies (according to DfID's terminology) but not secondary or theoretical/conceptual studies. Database interrogations were carried out using pre-defined search terms to identify relevant publications. These findings were added to the lists of identified relevant studies from a previous IDS literature review (Pueyo et al, 2013) on "The evidence of benefits for poor people of increased renewable electricity capacity" and studies identified through back-referencing of other literature reviews and key publications on the productive uses of electricity. In total, 71 studies were selected for inclusion in the literature review (with a further 2 studies being subsequently identified and reviewed).

Each publication was categorised according to its quality (high/medium/low) such that differences between different qualities of study could be examined, and the findings of higher quality studies given more weight.

For each publication, an attempt was made to identify the subjects' level of electricity access as it would be measured by the Global Tracking Framework (which is discussed in Section 3.5 below). Existing publications which only consider the impacts of electricity at the macro-level were excluded because they do not take into account different levels of electricity access, but rather simply use electricity consumption or infrastructure investments as their explanatory variable.

Poverty reduction was examined in terms of productivity, competitiveness, employment generation, enterprise revenue, sustainability of enterprises and overall impact on household income and expenditures.

The synthesis of the data explored regularities and discrepancies in evidence as regards:

- Different levels of access to electricity and increases in productive activity;
- Increases in productive activity and poverty related impacts;
- Different levels of access to electricity and poverty related impacts.

Different impacts were compared in order of how frequently they are reported. The synthesis also considered the level of attention given to a number of reported enabling/constraining factors that interfere with the causal chain.

3.3. Review of Policy/Regulatory Frameworks

Reviews were carried out of the prevailing policy and regulatory environment for electricity access programmes and productive use of electricity access in India and Kenya.

The reviews considered the policies set out in relevant articles of legislation and public statements and their impacts on the ease of provision of electricity access. Government-initiated programmes associated with these policies were explored, and each country's progress towards electrification and electricity access assessed.

The degree to which each country's policy environment is favourable towards electricity access programmes was assessed using the criteria around which the

Readiness for Investment in Sustainable Energy (RISE) framework[1] is built. These criteria are:

- Quality of national electrification plan
- Enabling environment for renewable energy developers to invest in mini-grids
- Enabling environment for Standalone Home Systems
- Level of funding support to electrification
- Affordability of electricity
- Ease of establishing a new connection
- Procedures for permitting a mini-grid

A more limited review of general policies and regulations affecting enterprises was also carried out in order to better understand the challenges that rural enterprises face when trying to improve their profitability through the use of electricity. This review drew primarily on the information provided by the World Bank's Ease of Doing Business Index, which assesses countries over a number of criteria including the ease of getting credit, registering property and paying taxes.

The results of these reviews for each country have been summarised in Section 4, and the recommendations which emerged from them have informed the conclusions and recommendations laid out in Sections 10 and 11.

3.4. Electricity Access Provider Stakeholder Consultation

A series of structured interviews were carried out with stakeholders from the electricity access sectors in India and Kenya. The stakeholders spanned the government, donor, NGO, private and academic sectors.

A questionnaire was used to gather the views of the stakeholders on the following topics:

- How current policy and regulation has been successful in promoting (and/or has impeded) electricity access initiatives, especially the provision of electricity for productive applications;
- What factors, in the view of the respondents are most significant in facilitating or hampering the take-up and use of available electricity access for productive purposes;
- Any possible amendments required related to policy and regulation to enable scaling up of electricity access initiatives for productive applications;
- Considerations in the design of electricity access initiatives;

[1] Readiness for Investment in Sustainable Energy framework developed by the World Bank Group as part of Sustainable Energy for All (SE4All) as a guide to the key policy and regulatory elements needed to create a an enabling environment for provision of electricity access.

- Best practices and lessons from government and private sector for provision of electricity access for productive applications;
- Requirements for scaling up such initiatives: finance, technology, institutions, business models and level of importance given to productive activities in designing electricity access projects.

The key outcomes of the consultations have been incorporated into the country context summaries in Section 4, and have informed the conclusions laid out in Section 10.

3.5. Field Research

The field research element of this study sought to gather primary evidence regarding the relationships between different levels of electricity access, productive uses of that electricity access and poverty outcomes through the study of eight pairs of communities across the case study countries. One of the communities in each pair had been the beneficiary of an electricity access programme.

Programmes were chosen to encompass a range of electricity access models, from solar lanterns through mini-grids to main grid connection[2]. This was intended to allow data to be gathered from people and businesses across a spectrum of electricity access levels. The programmes selected also covered different types of implementing agency, including government, private sector and NGO. Insofar as possible, the focus was on programmes which have been substantively implemented (so that their impacts can be observed) within the past few years (so that data is relatively recent). The selection was also been guided by the level and quality of data available and the willingness of programme stakeholders to engage with this study.

The programmes selected for study are shown in Table 1.

[2] All the off-grid programmes use solar photovoltaic as the generation source. One mini-grid, the Access:Energy system on Mageta Island, Kenya, also uses a wind generator in a hybrid arrangement.

Table 1: Programmes Selected for Study

Sl No.	Country & state/ county	Programme Name	Means of Electricity Access	Type of programme	Implementing Agency
1	**India** - West Bengal	Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY)	Main Grid Extension	Government led grid connected electricity access programme	West Bengal Electricity Distribution Company Ltd
2	**India** - Bihar	Husk Power Systems	Mini-grids	Private sector led entrepreneurship model	Husk Power Systems
3	**India** - Odisha	Lighting a Billion Lives Programme	Solar Lanterns	Civil Society led entrepreneur based model	The Energy and Resources Institute (TERI)
4	**India** - West Bengal	Mlinda Foundation	Mini-Grids	Civil Society led Joint-Liability Group based Mini-Grid model	Mlinda Foundation
5	**Kenya** - Kitui County	Solar Transitions	Solar Energy Centre & Lanterns	CSO led input from team of social scientists and practitioners	Led by University of Oslo
6	**Kenya** - Machakos County	Main Grid Extension	Main Grid Extension	Government led grid connected electricity access programme	Rural Energy Agency
7	**Kenya** - Kaijado County	CAFOD Kajiado	Solar Irrigation[3]	International NGO led grant-funded	CAFOD
8	**Kenya** – Kisumu County	Access:Energy Mageta Island	Mini-grid	Private sector	Access:Energy

The programme beneficiary communities were selected so as to include communities with a range of poverty levels, levels of productive and economic activity and scale and remoteness across each case study country. In addition, communities were sought which had a (preferably non-electrified) non-beneficiary community that was suitable for survey in the vicinity. The non-beneficiary community was selected such that it was as similar as reasonably practicable (in terms of socio-economic characteristics) to the beneficiary community (tThough it is recognised that the reasons for initially selecting communities to benefit from the electricity access programme implementation may have been socio-economic.) The characteristics considered in selecting the non-beneficiary communities were:

[3] Part of wider programme incorporating solar PV electricity access for schools and health facilities.

- Number of households in community
- Number of (registered) enterprises in community
- Average household income per month before programme instituted
- Most recent available average household income per month
- Distance of community from nearest tarmac road
- Distance of community from electricity grid
- Estimated time travel from community to county capital

Before carrying out the field research in each of the community pairs, discussions were held with the programme implementing agency to understand the aims and design of the programme and the impacts it was judged to have achieved.

The programmes and communities, and the selection process, are described in greater detail in the Case Study Reports.

Field Surveys

A questionnaire was developed and delivered to over 550 households and enterprises across the sixteen communities. The sample sizes for each community pair are given in Table 2. Although the survey teams aimed to survey equal numbers of women and men, strict quotas were not set and it is recognised that cultural factors may affect the willingness of certain household members to participate in the survey as lead interviewee. In the event, 43% (163) of those interviewed were female and 57% (219) male. The questionnaire was divided into seven sections:

Section 0. Details of productive uses in the home and owned/managed enterprises

Section 1. Household data: age, gender and occupation of interviewee and head of household; employment status; household income; perceptions of changes to health and education facilities, etc.

Section 2. Present household electricity access and factors affecting take up

Section 3. Past (pre-programme implementation) household electricity access

Section 4. Enterprise data: start year, sector, revenue, profit, employees and employee remuneration, etc.

Section 5. Present productive use electricity access and factors affecting productive use of electricity access

Section 6. Past (pre-programme implementation) productive use electricity access

Some sections were only asked of respondents for whom they were relevant, e.g. enterprises were only asked about past electricity access if they had been in existence prior to the implementation of the electricity access programme.

Table 2: Sample Size by Programme

Community Type	Target Sample Size (per programme)	Actual number surveyed								
		P1: RGGVY	P2: Husk Power	P3: LaBL	P4: Mlinda	P5: Solar Transitions	P6: Machakos Grid	P7: CAFOD Irrigation	P8: Access: Energy	**Total**
Beneficiary households	20-40	35	31	28	25	28	21	16	24	208
Non-Beneficiary households in Beneficiary community	10-20	10	11	15	12	7	10	7	2	74
Non-Beneficiary households in Non-Beneficiary community	10-20	12	10	12	12	15	14	9	13	97
Beneficiary SMEs	4-8	6	5	5	5	12	21	17	32	103
Non-Beneficiary SMEs in Beneficiary community	2-4	3	5	3	3	0	2	4	1	21
Non-Beneficiary SMEs in Non-Beneficiary community	2-4	3	0*	3	3	12	6	10	14	51
Total		**69**	**62**	**66**	**60**	**74**	**74**	**63**	**86**	**554**

* No SMEs were identified in Pachkaria, the Non-Beneficiary Community for the Husk Power programme.

Note: SME numbers above include instances identified through household surveys where productive activities are undertaken within the home with accounts kept separately from household accounts)

Community Feedback Workshop/Focus Group

On completion of the household and enterprise level surveys, discussions were held with stakeholders from the surveyed communities to:

1. Discuss the findings of the survey and validate those findings;
2. Understand the energy requirements of the community, and the extent to which they were presently being met;
3. Discuss any problems regarding electricity services and systems; and
4. Explore any changes to the current system that the community recommend in order to make it more robust and efficient.

Assessing Electricity Access Levels

The methodology for defining and measuring energy access under the SE4ALL Global Tracking Framework is still under development at the time of writing (November 2014). However, this study has used draft questionnaires and the tier boundary definitions so far available for Household and Productive Uses to establish a methodology that follows as closely as possible the latest versions of the Global Tracking Framework. In cases of uncertainty, guidance from the World Bank-ESMAP team was sought and followed as far as practicable given the timeline of the study.

The Global Tracking Framework is designed to assess energy access in all its forms, whereas the focus of this study has been solely on access to electricity. For this reason, some aspects of the Framework were simplified and rationalised to include only electricity access in order to facilitate the delivery of survey questionnaires and avoid unnecessary complication with respect to the analysis of survey data.

Electricity access tiers were first calculated by assessing the *attribute tiers* across the attributes defined by the Global Tracking Framework:

Household Electricity: Capacity, Duration/availability, Reliability, Quality, Affordability, Legality

Energy for Productive Uses: Capacity, Duration/availability, Reliability, Quality, Affordability, Legality, Health and Safety, Convenience

Table 3 and Table 4 illustrate the tier definitions used.

For productive uses and enterprises, attribute tiers were calculated separately for as many of the six ‘applications’ covered by the Global Tracking Framework (lighting, ICT and entertainment, motive power, space heating, product heating and water heating) as were relevant to the enterprise and for which electricity was regularly used. Relevancy was assessed by asking whether the application was ‘strictly necessary’ in order to carry out the productive activity, or whether the business would suffer in terms of productivity, sales, costs or quality without that application.

Table 3: Household Electricity Access: Tier Definitions[4]

Attributes			Tier-0	Tier-1	Tier-2	Tier-3	Tier-4	Tier-5
t_1	**1. Capacity** Amount of energy required to support different levels of power loads	For grid, mini-grid or standalone generators:	< 1 W	1-50 W	50-500 W	500-2000 W	>2000 W	>2000 W
		For battery-based systems:	< 2 Wh/day	2-200 Wh/day	200 Wh/day – 1.2 kWh/day	> 1.2 kWh/day	see note[5]	
t_2	**2. Duration/Availability** Average duration during which the primary energy source is available compared to the average duration during which it is required.	Total Supply (Required: 24 hrs)	<4 hours		4-8 hours	8-16 hours	16-22 hours	>22 hours
		AND	*Select lowest tier indicated by Total Supply or Evening Supply*					
		Evening supply (Required: 4 hrs)	< 1 hour	1-2 hours		2-4 hours		4 hours
t_3	**3. Reliability** Unscheduled outages/breakdowns in energy supply	No more than three unscheduled outages or breakdowns per week of more than 30 min each				No		Yes
t_4	**4. Quality** (Voltage)	Drops or fluctuations in quality parameters are only minor and rare with little or no impact on energy operations			No			Yes
t_5	**5. Affordability** Ability to afford the use of primary source of energy for required applications	Ratio of monthly expense for a consumption package of 365 kWh/year to monthly income		>10%				<10%
t_6	**6. Legality**	Energy supply is obtained through legal means (bill received or payment made)			No			Yes

[4] © International Energy Agency and World Bank, 2013.

[5] The highest tier that battery-based systems can achieve is Tier 3.

Table 4: Electricity Access for Productive Uses: Tier Definitions[6]

If the relevant application is needed but not used due to energy-related issues, the tier rating for that application is 0.

Attributes			**Tier-0**	**Tier-1**	**Tier-2**	**Tier-3**	**Tier-4**	**Tier-5**
t_1	**1. Capacity** Amount of energy required to support different levels of power loads	For grid, mini-grid or standalone generators:	< 1W	1-50 W	50-200 W	200 W – 2 kW	2 – 10 kW	> 10 kW
		For battery-based systems:	< 2 Wh/day	2-200 Wh/day	200 Wh/day – 1.2 kWh/day	> 1.2 kWh/day	see note [7]	
t_2	**2. Duration/Availability** % of usage hours	Average time electricity source available divided by the average operating hours	Less than 25%	25%-50%	50%-75%		At least 75%	100%
t_3	**3. Reliability** Unscheduled outages/breakdowns in energy supply	Number of unscheduled outages per week Cumulative length of unscheduled outages per week						< 4 outages *AND* < 2 hours
		THEN	*If reliability does not meet Tier 5 criteria, assess tier using impact on business operations*					
		Impact of unscheduled outages on business operations			Severe impact		Moderate impact	Little or no impact

[6] © International Energy Agency and World Bank, 2013.

[7] The highest tier that battery-based systems can achieve is Tier 3.

Attributes			Tier-0	Tier-1	Tier-2	Tier-3	Tier-4	Tier-5
t_4	**4. Quality** (Voltage)	Experience of situations in which appliances cannot be used or may get damaged because of low voltage or voltage fluctuations						Not experienced
		THEN	*If situations are experienced, assess tier using impact on business operations*					
		Impact of low voltage or voltage fluctuations on business operations			Severe impact		Moderate impact	Little or no impact
t_5	**5. Affordability** Ability to afford the use of primary source of energy for required applications	Ratio of monthly expense for a specified consumption package to monthly income			Cost is higher than 2 times the grid tariff		Cost is 1-2 times the grid tariff	Cost is less than or equal to grid tariff
t_6	**6. Legality**	Energy supply is obtained through legal means (bill received or payment made)			No			Yes
t_7	**7. Health & Safety** (electrocution, air pollution, burning risk, drudgery)	The electricity supply system has in the past or is likely to cause electrocution, pollution (fumes/smoke), burns or physical harm from drudgery		Solution has or is likely to cause **severe** damage		Solution has or is likely to cause **moderate** damage		Solution has not and is not likely to cause damage
t_8	**8. Convenience**	Obtaining fuel/batteries or maintaining the electricity source subtracts relevant time from the productive activity and reduces business productivity				Yes		No

The overall tier for households, or the application tier for enterprises, was calculated according to the Global Tracking Framework protocol by selecting the lowest attribute tier. The overall tier for enterprises was calculated by taking the average of the application tiers which had been assessed.

For productive uses of electricity, the numbers of enterprises using each of the six 'applications' covered by the Global Tracking Framework (lighting, ICT and entertainment, motive power, space heating, product heating and water heating) and the average tier achieved for that application were calculated.

For households and enterprises, and for each application where applicable, the numbers of respondents achieving each level for the attribute tiers were calculated in order to establish which attributes tended to constrain the household/enterprise's access level most frequently.

Data Analysis

Once levels of electricity access achieved by surveyed households and enterprises had been established, the data was analysed to explore any relationships between these electricity access levels and various indicators of productive activity (enterprise creation, revenues, profits etc.) and of poverty (employment, household income and education and health service provision).

The collection of data for beneficiaries, non-beneficiaries in beneficiary communities, and those in non-beneficiary communities, allowed comparisons to be drawn between:

- Individual households and enterprise which had, and had not, benefited from improved electricity access
- Those in communities which had and had not benefited from the access programme

In addition to exploring regularities between outcomes, which will inevitably be affected by the starting position and for which the direction of causation is difficult to establish (since, for instance, higher levels of electricity access are likely to result from higher income levels as well as higher income from better electricity access), collection of information on both the current situation and the pre-programme-implementation situation enabled analysis of relationships between change in electricity access and change in levels of productive activity and poverty. While this 'difference-in-differences' approach also suffers limitations (see Section 3.6 below) it is judged to be more reliable in identifying how improved electricity access may have enabled productive activity and/or led to poverty reduction.

The analysis looked at both relationships between average outcomes (and average changes) in terms of electricity access level and at regularities in individual outcomes and changes across the datasets. These relationships were explored on a programme-by-programme basis, across the four programmes in each country and (where appropriate) across all eight programmes.

Where appropriate, the field research data has been disaggregated (for example, by gender) to investigate more deeply some of the impacts reported in the literature. Where the literature reports a particular impact of electricity access on productive activities or on poverty outcomes, the field research data has been used to investigate the relationship between the <u>level</u> of electricity access provided and these impacts in the case study contexts.

A full description of the data analysis strategy and method is given in each of the Case Study Reports.

Value Analysis

Data provided by the programme developers supplemented with generic data was used to calculate the costs of providing electricity access under each of the programmes studied[8]. The capital costs of the equipment (generating plant[9], distribution system, solar equipment etc) and the costs of implementing the programme were brought together with operating and maintenance costs, fuel costs and administration costs, using a 15% discount rate, to derive an average annual cost of electricity provision per user for each programme. (These are costs of providing electricity and not the prices charged to users. They do not include costs, such as wiring or appliance costs[10], which will be incurred by end-users if electricity supply is to be transformed into electricity services.)

It should be noted that the costs derived may not be directly comparable or necessarily representative of the costs of the various forms of electricity provision in a wider context because:

- Programme development and ongoing overhead/administration costs, and the impact these have on average through life cost per user, will be very much affected by the scale at which the programme has been implemented.
- Mini-grid and grid extension costs in particular (but also costs of other forms of electricity) are highly location specific, being affected by geography (distance from the existing grid system), local topography, availability of primary energy resources for generation, size and population density of the community served. Thus it is highly unlikely that, for instance, the costs of a mini-grid installed in one location would align with those in another location.

Despite these limitations, by looking at how the resulting electricity access levels and impact on beneficiaries' household income compared with the cost of provision,

[8] Community-specific costs for the RGGVY grid extension programme were not available and average "cost-of-service" figures for the grid system in West Bengal (see Tariff Order 2011-12 and 2012-13, West Bengal Electricity Regulatory Commission, 1st December 2012), which encompass both urban and rural areas, were not judged to provide a useful comparator with the rural community electricity access programmes which form the focus of this study.

[9] For the grid extension programme in Kenya, the cost of the grid extension itself was combined with average costs for generating plant, fuel and other operating and maintenance costs and administration derived from figures published by Kenya Power.

[10] With the exception of solar lanterns where the end-use appliance is not divisible from the means of provision.

some inferences could be drawn regarding the relative value for money provided by the alternative means of provision.

3.6. Data and Analysis Limitations

While the literature review is believed to have captured the vast majority of relevant, high-quality publications in English it must be noted that books were not included in the review. Inevitably the review encompassed publications across a variable quality range. The highest standard of quality is provided by those publications which use quasi-experimental approaches with non-random treatment assignment that have a proper argumentation about how selection bias is controlled for. However, the majority of studies investigating the impacts of electricity access use non-experimental approaches, due to the practical difficulty, time and cost of randomly allocating electricity to specific households or businesses. The methods used to assert relationships between electricity access and poverty outcomes in the studies are not always robust, and it is sometimes the case that the estimators obtained cannot attribute a significant relationship between levels of access and outcomes. These limitations are discussed in greater detail in the Literature Review report.

It is recognised that the field research carried out as part of this study was subject to some of these same limitations. As with most of the literature, it was not possible to arrange for those who were to gain electricity access to be chosen at random; instead the research was based on examination of those who had and hadn't benefitted from pre-existing electricity access programmes, and thus unavoidably incorporated any inherent biases in the selection of those who were to benefit from these programmes.

Electricity access and income/wealth may be related in both directions; it is often the case that electricity access will be provided to those communities that are better able to pay for electricity, or have better infrastructure, or that are judged to be more likely to make productive use of it. The same factors may influence which people or businesses obtain electricity access within a community. On the other hand, some donors and programme implementers deliberately target the poorest communities or the poorest members of society, and so a reverse bias may exist in some cases.

To mitigate these effects the field research component largely employed a 'difference-in-differences' approach, comparing changes in certain enterprise and poverty indicators across populations classified by their level of electricity access, or the change in level of electricity access that they had experienced. To support this, surveys were carried out in paired beneficiary/non-beneficiary communities and respondents were asked for information about their past as well as present electricity access, incomes, enterprise revenues and profits etc. However, it is recognised that these approaches also have shortcomings. In particular:

a) Although non-beneficiary communities were selected to be as similar as possible to beneficiary communities in terms of location, pre-programme wealth and economic activity, there were still significant differences between the two communities in most of the programme pairs. The selection of a good 'control' community was especially difficult in India, where the majority of village centres have some level of grid electricity connection and it is mainly the hamlets that surround them that are the beneficiaries of off-grid electricity access programmes.

b) Despite efforts to reduce 'spill-over' effects by avoiding selection of community pairs in very close proximity, the need to choose pairs which are reasonably close (without which socio-economic comparability would have been difficult to achieve) mean that some such effects may remain.

c) While looking at changes helps to mitigate the effects of selection biases feeding through into the current position it is also recognised that data about past electricity access and the status of impact indicators relating to people's lives and livelihoods several years ago will be less reliable than that relating to their present position. Any findings relating to a change in electricity access or a change in an indicator must be seen in this light.

While efforts were made to ensure those interviewed within communities were selected randomly it is also recognised that some systematic biases may remain regarding the selection of interviewees on, for instance, a geographic basis (ease of access to a premises possibly being related to its remoteness or type of land use by its occupants) and a demographic basis (the time of day of survey will influence the type of person who is available for survey, and willingness to participate may be related to age and gender, among other factors).

The enterprises surveyed included both standalone businesses and enterprises based on productive activities carried out within the home. They also spanned a range of businesses types across the agricultural, small-scale manufacturing and service sectors. (Figures 8 and 9 in section 6.1 indicate the variety of enterprises surveyed). It is recognised that different types and scale of enterprise will have different energy needs, and will vary in their impacts on the communities within which they operate. However, given the issues regarding sample size discussed below, it was not considered practicable to differentiate within this study between the impacts of electricity access on different types of enterprise, or between the poverty impacts of different kinds of enterprise achieving electricity access.

The statistical significance of the quantitative results varies by data type and because the effective sample sizes differ for each relationship or characteristic under examination. The quantitative results presented in this report and the Case Study reports that accompany it may be classified into three types:

Type 1. Comparison of mean value for one subgroup among the sample with the mean value for another subgroup;

e.g. mean household income for beneficiaries in Community A compared to the mean household income for beneficiaries in Community B

Type 2. Comparison of the proportion of one subgroup that meets a certain criterion with the proportion of another subgroup that meets that criterion;

e.g. proportion of beneficiary enterprises that were created after the electricity access programme compared to the proportion of non-beneficiary enterprises that were created after the electricity access programme

Type 3. Correlation between two variables as recorded for each individual in the sample or a subgroup

e.g. correlation of productive use electricity access tier and enterprise profits within Community A

The field research involved surveys of more than 550 households and enterprises (260 in India and 294 in Kenya). However, this sample size is significantly reduced when impacts are considered for subgroups of the overall sample. Some of the assessments were only valid when considered at the community (or community-pair) level because of differences between the countries, the programmes themselves and their social and economic contexts. In some cases data regarding a particular variable was only available for some of the respondents. For example, not all enterprises were in existence prior to the implementation of the electricity access programme in that community, and so the pre-programme level of electricity access could not be assessed. Likewise, not all households kept separate accounts for their household and productive activity's finances, meaning that impacts for them of the productive use of electricity could not be investigated. Much of the analysis compared beneficiary and non-beneficiary groups or beneficiary and non-beneficiary communities.

The statistical significances of results belonging to the first type (Type 1) were tested using the Students t-Test. The assessment of mean electricity access levels for beneficiary and non-beneficiary groups in a community pair showed statistically significant differences in seven out of eight pairs for enterprises and all seven pairs for households[11]. Significant differences in the changes in electricity access experienced by the two groups were also observed in six of eight case studies (for enterprises) and all seven pairs (for households). However, where differences in the mean values of impact indicators (from which possible causalities are inferred) are apparent, they often do not pass the test for 95% confidence. The lack of confidence can be attributed to small sample sizes (when working at a highly disaggregated level) but also to the large variation observed in most of the impact indicators. In more than half of instances, the standard deviation is greater than the mean[12]. This level of variability was not anticipated at the research design stage. It is also possible that the true distributions for some of the indicators studied are significantly non-Gaussian, in which case the t-test confidence interval calculations would be invalid.

Results belonging to the second type (Type 2) were tested by calculating the standard error of the proportion. When the proportions differ by more than 1.96 standard errors, there can be 95% confidence that a true difference exists. Where apparent differences exist in the proportions of the subgroups that fulfil a certain criteria, the statistical significance tends to be better than for the differences between absolute values. Nevertheless, not all results pass the test for 95% confidence because of the relatively small size of the subgroups after disaggregation.

[11] For further details of the statistical validity of results at a case-study level, see the Case Study reports.

[12] The standard error on the mean is affected to a greater extent by the standard deviation of the data (directly proportional) than by the sample size (proportional to the inverse square root).

The statistical significance of the quantitative results presented for each of the two Case Studies is indicated in the individual Case Study reports. The conclusions presented in this, overall, report regarding differences between groups are qualified, where applicable, with an indication of the confidence that may be placed in that conclusion. However, this report more often considers results aggregated across all the survey respondents, or all respondents in one of the case study countries, and so the statistical significance of the results in this report is generally much better than for the results presented in the Case Study reports. However, even on an aggregated basis a number of the results do not pass the test for 95% confidence.

For correlations (Type 3), the following boundaries were used to determine strength and significance:

Pearson's Correlation Coefficient	R-squared / Coefficient of Determination	Strength of Correlation
0 – 20%	0 – 0.04	Negligible
20 – 40%	0.04 – 0.16	Weak
40 – 70%	0.16 – 0.49	Moderate
70 - 100%	0.49 – 1.00	Strong

The statistical significance of the correlation coefficients was also tested. In general, the small number of data points for which the correlations could be calculated[13] meant that the confidence intervals on the correlations reported were typically rather broad. For this reason, in general only limited confidence can be placed on the stated strength of correlation (negligible/weak/moderate/strong).

Finally, the narrow range of levels of electricity access found within the studied communities (despite the range of modes of electricity access provision) has placed some restrictions on the type of analysis that could be used to draw conclusions pertaining to the level of access and impacts. This issue is further discussed in Section 5.

Despite these limitations, this research provides a useful contribution to the body of knowledge surrounding interactions between electricity access, productive use and poverty impact. While further work would be needed to validate its conclusions and investigate their applicability in different contexts, it nevertheless represents a significant advance in separating characteristics (levels) of electricity access from the social-economic context in which access is provided and so understanding and quantifying the respective influences of level and context on the extent to which access is likely to support productive activity and lead to poverty reduction.

3.7. Synthesis of Research Elements

The four components of the research – the literature review, the policy/regulatory reviews, the stakeholder consultations and the community surveys - have been

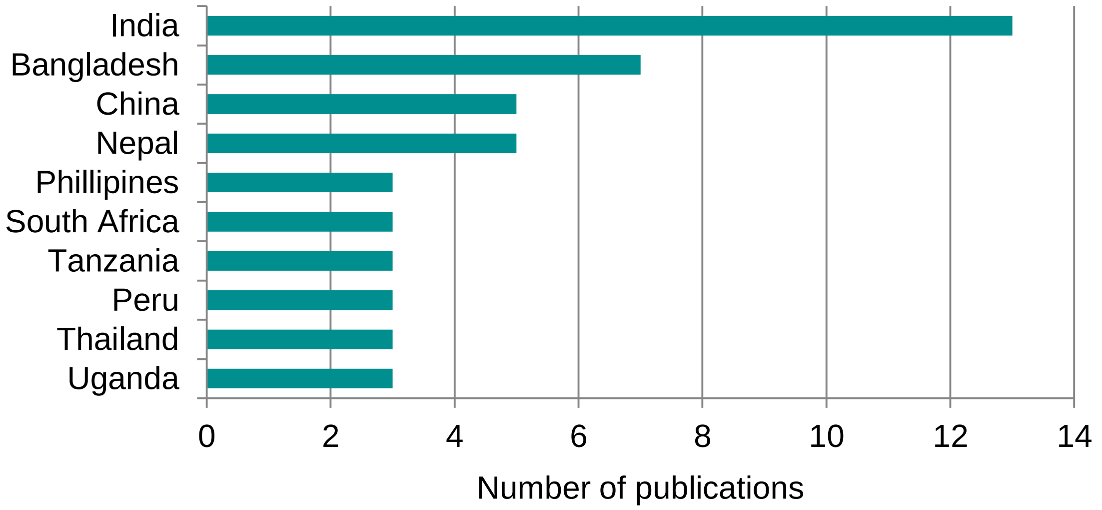
[13] The number of data points for correlations was often significantly below the sample size for the determination of the variables alone because of the exclusion of certain respondents (e.g. those enterprises which did not exist prior to the electricity access programme).

considered together throughout this report to inform the conclusions reached. In undertaking this synthesis we have sought to identify areas of agreement within the literature and between it and the case studies (which indicate that greater confidence can be placed on these observations) and areas of disagreement (which would tend to cast doubt on these conclusions or to indicate that they are context-specific).

4. Country Contexts

The publications that link electricity access to poverty outcomes reviewed as part of this study cover a wide range of developing countries from Asia, Africa and Latin America. Figure 1 shows the ten most widely researched countries by number of studies.

Figure 1: Number of studies per analysed country



The most widely analysed country is India, followed by Bangladesh. This is understandable as India has by far the largest electricity access deficit in the world, exceeding 300 million people. Bangladesh is the third country with the largest access deficit, with 66.6 million without electricity, after Nigeria (SE4ALL, 2013).

This current study drew on this wider geographic base but sought to validate the conclusions of the literature through case studies in Kenya and India which serve as examples of electricity access and its use in Africa and Asia. The electricity access position and policy environment in each of Kenya and India are outlined below.

4.1. Kenya

In spite of recent robust economic growth, consumption of modern energy in Kenya is still very low. Kenya's per capita electricity consumption is estimated to be 156 kWh per capita (IEA, 2011) compared to the global average of 2,751 kWh per capita, and around one-sixth of the per-capita consumption in India. The number of electrical connections has risen more than seven-fold since 1990, leaving 51% of urban households with access to grid electricity but only 5% of rural households. The number of Kenyans without access to electricity in 2011 was 34 million (IEA, 2013).

The pace of Kenya's rural electrification is accelerating, with an average increase in the number of connections of 23% per year between 2009 and 2012. However, this rate was still far below that which is needed in order to achieve the utility's target of 40% rural grid penetration by 2020.

Achieving this increase in grid connectivity will also require significant expansion of Kenya's grid generation capacity. At present, instances of demand exceeding supply cause frequent blackouts and necessitate scheduled power outages. Fuel supply problems for thermal power stations, poor plant reliability and high system losses are also key factors.

The Government of Kenya provides substantial subsidisation to domestic grid electricity consumers, but this subsidy is not well-targeted. Consumption of electricity up to 50kWh/month is charged at the so called 'lifeline tariff', a subsidised rate of around 2 cents (US) per kWh. Although this tariff is intended for the poor, in practice it applies to all domestic consumers.

The process of applying for and receiving a new grid electricity connection can be lengthy and excessively bureaucratic for both households and enterprises.

The Kenyan government has recognised that off-grid electrification will be necessary in those areas that are remote from the grid or with dispersed or nomadic populations. The *Rural Electrification Master Plan* states a target of 100% electrification (by on- or off-grid means) across the country by 2020. To date, the Rural Electrification Authority (REA) oversees 15 operational public mini-grids with a total installed capacity of 15MW; a further 14 are planned. Users of publicly-owned mini-grids are charged the same tariffs as grid electricity consumers, which are uniform across the country. Privately owned mini-grids may set their own tariffs, but these must be approved by the regulator. The level of acceptable tariffs does not normally allow small-scale electricity providers to operate on an economic basis. Medium-scale privately owned mini-grids have been successfully installed in more densely-populated rural areas and an interesting model that is emerging on a larger scale consists of industrial cogeneration plants who deliver their surplus electricity to local communities via mini-grids. Larger mini-grid projects are more likely to be able to cope with the often-unwieldy permitting and licensing procedure mandated by the regulatory bodies.

All mini-grid equipment and equipment for standalone renewable systems are VAT and import duty-exempted. Minimum performance standards have been set for standalone Solar Home Systems.

A Feed in Tariff policy is in place, but lacks provisions to facilitate planning and investment in off-grid renewable electricity. The 20 US¢/kWh tariff that applies to off-grid solar is helpful but is not high enough to stimulate rapid uptake.

The setting of a grid tariff that is uniform across the country means that urban consumers effectively "cross-subsidise" rural consumers, to whom supplying electricity is comparatively much more expensive. This cross-subsidisation also applies to mini-grids owned and operated by the national utility. However, there is no mechanism for cross-subsidisation of private off-grid electricity supply, meaning that mini-grid electricity appears to be much more expensive than grid electricity in all other rural areas. The higher price of off-grid electricity means that enterprise users may struggle to compete with nearby grid-connected enterprises because their costs of production or service provision are higher. Low uptake of off-grid electricity access, especially among potential productive users, will itself harm the viability of off-grid programmes and increase the cost of supply for those who have taken up access.

A final disincentive to mini-grid development is found in the lack of regulatory provision for the protection or compensation of mini-grid developers/operators in the event that the national grid is extended to the area where a mini-grid has been developed.

4.2. India

India's progress towards providing electricity access for its population has been laudable, with installed capacity having increased almost 200-fold since 1947 and even greater relative increases in the number of villages connected to the grid and in per-capita consumption. Off-grid electricity has been widely deployed in areas which are inaccessible for grid connectivity. Off-grid solutions also find a niche in hamlets that suffer low prospects for electrification because they are not recognised as villages for planning purposes. Nevertheless, in spite of this progress 306 million Indians were still living without electricity in 2011 (IEA, 2013).

Electricity access varies significantly by state, with some of the larger and poorer states lagging behind. Specifically, the states of Uttar Pradesh (20 million households), Bihar (15 million households) and West Bengal (9 million households) account for more than 50% of the non-electrified households in India.

At the same time, India's central electricity system cannot keep pace with demand from the households, farms and enterprises that do have a connection. Generation is frequently limited by coal shortages whilst high transmission and distribution losses (including theft) further subtract from the energy that can be delivered to users. The electricity supply gap is a major cause of grid unreliability and scheduled blackouts, as well as voltage fluctuations that can limit the use of power or damage equipment.

India's electricity sector is heavily subsidised by government, with spend representing 1.5% of GDP. The sector receiving the largest share of subsidy expenditure is the agricultural sector, which consumes a quarter of all electricity mainly for irrigation and water pumping applications.

The electricity access problem in India suffers from a lack of an integrated policy framework, division of the energy sector across multiple agencies, overemphasis on serving urban customers, misdirected subsidy regimes, ineffective implementation, poor governance of the sector, resource constraints and other structural factors (Balachandra, 2011; Krishnaswamy, 2010; Kemmler, 2007).

The *Electricity Act (2003)* and its daughter policies the *National Electricity Policy*, the *National Tariff Policy* and the *Rural Electrification Policy* offer improved approaches and new targets with respect to electricity access. The Act envisaged both the continued extension of the reach of the grid and the addition of significant new off-grid capacity by way of standalone systems. Facilitating measures for off-grid electrification included the relaxing and removal of licensing requirements for electricity generation and, in rural areas, electricity distribution and sales. This is an important facilitator for investment in mini-grids. Furthermore, the *Rural Electrification*

Policy acknowledges the role of electricity in productive activity and livelihood creation in rural areas, and requires special efforts to be made to promote economic activities through electricity provision.

Several electrification programmes operate under the framework set out by the *Electricity Act* and subsequent new government policies. The *Rajiv Gandhi Grameen Vidyutikaran Yojana* (RGGVY) programme is charged with rural electrification via grid extension, with emphasis also on rural development, employment generation and poverty alleviation. However, the RGGVY programme has been criticised for failing to look beyond lighting as an application of electricity and not allowing sufficient provision for enterprises, an approach that has resulted in the installation of hardware that is poorly suited for supplying productive uses. The *Remote Village Electrification Programme* (RVEP) focuses on remote villages and non-electrified hamlets of grid-connected villages, providing electricity access mainly through solar home systems and solar mini-grids, including electricity for community facilities and services and productive uses. The *Jawaharlal Nehru National Solar Mission* (JNNSM) aims to incentivise the installation of 22 GW of solar power, both on- and off-grid, by 2022. The first phase has focused on promoting off-grid systems to serve populations without access to commercial energy.

Some important barriers to investment in off-grid energy by the private and non-governmental sectors remain. For mini-grid developers, uncertainty regarding grid extension plans substantially increases risk, while the design of the subsidy support for mini-grids does not meet the needs of developers in challenging geographical areas. There is a requirement for grant funding or supportive finance to cover the initial years of electricity access programmes, when take up can be slow as people and enterprises adjust their activities and invest in appliances.

The existing legal and regulatory enshrinements allow active cross-subsidisation of rural grid electricity supply by urban consumers through differential tariffs, meaning that rural consumers are often paying less than the cost of supply given the remote and dispersed nature of the load they represent. There is no mechanism for cross-subsidisation of private off-grid electricity supply, meaning that mini-grid projects struggle to compete with the tariff prevailing in nearby grid-connected villages.

Further barriers exist to prevent poor people investing in electricity access technologies for themselves. Although Solar Home Systems are eligible for subsidies of around 40%, the collateral requirements for bank loans that are designed to finance the remaining 60% of the cost are unrealistic for most. The unit cost of electricity from many off-grid systems is often several times the (subsidised) grid electricity tariff, putting the cost of electricity access beyond the reach of the poorest.

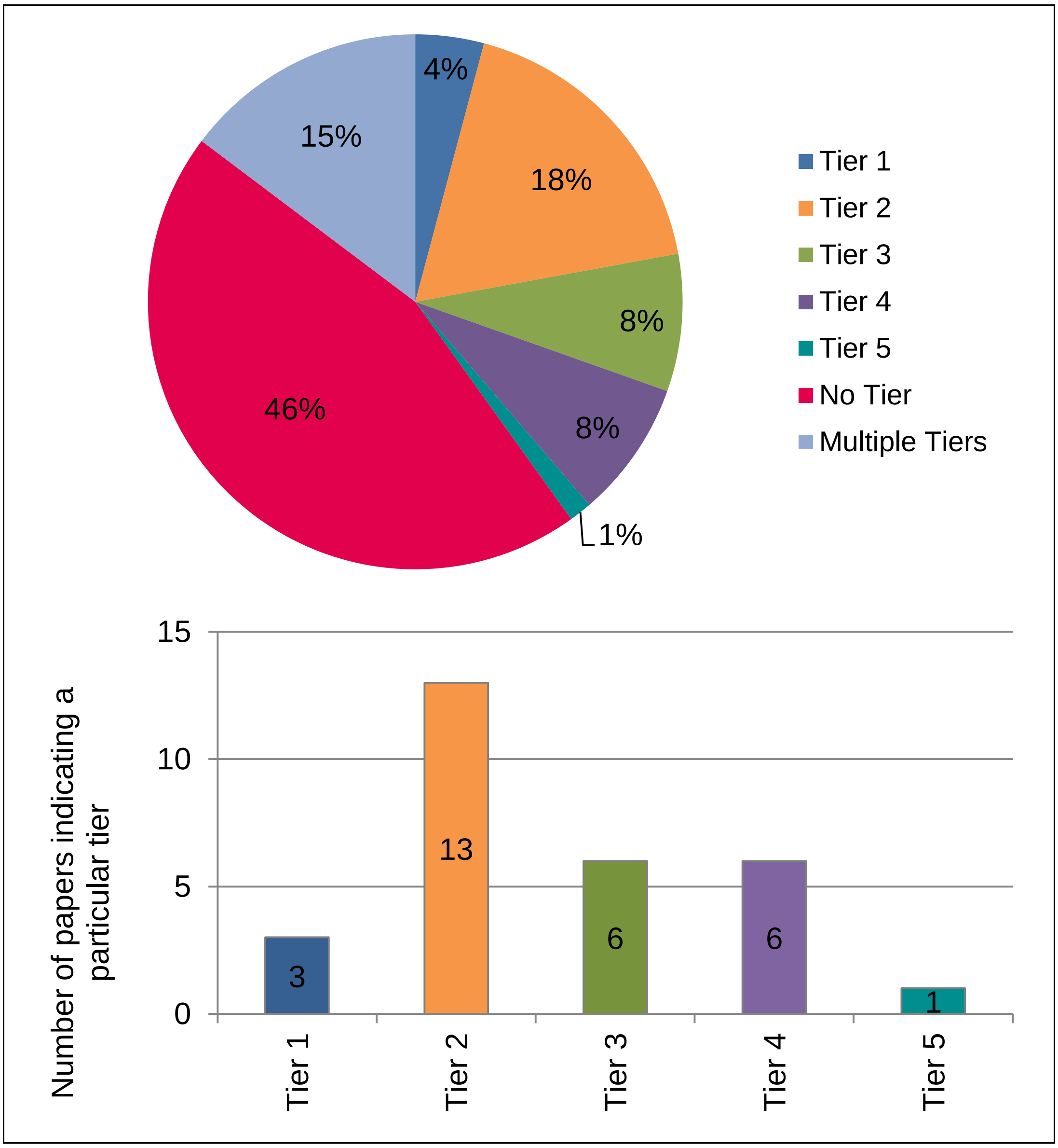
For enterprises, the time and cost involved in securing a new electricity connection can be a major barrier to productive use of electricity when the only available option for supply is the grid. Lack of awareness, and difficulties in obtaining information, can prevent small enterprises from benefitting from government schemes that may help them to use electricity productively.

5. Electricity Access Levels

As described in Section 3.5, levels of electricity access for this study were defined in terms of the access's attributes (capacity, duration/availability, reliability, quality, affordability, legality, health and safety, convenience) in line with the Global Tracking Framework being developed by WB/ESMAP.

The studies included in the literature review had not, generally, undertaken any assessment of access level; however 29 of the 71 studies contained enough information for the researchers to estimate a likely tier of electricity access. Some studies referred to multiple electrification programmes, populations or experiences of electrification such that there was not a single tier of access indicated. Figure 2 shows the proportion of the reviewed studies that refer to each tier (or no/multiple tiers).

Figure 2: Tiers of electricity access identified for the reviewed papers

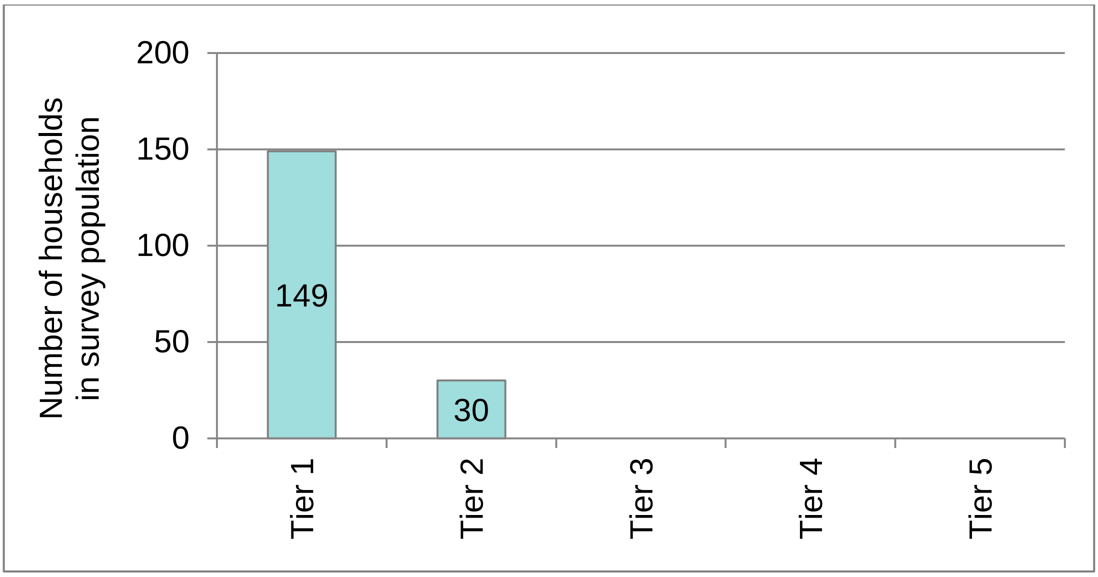


Of the studies that indicated a single tier, most pointed to a level of electricity access for the populations or programmes studied of Tier 2. Few studies indicated levels of electricity access that correspond to the extremes of the scale, Tier 1 or Tier 5. It should be recognised that the likely tier of electricity access referred to in each publication was deduced using the information available in that publication regarding the different attributes of electricity access (capacity, duration/availability, reliability, quality, affordability, legality, health and safety, convenience). In most cases, information was only available regarding a few of the attributes. The GTF protocol requires that the overall tier of access is determined by the lowest attribute tier. This means that, in the absence of full information, there will be a tendency to overestimate when deducing the tier.

By contrast, the field research carried out as part of this study used the SE4ALL Global Tracking Framework protocol at the primary data gathering stage to determine the level of electricity access of each household or enterprise surveyed. This means that the overall tier generated takes into account all applicable attributes of electricity access. (This may explain some of the difference in energy access tier levels found in the literature reviewed and in the research carried out as part of this study.)

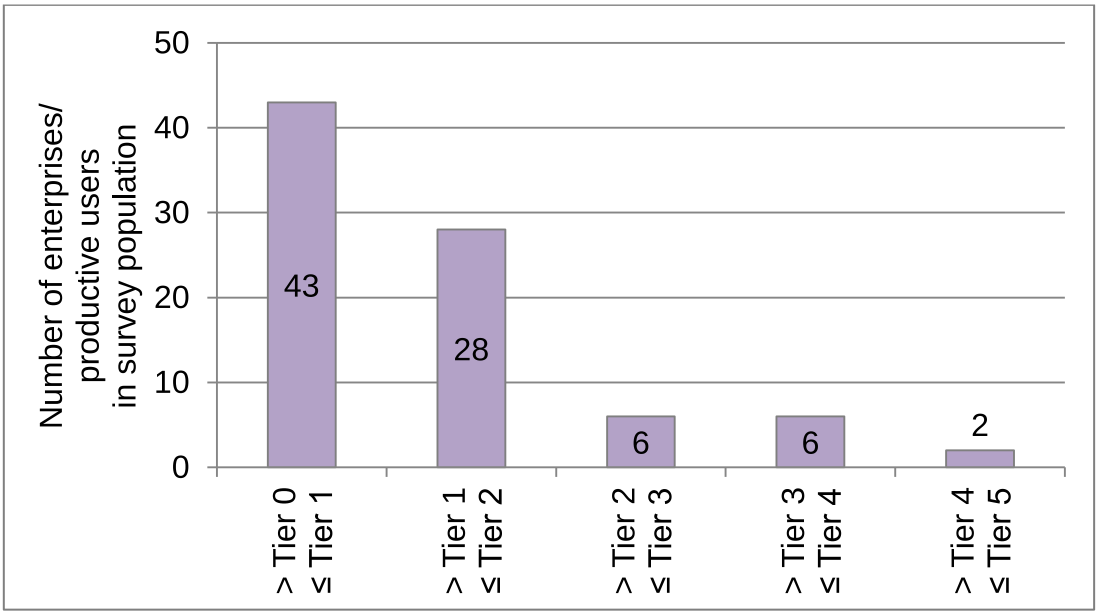
Unlike the studies covered by the literature review, this research generally found electricity access levels at the lower end of the scale, as shown by Figure 3 and Figure 4.

Figure 3: Tiers of electricity access amongst the households surveyed (only those with access)



None of the households, even those with grid connections, were assessed as having more than Tier 2 electricity access. Most community pairs displayed a ‘binary’ electricity access situation, with households being assessed at either Tier 0 or Tier 1. Some respondents achieved Tier 2 under the two grid extension programmes and the Access:Energy mini-grid on Mageta Island, Kenya. Two Kenyan non-beneficiary respondents achieved Tier 2 access thanks to ownership of Solar Home Systems which they obtained independently of the programme under study.

Figure 4: Tiers of electricity access amongst the productive users surveyed (only those with access)



The spread of levels of electricity access for productive use was broader, although over 80% still had tiers of less than or equal to Tier 2[14]. The respondents who achieved higher than Tier 3 access were all beneficiaries of the CAFOD Solar Irrigation programme in Kenya. They reported that motive power was the only application relevant to their productive activities (farming and food preparation/sale) and the form of electricity access they used scored highly across all attributes. Grid and mini-grid connections allowed some Kenyan enterprises to achieve between Tier 2 and Tier 3 access. All Indian enterprises, and the remaining Kenyan enterprises, had less than or equal to Tier 2 access.

It would appear that the spread of access levels was narrow because even the seemingly superior means of electricity access provision (grid extension, mini-grids) provided a supply that tended to score poorly across several of the attributes. Across all the grid and mini-grid programmes studied, a common theme was that households' and enterprises' access levels were being constrained by low capacity, poor duration and poor affordability. The Global Tracking Framework protocol selects the lowest-scoring attribute to determine the overall access tier for that household or for that productive use application. Therefore, if a particular electricity supply scores badly on just one attribute, the overall tier assessment is low. Whilst this approach has the benefit of recognising that a user's ability to benefit from electricity access can be constrained by a single attribute, it means that the overall access level measurement does not distinguish between access which is limited by one or by multiple attributes.

[14] Because the overall productive uses tier may be the average of several different application tiers, the overall tier may not be a whole number.

Of the 71 studies included in the literature review, only 10 acknowledged that different levels of access to electricity can achieve different poverty impacts and describe or quantify these. The remainder either considered electricity access as a binary variable (yes or no), or the subjects of the studies did not cover a sufficiently wide range of electricity access levels to attempt to assess the impact of different levels on the populations analysed.

The field research component of this study was designed to investigate the impacts of different levels of electricity access on productive uses and poverty outcomes. It was anticipated that within most of the community pairs studied there would be a range of different levels of electricity access; the qualities and attributes of the technology or service would be different for different users, and the needs of those users would also vary. Certainly it was expected that by covering a range of electricity provision types (from solar lanterns to grid connections) the overall data set obtained would include a significant spread of assessed access tiers.

In practice, the narrow range of levels of access assessed for both households and enterprises placed some restrictions on the tools that could be applied to analyse the impact of different levels of access. Analysis of correlations between access tiers and impact indicators proved less meaningful than had been hoped because within a community pair the predictor variable (access tier) often just took two values (e.g. Tier 0 and Tier 1). The correlations that could be analysed across a country data set, or the whole data set, were necessarily restricted to comparing changes in access and changes in indicators because of the differing starting points of the communities.

These restrictions have meant that the analysis of the impacts of different levels of access and the conclusions drawn regarding the impacts of the eight programmes compared with the level of access they provided has tended to consider the averages of these variables across each community's beneficiary population[15].

Use of the Global Tracking Framework approach has allowed levels of electricity access to be assessed for the field research and estimated for some of the studies included in the literature review. The band of access levels assessed through the field research was relatively low and narrow because even seemingly "higher-level" means of electricity access provision (grid extension, mini-grids) tended to provide lower than expected access due to poor capacity, duration and affordability.

[15] This analysis excludes the 'reference cases' that are the non-beneficiary communities, and therefore is not able to pick up on impacts that may be conferred to non-beneficiaries within the beneficiary community as a result of increased economic activity or better community service provision in the local area. The analysis also necessarily excludes the many other aspects across which the communities that benefitted from each programme vary, which may also, along with electricity access, influence the outcome under consideration.

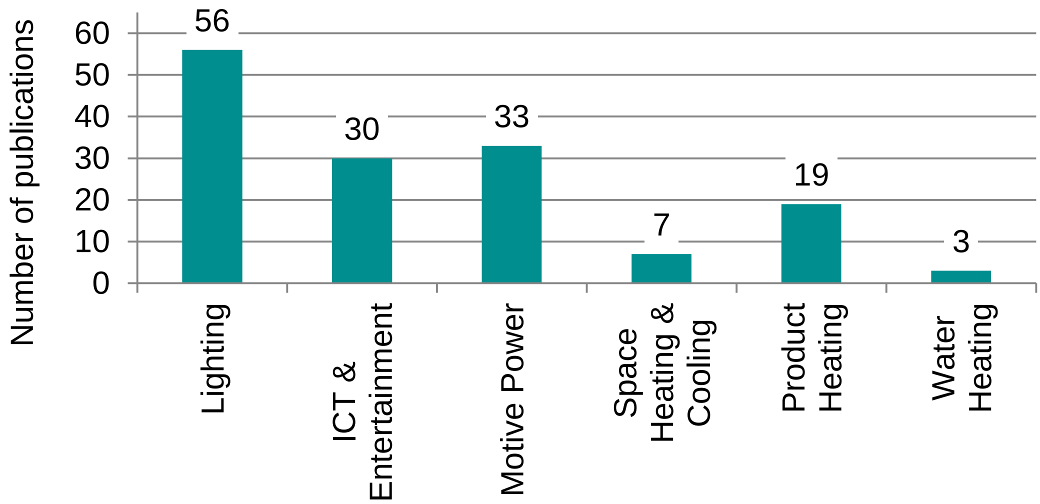
6. Productive Use Impacts

6.1. Applications of Electricity for Productive Uses

The SE4ALL Global Tracking Framework defines six ‘applications’ of energy for productive uses: lighting, ICT & entertainment, motive power, space heating, product heating and water heating. Electricity can power any of these applications.

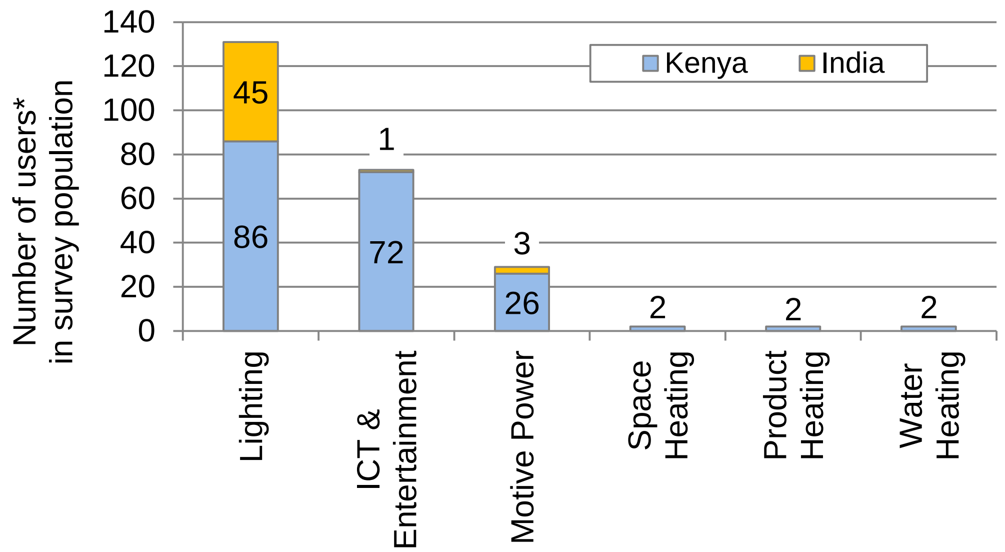
In the literature, lighting is the most widely reported productive application of electricity – see Figure 5. Lighting was also by far the most commonly used application amongst the communities surveyed as part of this study (Figure 6). Roughly equal numbers of publications report ICT and entertainment and motive power applications. These applications were also widely used across the survey samples, but ICT and entertainment was dominant and motive power less frequently used. Significant numbers of papers included in the literature review cover the three types of heating as productive uses of electricity, but electricity was very rarely used for heating in the communities studied as part of this research.

Figure 5: Number of studies reviewed referring to applications of electricity for productive uses



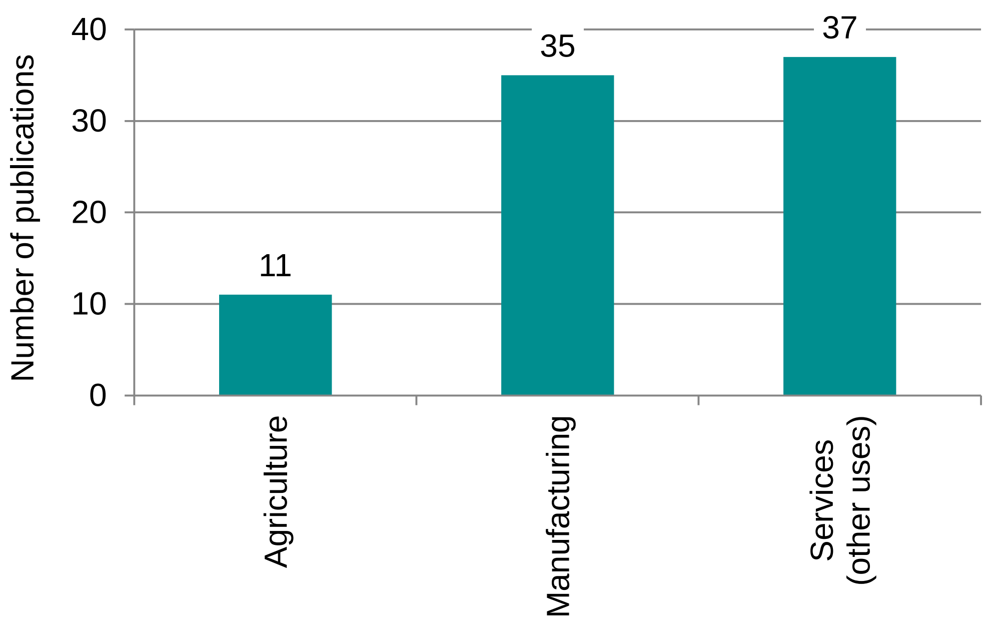
Broadly the spread of applications identified in the literature and that found in the field research are similar. The greater predominance of lighting and ICT and the lower representation of motive power and heating applications in the field research sample may reflect in part the focus of the field research on relatively small and remote communities and in part the generally low levels of electricity access provided through the programmes. It seems probable that the low number of heating applications identified through the field research is also partly a reflection of the geographical focus of the research (making space heating unnecessary), and of the continued use of non-electrical energy for heating applications in the communities surveyed.

Figure 6: Number of users in survey population of each application of electricity for productive uses[16]



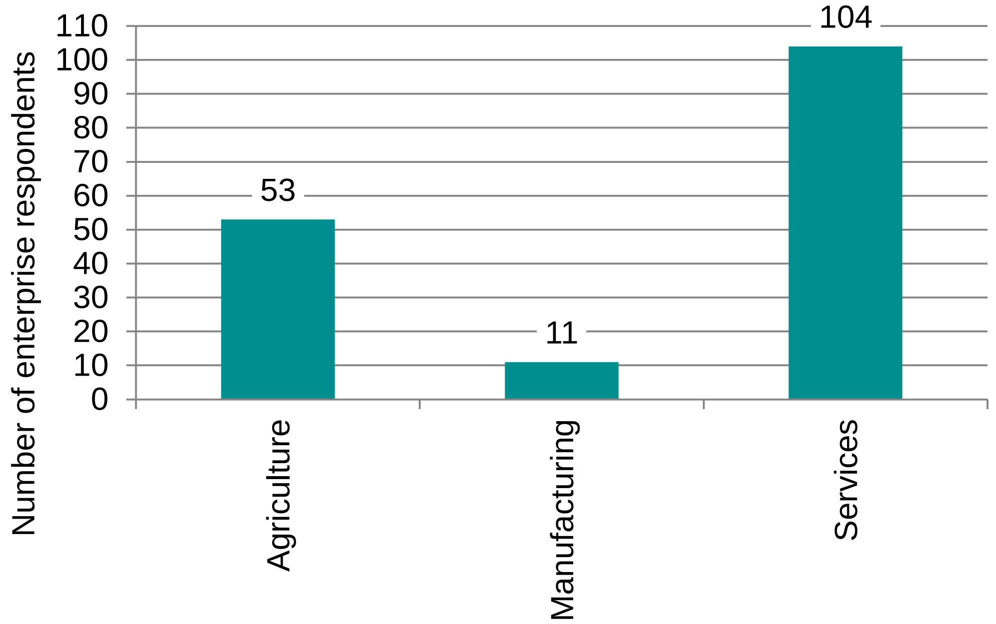
Whereas most studies in the literature refer to electricity use for manufacturing or in the sevice sector (in almost equal numbers), with a smaller proportion refer to agricultural uses (Figure 7), enterprises surveyed as part of this study were predominantly in the agriculture and service sector, with only a small number in manufacturing (Figure 8), reflecting the character of the communities studied.

Figure 7: Number of studies in the literature referring to types of businesses per sector



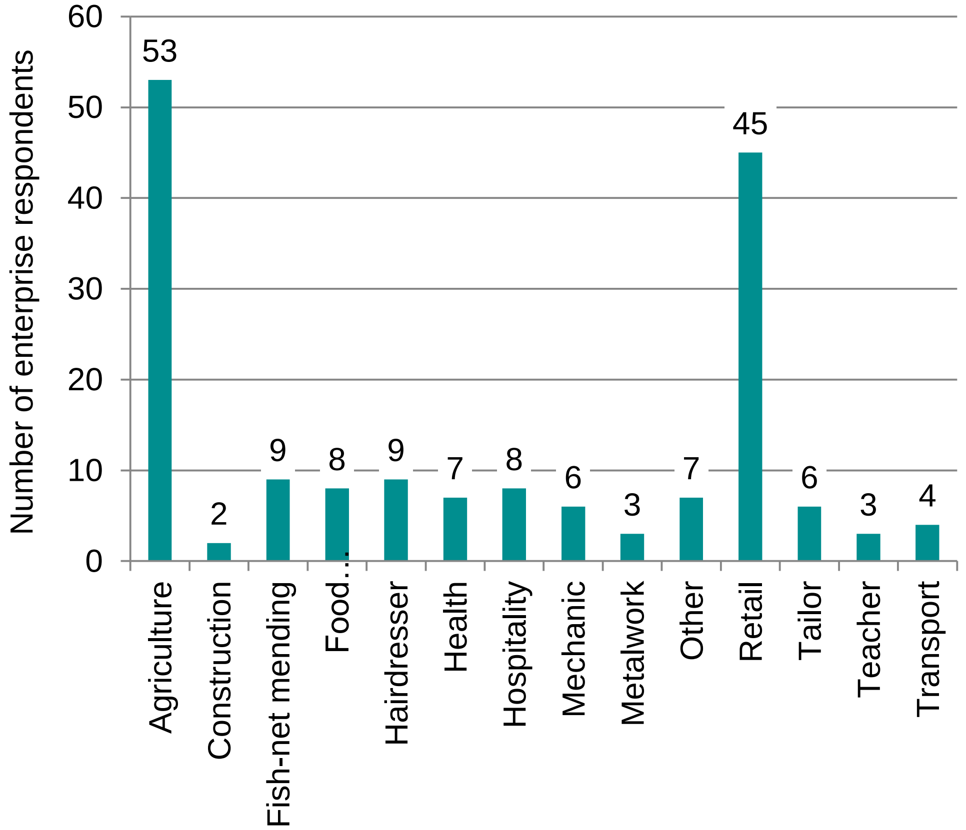
[16] More than ten times as many surveyed household respondents in Kenya as in India carried out a productive activity in the home. On the other hand, respondents in India were three times more likely to own or manage an enterprise outside the home but these owned or managed enterprises were still much fewer in number than productive activities in the home. This led to a higher number of productive users being included in the field research in Kenya compared to India.

Figure 8: Number of enterprises surveyed, by sector



A more detailed examination shows the heterogeneity in the enterprises surveyed:

Figure 9: Number of enterprises surveyed, by type of business



6.2. Impacts of Electricity Access for Productive Uses

The literature reviewed looked at the impact of electricity on a number of indicators relating to enterprises and productive activities such as:

- Business revenues and profits
- Agricultural productivity or output
- Creation of new enterprises
- Direct and indirect employment effects
- Production, productivity or value added of microenterprises
- Number of hours that business stay open
- Propensity to run a home business
- Wages

The most widely reported channels through which electricity can lead to income generation and poverty reduction are:

- Electricity enables new or improved non-farm activities to be undertaken. New products that could not exist before electrification fill new niches producing higher incomes.
- Electricity reduces production costs, improves the competitiveness of local industries and increases sector viability and/or reduces barriers to entry for new domestic entrants.
- Electricity enables an increase in agricultural (e.g. through irrigation) and non-agricultural output.
- Electricity enables better access to market information and weather forecasts and increases the life of perishable goods, allowing more optimal pricing decisions for activities such as fishing or agriculture.
- Electricity enables local processing and storage reducing agricultural wastage, improving the market for small-holder farmers, reducing food imports and increasing domestic food supply, thereby reducing hunger.
- Electric light extends the working day so leading to increased production or sales.
- Electrification has an expansive effect on local demand, partly due to people moving from outside areas to the community.

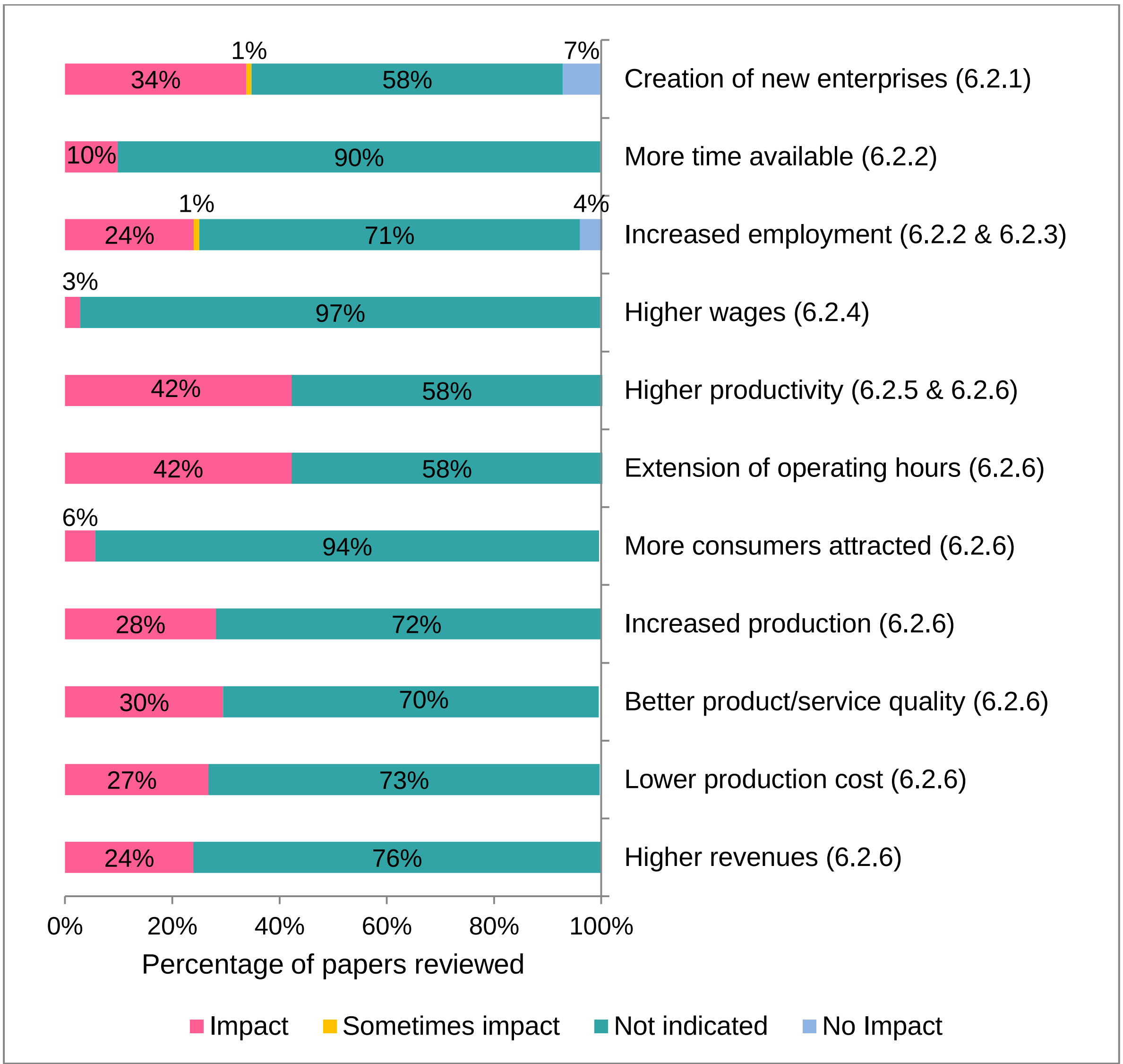
However, previous literature reviews, such as Attigah and Mayer-Tasch (2013) and Pueyo et al (2013), have not found straightforward relationships between electricity access (considered as a binary variable) and poverty outcomes. The former review finds that the micro-level literature on productive use impacts of electrification programmes is generally inconclusive, indicating that access to and use of electricity by small and medium enterprises "does not automatically lead to intended development results such as increased productivity, profits and income, and knowledge on the conditions under which this is the case are still sketchy”. The authors point at the highly country- and context-specificity of impacts that prevents the drawing of definite conclusions.

Pueyo et al (2013) conclude that, regarding the relationship between electricity consumption and poverty impacts, direct and short-term non-income benefits for households are more strongly and consistently reported than income-related outcomes. This is because income-related outcomes depend not only on electricity but also on a number of factors jointly enabling its productive use. Electricity use outcomes are consistent for employment and time allocation, particularly for women. Several authors report increases in women’s employment, total hours of paid work, and probability of participating in non-farm or non-household work. There is also robust evidence of positive impacts for women’s empowerment. Improvements in education are widely and consistently reported. Evidence is weak regarding health and environmental improvements facilitated by the use of electricity. Even though productive uses are seen as those having the highest potential to reduce poverty, robust evidence is scarce as regards impacts of electricity on the creation of enterprises or the improved performance of existing ones.

The figure below (Figure 10) shows for each type of potential impact on productive activity what percentage of papers included in the literature review:

- analysed it and found a positive impact,
- analysed it but found no significant impact
- found that the impact takes place in some circumstances
- did not analyse this issue.

Figure 10: Percentage of papers reporting productive use impacts of electricity (direct and indirect)



(The number against each impact indicates the section in which it is discussed below)

The creation of new enterprises is widely studied in the literature, with most studies analysing the topic agreeing on the positive impact of electrification. Increased productivity and extension of operating hours are also common topics where the literature agrees on the positive impact of electricity. Among all potential impacts, those that are indirect and depend not only on electricity, but on another set of enabling factors, are more contentious in the literature. These include impacts on employment, wages and investment.

The findings from the literature and from the field research in relation to each potential impact are brought together below.

6.2.1. Enterprise Creation and New Productive Activities

It can be expected that improved electricity access will encourage the creation of enterprises as new productive or value-adding activities become possible in a community or region. This can be a direct result (electricity-powered technology permitting previously-impossible activities) or an indirect result (a shift in time use enabling people to engage more in productive activities, or increased purchasing power of people within the community). However, in order for enterprise creation to take place and new enterprises to survive, it follows that there must also be sufficient demand for the product or service offered. Where new electrified enterprises compete with existing un-electrified enterprises, it is possible for the new enterprises to displace the old such that there is no net increase in enterprise activity.

The impact of electricity on enterprise creation is inconsistently reported in the literature. Several authors refer to the creation of new enterprises as a result of electrification (Bastakoti, 2003; Bensch and Peters, 2010; Oakley et al, 2007; Peters et al, 2011; Yadoo and Cruickshank, 2012). Many of these new businesses rely on electricity for their activities and therefore would not have been economically possible without power. Examples include welding shops, printing shops, iron fabrication, battery charging, ice production, food drying or soap making. These new enterprises would not be expected to 'crowd out' existing enterprises, apart from presenting a potential diversion for local consumers' purchasing power. On the other hand, Khandker et al (2012) find no evidence of additional rural industries as a result of rural electrification in Vietnam, but the propensity to run a home business is found to increase by 10.7% in electrified households in the Philippines (UNDP and World Bank, 2002).

Of the publications reviewed that provided sufficient information for an electricity access tier to be estimated, those papers which imply Tier 3 or Tier 4 access often report the creation of enterprises as a positive impact. Tier 2 publications are less likely to report new enterprise creation.

The case-study research carried out as part of this study was also inconclusive regarding enterprise creation as a result of improved electricity access. Overall, the fraction of surveyed enterprises that had been created since the implementation of the electricity access programmes was not greatly different between beneficiary and non-beneficiary communities, or between enterprises that were themselves beneficiaries and enterprises that were not.

In Kenya (where the number of enterprises surveyed was much higher – see Section 6.1), around 30% of all enterprises surveyed had been started after programme implementation in both beneficiary and non-beneficiary groups. However, the picture is rather different in India, where the rate of enterprise creation appeared to be around 3 times higher in the beneficiary than in the non-beneficiary communities. Only half of the new enterprises in the beneficiary communities were themselves receivers of improved electricity access under the programmes studied, which could indicate that there are significant indirect impacts within those communities. However, there did not appear to have been different scales of increase in household income between the beneficiary and non-beneficiary communities, suggesting that increased purchasing power is not in itself responsible for encouraging the creation of new enterprises.

No patterns were found when comparing the level of electricity access for productive use provided under each programme (the average tier of electricity access for beneficiary enterprises) and the proportion of beneficiary enterprises created post-programme (a proxy for the rate of creation of new enterprises). The enterprise creation rate for the half of communities with the highest access tier is similar but slightly lower than the rate for the half with the lowest tier.

In addition to allowing new enterprises to be started, electricity access can allow existing enterprises to diversify their activities, either individually or collectively.

In the literature, the presence of electricity is associated with a higher diversity in the activities of microenterprises. These new activities tend to perform better than pre-electrification enterprise activities (Peters et al, 2011). Oakley et al (2007) conclude that the introduction of electricity into two poor South African communities (urban and rural) had a significant impact on the number, type and collective volume of microenterprise activity, but overall it had a limited livelihood impact due to minimal employment creation and limited increases in turnover.

The diversification of enterprises can be enabled by the adoption of more diverse electrical appliances. The reviewed publications that imply Tier 1 access report few productive use applications beyond lighting. As the tier of electricity access increases, more diverse applications are used, although even at Tier 3 and Tier 4 some enterprises still do not use electricity for productive activities that enhance their sales or profits. A level 5 tier of access allows the use of electricity for manufacturing processes that require a continuous and reliable supply, such as tea processing, which make use of electricity across multiple applications.

The bulk of the literature supports the view that electricity access enables enterprise creation. This was upheld by our research in India but not in Kenya. The impact in India appeared to be a community effect rather than related to the electricity access status of individual enterprises. In the literature, enterprise creation appears to be associated with higher levels of electricity access but no such pattern could be discerned in data from the field research carried out as part of this study.

6.2.2. Time Use and Take-up of Employment

A shift in time use (for women in particular) is a frequently reported impact of access to electricity, but findings are sometimes contradictory.

Electricity increases the productivity of unpaid household work and can enable more hours to be spent doing paid work or carrying out income generating activities. Even very low levels of electricity access, allowing few applications beyond lighting, enable people to carry out activities at more convenient times of day and to make better use of darkness hours.

Many publications note positive impacts of these shifts in time use on the take up of employment. They draw links between the increase (mostly female) in labour supply resulting from the shifts in time use and potentially higher employment rates. Some of the estimates provided by the literature include:

- reduction of the amount of time spent on non-market home production activities by 1.09 hours per day (UNDP and World Bank, 2002);
- increase in the propensity of rural Nicaraguan women to work outside the home by 23% (Sadanand, 2013);
- increase in employment hours by more than 15% for women and 1.5% for men (Khandker et al, 2012);
- increases in regular wage work for men by 16.6 days per year, but reduction of male casual work by 10.4 days, while casual work for women increases by 6 days per year (van de Walle, 2013);
- increases in female employment by 9 to 9.5 percentage points within 5 years (Dinkelman, 2008);
- increase in the participation rate in NFEs by 13.3 percentage points and the expected number of NFEs operated by each household by 1.5 times when the household utilises electricity (Gibson and Olivia, 2010).

It should be noted that several of these publications report no impacts on male employment (Dinkelman, 2008; Sadanand, 2013). Other publications report no significant overall contribution to local employment of improved electricity access (ADB, 2010; UNDP, 2012), or report findings that are contradictory to those presented above. Evidence provided by Costa et al (2009) found that access to electricity does not have an impact on the hours worked by women in domestic activities, but does increase work opportunities for men but not for women.

The shift in time use does not always favour employment or productive activity. Barnes et al (2002) find that the time electrified households save in household activities appears to be used to increase leisure time and social activities, not for productive activities. A similar conclusion is reached by (IDS, 2013) as electrified villages in China indicate that the major benefits are related to quality of life: lighting, television and reduced labour on domestic tasks, but the possibilities to increase income are very limited.

While a few of the reviewed publications which imply Tier 2 electricity access report increased employment as an impact, at Tier 3 and Tier 4 the papers more strongly report people having additional time available for paid work. Where lighting is the main use of electricity (true of most rural areas in Kenya and India), it is mostly used for doing household chores rather than for income generating activities (Kooijman van Dijk and Clancy, 2010; Clancy et al, 2005) and jobs that are created through shifts in time use are generally unskilled, obtained through self-employment rather than formal employment, of a precarious nature and with limited potential to generate income for the community as a whole (Chowdhury, 2010; Kooijman van Dijk and Clancy, 2010; Dinkelman, 2008; Oakley et al, 2007). Thus the literature appears to imply that the scale of increased employment and the types of employment taken up will depend on the level of electricity access provided.

The field research carried out as part of this study did not seek to directly measure or describe the shifts in time use that result from improved electricity access. Data collected on the employment status of the interviewees does not indicate increased levels of employment[17] resulting from any shift in time use for household beneficiaries (if present), though feedback from the communities involved in three of the Kenyan programmes (the Machakos grid extension, the Access:Energy Mini-grid on Mageta Island, and the Solar Transitions Centre in Kitui County), identified increased working hours and longer operating hours for small businesses as important impacts of electrification.

Overall, employment was higher among non-beneficiary respondents than beneficiary respondents both before and after programme implementation, and medium confidence (76%) can be placed in this result prevailing across the whole of the communities. However, the picture was quite different in the two case study countries; in India, non-beneficiary employment was considerably higher than beneficiary employment[18], whereas in Kenya the employment rate was broadly the same for both groups.

Non-beneficiaries also saw a greater <u>increase</u> since programme implementation in the number of respondents who were employed (12% increase compared with 8% increase among beneficiaries). This time, the Kenyan cases display a much greater difference between the two groups, with non-beneficiaries seeing an increase in employment three times that seen by beneficiaries[19]. These findings are contrary to what would be expected if household access to electricity enabled increased take up of employment though shifts in time use. When beneficiaries and non-beneficiaries are compared within the beneficiary communities only – which should mean that some systematic differences are removed - the differences are even starker: people

[17] Employment in this context (and throughout this report) includes both more formal paid employment and those undertaking productive activities within the home.

[18] The confidence in the difference at the whole-community level is greater than 95%. A possible explanation for the improved employment prospects for non-beneficiaries may be found in the focus of national development initiatives (Mahatma Gandhi National Rural Employment Guarantee Act, National Rural Livelihood Mission etc.) on the most economically deprived areas.

[19] It must be noted that these differences are nevertheless small considering the uncertainties in the results for past and present employment rates (despite sample sizes of around 200 for each group overall, and at least 77 in each group at a country level), so only very low confidence can be placed in these findings.

who were not beneficiaries of the programme saw more than fivefold greater increases in employment than beneficiaries. However, the small sample sizes involved at this disaggregated level and the non-random nature of interviewee selection (see Section 3.6) mean that these findings carry a particularly low confidence level.

The picture is somewhat different when the data is disaggregated by gender (although sample sizes are even smaller and systematic biases likely to be more pronounced). At the time of survey, female employment was roughly equal amongst beneficiaries and non-beneficiaries (from both communities in each pair). However, there had been a considerably greater increase in employment among the non-beneficiary females group (60% increase) compared with beneficiary females (5% increase)[20]. This pattern is closely replicated when considering respondents from only the beneficiary community.

For males, the employment rate at the time of survey was higher for non-beneficiaries (63%) than beneficiaries (56%)[21]. No statistical significance can be attributed to the difference in the increase in employment since programme implementation for beneficiaries and non-beneficiaries. Amongst the non-beneficiaries, a large number of men had gained employment (most of whom were from the beneficiary community), but this increase was offset by a large number who had become unemployed (mostly in the non-beneficiary community). This finding may provide evidence in favour of the positive impact of electricity access in terms of men's employment within a community. This impact is not restricted to those people who received improved electricity access in their own homes, but rather seems to be a result of greater economic activity in the wider community.

When the <u>level</u> of electricity access for productive use provided under each programme was compared with increases in employment, a possible positive relationship was observed as shown in Figure 11.

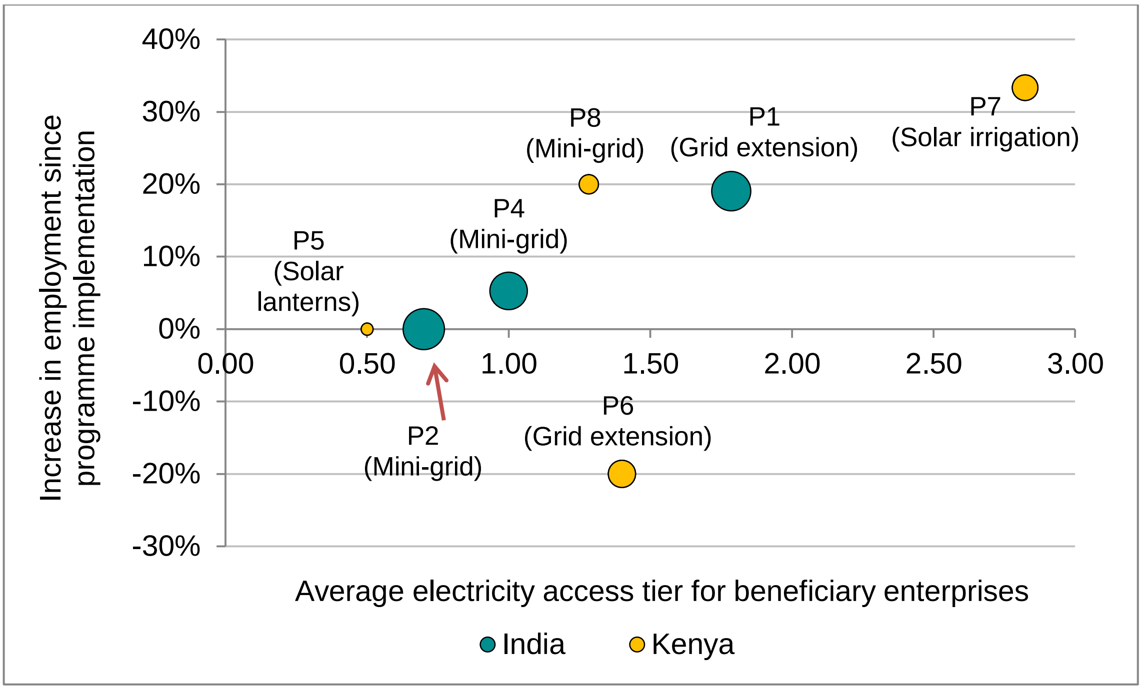
No relationship was found when <u>increase</u> in level of electricity access for productive use was compared with increase in employment. This could be because the communities had quite different starting points in terms of electricity access, and either:

- the impact of the move from one tier to another is not proportional to the magnitude of that move; and, or
- there is a threshold level of electricity access only above which are there impacts on employment.

[20] Despite the striking difference among survey respondents, the propagation of errors on the proportions means that only low confidence (51%) may be placed in the prevalence of this difference at the level of the whole communities.

[21] Low confidence (50%) in the difference in the population.

Figure 11: Increase in employment vs. average programme electricity access tier for productive use[22][23]



Many, though not all, publications report increased employment, particularly amongst women, as a result of shifts in time enabled by electricity access. Our research did not bear this out, finding similar or higher levels of employment, and higher increases in employment, amongst those who had <u>not</u> benefitted from improved household electricity access than those who had.

More of the papers indicating higher, rather than lower, levels of access report increased employment as an impact. Data from our study also indicates a possible positive relationship between level of electricity access for productive use and increases in employment.

[22] The larger bubbles represent data points for which the calculated variable (% increase in employment) is based on a larger number of respondents. Although this means that these data points are more reliable, they will tend to represent samples with a higher employment rate pre-programme, which may itself be an important factor.

[23] All beneficiaries from the community studied under programme P3, the Lighting a Billion Lives solar lantern programme, identified themselves as being unemployed or retired both before programme implementation and at the present time. Uncertain question interpretation in the local language may mean that some of these people are engaged in productive activity but do not receive a wage.

6.2.3. Use of Labour

The take up of employment is not only related to the supply of labour, but also to the demand for that labour. This demand may be driven by the creation of new enterprises and commencement of new productive activities (see Section 6.2.1), or by an increase in the number of people employed (or the hours for which they are employed) by existing enterprises.

In the literature, estimates of the job creation potential of improved electricity access tend to focus on particular attributes of electricity access such as reliability or capacity. IFC (2012) estimates that if there had been no power outages at all in 2005, 5.2 million additional jobs could have been created in the manufacturing sector in India. This amounts to about 1.2% of the total labour force. However, it must be noted that these estimates are made under the assumption that each firm would decide to hire as many employees as required to produce the amount of sales that would not be lost if they did not have to face power outages, which is not completely realistic.

The impacts of improved supply capacity are also found to be significant. A one percent growth in electricity consumption in India is calculated to result in a 0.53% growth in employment (IFC, 2012). Better supply capacity can also enable industrial development, as shown by a hydropower project thanks to which Bhutan was able to allot additional industrial licenses for power intensive industries like steel.

Most of the people who gained improved electricity access under the programmes studied for this project had no access prior to programme implementation, making it difficult to draw conclusions regarding the impact of improvements to a particular attribute of electricity access like reliability or capacity.

The impact on employment by enterprises of the improved electricity access provided by the programmes studied was investigated by comparing the employment rates among those in households who had not benefited from electricity access in the beneficiary community and the non-beneficiary community, and by comparing the average number of employees per enterprise.

In non-beneficiary communities, female employment among respondents increased significantly since programme implementation (from 27% to 42%) whereas male employment decreased (from 66% to 59%)[24]. The change in employment rate among non-beneficiary female respondents in the beneficiary community is broadly similar to that in the non-beneficiary community, however, among the male respondents, non-beneficiaries in the beneficiary community saw the employment rate increase by more than half whereas those in the non-beneficiary community saw employment fall.

It proved impossible to form conclusions regarding the number of employees per enterprise in India because very few of the enterprises surveyed employed anyone outside the immediate family of the owner or manager. In Kenya, the number of

[24] These results must be treated with caution due to large uncertainties associated with the small sample sizes (only a quarter of the respondents were from non-beneficiary communities).

employees per enterprise[25] was slightly higher among beneficiary enterprises, and the increase in number of employees since programme implementation was also slightly, but not conclusively, higher. No correlations were found between the increase in electricity access tier and the increase in the number of employees, either at the individual enterprise level or the programme-by-programme level.

Previous studies argue that improvements in the attributes, such as reliability, of electricity supplied lead to increased employment by enterprises. In the cases researched as part of this study, the response seemed to be significantly gendered, with female employment rising in both beneficiary and non-beneficiary communities, while male employment rose in beneficiary but fell in non-beneficiary communities. No correlations were observed between increase in electricity access tier and increase in number of enterprise employees.

6.2.4. Employee Remuneration

The impacts of electricity access on employee remuneration appear from the literature to depend on context and on the gender of the employees. The literature that looks at impacts of electricity on wages finds that women's wages decrease with electricity, while male wages increase (Dinkelman, 2008; Grogan and Sadanand, 2011).

This study did not seek to investigate the wages of individuals, but looked at average remuneration for employees of enterprises. Employees' gender was not determined and disaggregation by gender of employee was therefore not possible.

For the cases in India no conclusions regarding employee remuneration could be drawn because it was so rare for enterprises to employ anyone outside the immediate family of the owner or manager.

In Kenya, the average employee remuneration was about 20% higher for beneficiary enterprise respondents[26]. Both beneficiary and non-beneficiary enterprises saw increases in employee remuneration since programme implementation, but the change was less significant for beneficiary enterprises. No correlations were found

[25] Calculations regarding changes in electricity access and impacts exclude those enterprises that have been created since the programme implementation.

[26] Only low confidence (46%) may be placed in the prevalence of this difference at the whole-community level.

either at the individual enterprise level or the programme-by-programme level between level of electricity access and employee remuneration.

The studies in the literature that look at impacts of electricity on wages find that women's wages decrease, while male wages increase.

In this study employee remuneration in Kenya was higher amongst beneficiary enterprises, but had <u>increased</u> more amongst non-beneficiary enterprises. There was no evidence of correlation with level of electricity access.

6.2.5. Agricultural Productivity

Increases in agricultural productivity are inconsistently reported in the literature. Barnes and Biswanger (1986) find that electrification had an impact on agricultural productivity in India when it induced investments in pumpsets but did not generate the explosive growth anticipated by many early planners. In another publication, Barnes et al (2002) indicate instead that (highly subsidised) electrification of pumpsets has been highly effective in India contributing to a spectacular increase in agricultural productivity and living standards. However, these results are not based on a detailed analysis taking into account other confounding variables.

UNDP and World Bank (2002) find that electricity has no effect on agricultural output or income. Cecelsky and Glatt (1982) instead explain that when electricity is used for irrigation the value of output often increases several-fold in a short period, but because irrigation can also be done with diesel or mechanically powered (e.g. wind) pumpsets, most of the benefits cannot be solely attributed to electricity.

Beyond the use of electricity for irrigation pumping, the impacts of electricity access on agricultural productivity are not high because other applications of electrical power are limited. The main application of energy that impacts agricultural productivity is mobile motive power (tractors and field machinery), for which electricity is not used.

One of the case studies for this research, the CAFOD Kaijado Community Solar PV Project, involved the installation of solar pumps for irrigation and providing water to community-use greenhouses. Although agricultural productivity was not explicitly investigated, the field research data indicates that farm enterprises making use of the solar irrigation facility have seen their revenues and profits increase by slightly more than non-beneficiary enterprises. However, the solar irrigation formed only part of a wider programme making it difficult to draw strong conclusions about the impact of the solar irrigation component.

Some studies in the literature report significant impacts of electricity access on agricultural productivity through improved irrigation, while others report no impact.

One of the cases in this study focussed on energy for irrigation and in that case farm enterprises making use of the solar irrigation facility had seen slightly higher revenue and profit increases than non-beneficiary enterprises.

6.2.6. Business Revenues and Profits

It is expected that improved access to electricity will tend to increase enterprises' revenues or profits by either:

Increasing sales: There is demand for a new or improved product or service that is only possible at that place and time thanks to electricity access, or electricity access improves peoples' purchasing power (through increased income or reduced expenditure) such that they can better afford to pay for the product or service. Increased operating hours is one of the most strongly reported impacts that will increase an enterprise's sales.

Increasing productivity: Electricity access can allow more output for a given input in terms of labour, materials, capital or energy.

Increased value added or quality: Electricity access can enable new processes that can add greater value to a product or service than non-electrified processes. Electricity access can also enable quality improvements, reducing waste or increasing product/service value. This has the potential to increase an enterprise's revenues and/or profits.

Decreased costs: Electricity may allow an enterprise to reduce costs, thus potentially increasing its profits.

However, both the literature and the findings of this study are inconclusive with regard to the impact of improved electricity access on business revenues and profits.

Most studies suggest that electrification is a necessary but not sufficient condition for enterprise success, finding that changes in income and profits following electrification are small (and in some cases negative)[27]. The reasons proposed for this result are market saturation (Kooijman van Dijk and Clancy, 2010), limitations of the local market (Kooijman van Dijk, 2012), low usage beyond lighting, low quality of supply and a lack of sufficient production scale that makes investments in electricity worthwhile.

[27] Many of the papers reporting lack of impacts analyse a level of access equivalent to Tier 2, some others do not provide enough information to be able to assume a level of access and one refers to a level of access similar to tier 3 or 4.

Three papers report positive impacts for business income and profits (Bose et al, 2013; Kirubi et al, 2009; Matinga and Annegarn, 2013). Kirubi et al (2009) report significant impacts as electricity improved the productivity of artisans and enabled higher sales of 20-80% for carpentry businesses and 20-70-% for tailoring businesses in Kenya. The other two papers provide anecdotal evidence.

Two authors find that a connection to electricity per se is not found to have a significant impact on the profitability of microenterprises (Akpan et al 2013; Cook et al, 2005).

Some interesting insights are provided in Peters et al (2011), who show a differentiated impact for enterprises created before and after electrification. There are no positive impacts of electrification for firms created before grid access. Profits from connected pre-existing firms in the access region are actually lower than their matched counterparts in the non-access region, even though the difference is not significantly different from zero. However, electricity-reliant firms created after electrification perform much better than pre-electrification firms (and better than those newly-created firms for which electricity is not essential)**.** These newly-created electricity-enabled enterprises use more electric appliances than pre-existing electrified enterprises and have better market access because they offer new products to final consumers and intermediate products to other enterprises. However, among the traditional manufacturing sector, Peters et al also find some crowding out effects among competing firms, leading to job losses and decreased profits. The newly-created electrified enterprises can also negatively affect pre-existing enterprises by diverting local consumers' purchasing power.

The differences in enterprise income of electrified and non-electrified communities reported by other studies (Meier et al, 2010; Mulder and Tembe, 2008) is likely due to the fact that electrification reaches first those communities with road access and in market hubs, and are therefore more likely to have healthier revenues. However, this selection bias is not taken into account in their methodologies.

Obeng and Evers (2010) find that the impacts depend on the types of electricity-using activities. Shops and drinking bars experience an increase in income as a result of electrification with solar PV, but among other types of business there are no income differences between electrified and non-electrified enterprises. In fact, electrified tailors and chemical shops had lower income than non-electrified ones. A possible explanation for this finding is enterprises' differing abilities to profit from increased operating hours, one of the most commonly reported impacts in the literature. 42% of the publications covered by the literature review, including World Bank (2008) and UNDP and World Bank (2002), observe increases in business hours with electrification. However, these publications are not able to link increased operating hours to increased enterprise revenues.

A handful of studies recognise that the quality of the electricity supply can play a major role in determining the impact on enterprise performance, suggesting that reliability and predictability are crucial for impact on income (Khandker et al, 2012; Kooijman van Dijk and Clancy, 2010; Kooijman van Dijk, 2012; Maleko, 2005). Blackouts or fluctuating voltage cause damage to appliances and products and can force enterprises to stop operation.

Running a generating set has been found to make enterprises more productive and profitable. Studies tend to present this impact as an avoided loss; for example Eifert et al (2008) report that power outages lead to losses in sales of between 3% and 7% in poor African countries. Power outages and are often rated by African and Indian enterprises as the highest constraint on enterprise growth (Goedhuys and Sleuwaegen, 2010; IFC, 2012). Generating sets can support enterprises to cope with unreliability. Some estimates show that for every unit increase in the expenditure of running a generating set the profitability of microenterprises can increase by 13.1% (Akpan et al, 2013) and that electricity access supplemented with the possession of a generator increases the average enterprise's growth by 2% (Goedhuys and Sleuwaegen, 2010). However, the high estimates of the first study could be due to self-selection bias not dealt with, as the most profitable companies are also those that can afford to purchase and operate a generating set, the cost of which can be considerable. The total expenditure on generating sets by some enterprises in Nigeria is up to three times the tariff for grid electricity (Akpan et al, 2013), up to ten times the price of grid electricity in some African low income countries (Eifert et al, 2008) and a very high cost for Indian industrialists (IFC, 2012).

The extension of working hours is reported at all levels of electricity access from Tier 2 to Tier 4, as is better product/service quality. Higher productivity and increased production (leading to higher revenues) are reported at Tiers 3 and 4. Lower production costs, including energy costs, are reported at all levels from Tier 2 upwards. At the highest end of the scale, the lower operating costs borne by industries with Tier 5 access relative to industries with lower tier access contribute to their global competitiveness.

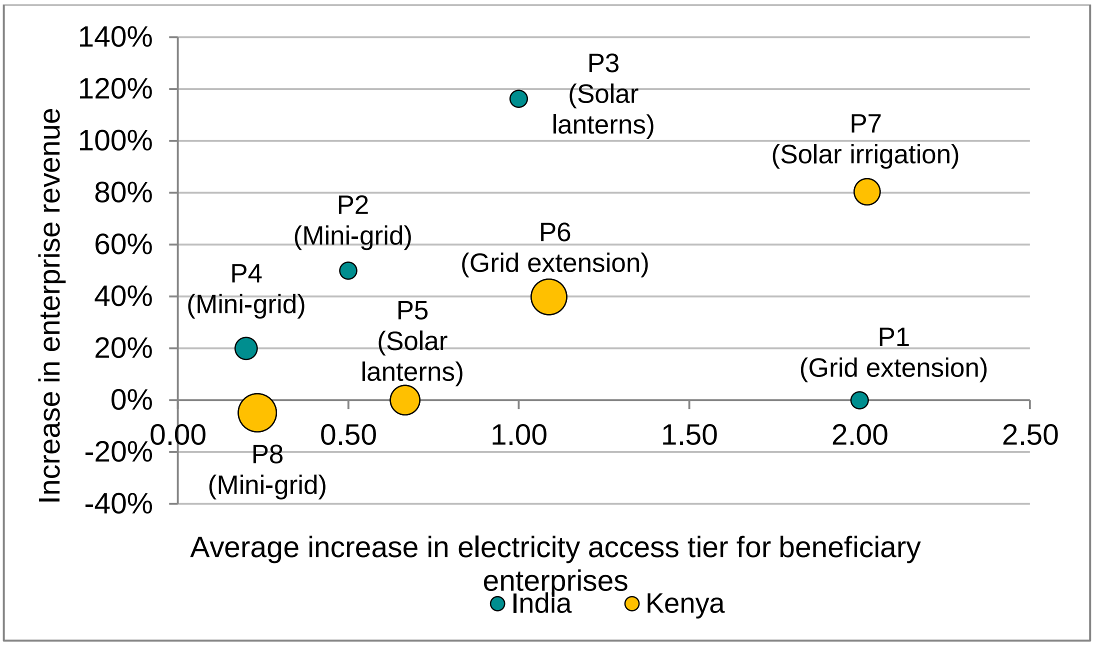
In the communities surveyed for this study, the impacts of electricity access for enterprises in terms of revenues and profits appear to be quite different in the Kenyan and Indian contexts.

The difference in average revenues between beneficiary and non-beneficiary enterprises in India is negligible. Similarly, whether or not an enterprise had benefitted from an electricity access programme did not significantly affect the increase in revenues that had occurred since before programme implementation. On the other hand, in Kenya, the surveyed beneficiary enterprises enjoyed revenues that were more than twice those of non-beneficiary enterprises[28] (though it cannot be known which is cause and which is effect). The increase in revenues since programme implementation also appeared to be somewhat greater for beneficiary enterprises.

Figure 12 plots the average percentage increase in enterprise revenues for beneficiaries of each of the eight programmes against the average increase in enterprise electricity access tier for those programmes. Although the relationship is clearly not straightforward, there appears to be a loose positive relationship between the increase in revenue and the increase in electricity access.

[28] The confidence in this difference at the whole-community level is greater than 95%.

Figure 12: Increase in enterprise revenue vs. average programme electricity access tier for productive uses[29]

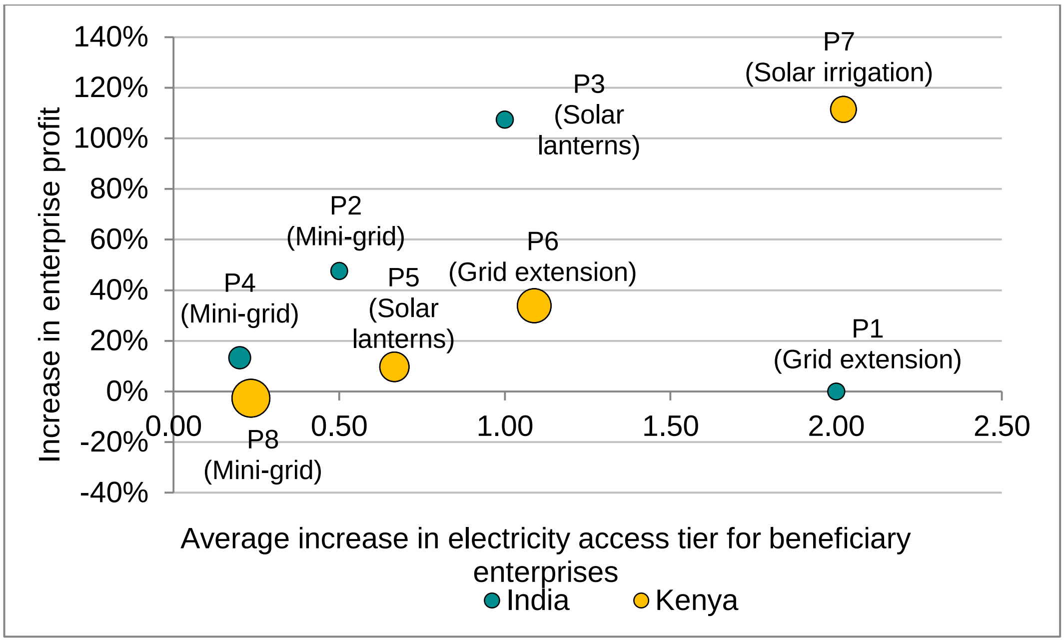


In both case study countries the average profits of beneficiary enterprises are 20 – 25% higher than non-beneficiary enterprises. In India, the average increase in beneficiary enterprise profits is slightly higher than the increase seen by non-beneficiary enterprises; in Kenya, this order is reversed.

In Figure 13, the average proportional increase in beneficiary enterprise profits for each of the eight programmes is plotted against the average increase in enterprise electricity access tier. As with revenues, the relationship appears to be loosely positive.

[29] The area of the bubbles represents the number of data points for which the average increase in revenue is calculated. This means that larger bubbles can be considered more reliable, but it must also be noted that larger bubbles represent communities with higher numbers of enterprises which may therefore have different economic characteristics in other ways.

Figure 13: Increase in enterprise profit vs. average programme electricity access tier for productive uses[30]



When each programme is considered separately, some of the field research data showed strong correlations between electricity access tier and enterprise revenues and profits. The Lighting a Billion Lives solar lantern programme in India shows a close relationship between the tier at which an enterprise was assessed (Tier 0 or Tier 1) and the revenues and profits of that enterprise. The same is true of the change in electricity access and the change in revenues/profits. A likely reason presents itself for the clear success of the LaBL programme in terms of enterprise revenues and profits. The majority of enterprises surveyed are involved in fish net mending, an activity that is greatly assisted by the availability of electric lighting. Carrying out the mending after sunset means that it is not done at the expense of time spent catching fish.

Data related to the Mlinda Foundation minigrid project also shows a close relationship between access tier and enterprise revenues/profits, but the number of data points obtained was small and the situation complicated by the fact that several enterprises had previously used electricity from a small informal mini-grid[31] prior to the Mlinda mini-grid installation. This meant that the average change in access tier was small. For the other programmes, the relationships observed were often conflicting and in some cases even negative.

[30] The area of the bubbles represents the number of data points for which the average increase in profit is calculated. This means that larger bubbles can be considered more reliable, but it must also be noted that larger bubbles represent communities with higher numbers of enterprises which may therefore have different economic characteristics in other ways.

[31] A local entrepreneur supplied neighbouring businesses with power from a diesel generator.

In general, the Community Workshops did not produce strong feedback regarding the impact of improved electricity access on enterprises revenues and profits, though, the residents of the communities in Machakos County, Kenya (grid extension programme) felt that electricity access had reduced costs of doing business.

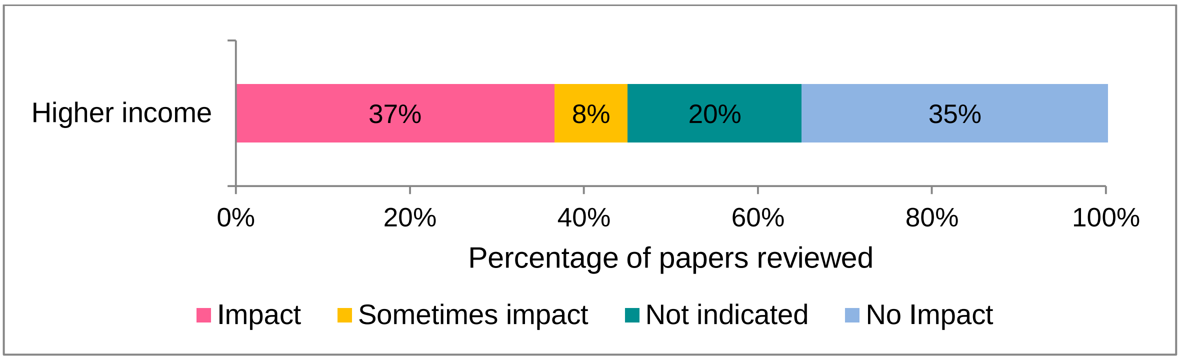
The literature finds that longer working hours and better productivity can lead to increases in revenues and profits for enterprises receiving improved electricity access, but the impacts are generally small. Firms created after electrification which could not operate without electricity tend to perform better than pre-existing enterprises or those newly-created enterprises that do not rely on electricity.

The field research findings regarding business performance are mixed; data from some of the community pairs studied showed strong correlations between (changes in) access tier and (changes in) revenues or profits, but there were no clear and consistent impacts across all communities. Loose positive relationships were found between increase in electricity access and increases in revenues and profits of beneficiary enterprises in each programme location.

7. Poverty Impacts

The effects of household electricity access on poverty indicators for that household may take place in isolation or may exist as a result of changing interactions with the community. Isolated impacts include changes in household expenditure patterns, education and health. Households may also experience poverty impacts from electricity access through shifts in time use described in Section 6.2.2, or through increased productive activity in the home. Further poverty impacts may be felt via paid employment outside the home or the ownership of enterprises, or through improvements in the community or non-enterprise services people are able to access (such as education or health facilities).

Figure 14: Percentage of papers reporting poverty impacts



7.1. Household Income

There are several mechanisms by which household income may be increased as a result of improved electricity access. The shifts in time use described in Section 6.2.2 may enable increased productive activity in the home, or increased employment outside the home. Electricity access itself may enable previously-unfeasible productive activities in the home or the wider community.

7.1.1. Impact of Household Electricity Access

The literature is inconsistent as regards the household income generation and poverty reduction potential of electricity. Of the community-specific publications covered by the literature review, seven papers refer to positive income generation and poverty impacts of access to electricity for households (Anderson and Berg et al, 2005; Calderon, 2005; Sharif et al, 2013; Legros, 2011; Yadoo and Cruickshank, 2012; Bose, 2013; Etcheverry, 2002). Ten papers conclude that impacts were minimal or non-existent (AfDB, 2011; ADB, 2005; ADB, 2010; Banerjee, 2011; Brossman, 2013; Green, 2004; Harsdorff and Bamanyaki, 2009; Herrin, 1983; World Bank, 2008; Palit et al, 2013). Studies reporting positive impacts tend to be of lower quality, do not take into account confounding variables, are based on the author's perceptions or lack robust statistical analysis. Papers that report no impacts on poverty or income generation are generally of higher quality, but tend to refer to low levels of access to electricity. When a specific tier can be assumed, it is mainly tier 2, followed by tier 1, with only one study referring to a higher level of access equivalent to tiers 3 or 4. Lack of impact is attributed to low consumption levels, equipment malfunction and lack of productive uses. When income generation happens, it is mostly in non-farm enterprises that represent a small percentage of total household incomes.

Most of the literature analysing household income across multiple communities reports positive impacts as a result of household electrification. Khandker et al (2009a) find that electrification can increase total income by 12% in Bangladesh. Khandker et al (2012) find that household income per capita can increase with electrification by nearly 39% in India, and 25% in Vietnam. In India, the increase is mostly in non-farm income, whereas in Vietnam it is farm income that drives the overall income increase. As with household expenditure, Van de Walle et al (2013) find a much lower impact of electricity on income in India than the one reported by Khandker et al (2012). Various studies have shown that more home-based businesses are created in households with electricity than in those without (ESMAP 2002; Barkat et al. 2002).

Bensch et al (2010) find that there is a significant increase in total household income in Rwanda but results should be interpreted with caution due to a potential selection bias. In fact, in the populations studied, connected households were not using electricity to operate appliances linked to income generation activities and therefore the higher income may have been due to pre-existing advantages in connected households.

None of the publications reviewed attempted to link the impacts in terms of household income to the level of household electricity access.

Across the samples surveyed under the field research component of this study, household income was significantly higher among beneficiary households compared with non-beneficiary households. In India, beneficiary incomes were more than 50% higher than non-beneficiary incomes[32]; in Kenya, the difference was more than 100%[33]. This may in part be accounted for by the greater ability of higher income households to secure access and/or to secure improved access (self-selection bias), however the beneficiary households had also seen a greater increase in income since programme implementation. In both countries, beneficiaries saw increases around a third greater than non-beneficiaries (though this too may be an effect of pre-existing advantages).

Figure 15 shows the average increase in electricity access tier[34] plotted against the average increase in household income for each of the seven programmes that provided household access[35]. Given the narrow range of levels of electricity access

[32] The confidence in this difference at the whole-community level is greater than 95%.

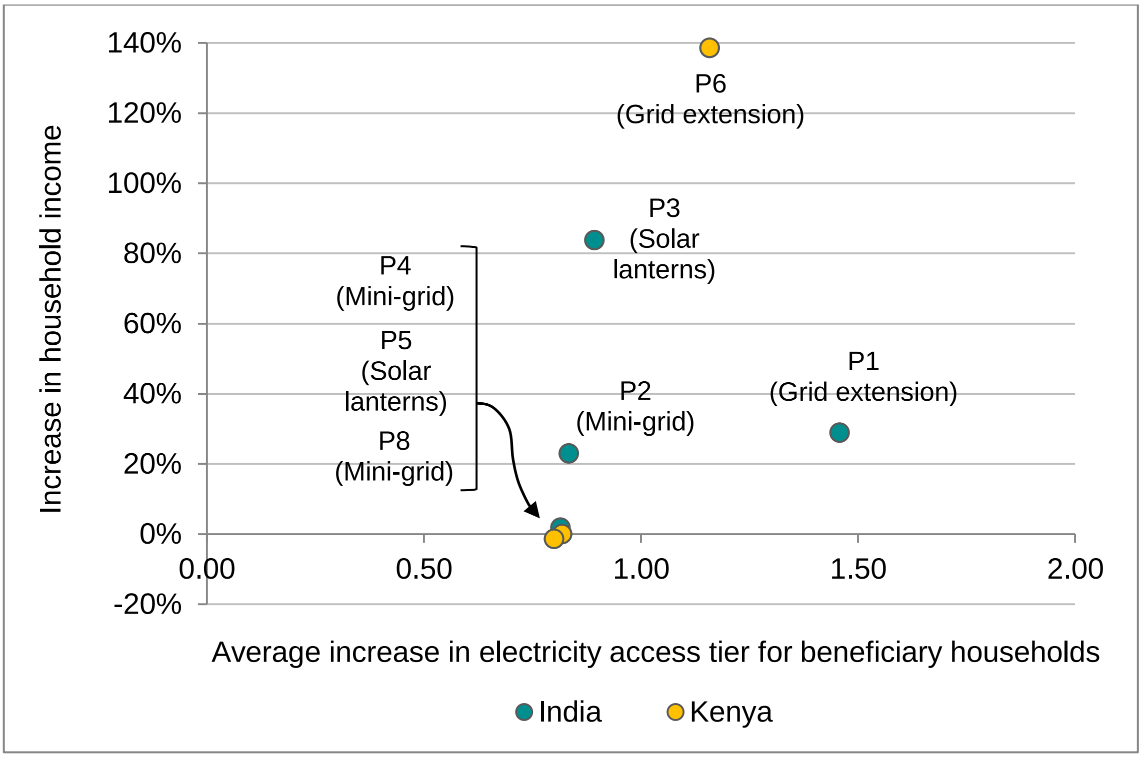
[33] Medium confidence (85%) can be placed in the prevalence of this difference at the whole-community level.

[34] Since almost all household beneficiaries had no electricity access prior to programme implementation, the plot of current electricity access tier and increase in household income looks very similar.

[35] P7, the CAFOD solar irrigation project in Kenya, did not provide electricity access for households.

provided by the different programmes, it is difficult to discern any clear relationship between level of access and increase in income. The grid extension programmes, which provided better than Tier 1 access, tended to be accompanied by larger increases in household income. However, the Lighting a Billion Lives solar lanterns programme in India (P3) was also accompanied by a very large increase in household income, attributed by community members to their increased economic activity (mending fishing nets by night whilst fishing for more hours during the day).

Figure 15: Increase in household income vs. average programme household electricity access tier



When each programme is considered separately, the only programme for which the field research data showed strong correlations between electricity access tier and household income was the Lighting a Billion Lives solar lantern programme in India. The data indicated a close relationship between the household electricity access tier (either Tier 0 or Tier 1) and household income, and also the change in electricity access and the change in income.

Section 6.2.6 reported that the strongest correlation between enterprise access and financial impacts was also found among the data from the LaBL programme. The strong relationship between household access and income indicates that the impact on poverty occurs through households' access to electric lighting, but this does not mean that it cannot also occur through the increased productive activity enabled through enterprises' access to electric lighting.

7.1.2. Impact of Enterprise Electricity Access

The mechanisms by which electricity access for enterprises outside the home might affect household incomes are more various and generally less direct. Enterprise owners (including co-operative members) may see growth in their household incomes as a result of increased enterprise profits. This includes people who own newly-created enterprises. Otherwise, income may increase through increased employment by household members (number of hours worked) and/or better wages, impacts explored in Sections 6.2.2 and 6.2.4. These impacts are difficult to disentangle from the impacts of household electrification given that almost all electrification projects that provide enterprise connections also provide domestic connections (World Bank, 2008).

As might be expected, the literature gives far less attention to the impacts on households of non-household electricity access than the more easily explained impacts of household access. The findings of previous research are also more mixed. In a study of two communities in South Africa that saw the introduction of improved electricity access, Oakley et al (2007) conclude that the livelihood impacts of significant changes to the number, type and collective volume of microenterprise activity were minimal. The lack of impact was found to be due to minimal employment creation and limited increases in turnover. IDS (2013) show limited potential for income generation of the provision of electricity to Chinese rural areas, with diesel being the primary fuel associated with production activities rather than electricity.

The papers reporting positive impacts on the number of working hours (Anderson and Berg et al. 2005; Bose et al, 2013; Chakrabarti, 2002; Obeng and Evers, 2010) do not explicitly draw links to income generation.

The poverty impacts of electricity access for non-home productive uses were investigated by comparing, across a community, the average programme electricity access tier (or increase in tier) for non-home enterprises and the average increase in household income. The field research data does not reveal any relationship between these variables; however, this is not surprising given the numerous factors that influence household income, including the influence of household electricity access.

An alternative would be to infer poverty impacts from data regarding employment and wages; however, this would go well beyond the scope of the current study to investigate multi-stage relationships (e.g. electrification → increased employment → increase household income), requiring detailed data to be gathered regarding matters such as the sources of household income, wages of each working household member, the electrification status of the employer organisation of each household member etc.

The literature is fairly evenly divided regarding increased household income as an impact of improved household electricity access, with those publications looking at higher levels of access more likely to report such an impact.

In most of the cases looked at as part of this study, increased household income was found. No pattern was found between the level of access and the magnitude of the impact.

Enterprise electricity access may affect household income via employment creation, wage increases or profit retention by enterprise owners. Published evidence of the impacts of enterprise electricity access on household income is sparse, and reports that impacts are minimal. Our case studies also found no clear relationship.

7.2. Household Expenditure

The more straightforward changes in household expenditure which tend to accompany basic (Tier 1 or lighting-only) **household** electricity access are well understood. Poor households who previously used kerosene or other liquid/solid fuels for lighting usually experience a significant reduction in their expenditure on lighting when they take up electricity access. This is true even for off-grid electricity access when the unit cost of electrical energy can be tens of times higher than the 'standard' grid rate. This reduced expenditure on energy frees up money in the household budget to spend on other things, including life-enhancing goods or services like health products and education.

Beyond very basic electricity access, most of the literature analysing household expenditure reports increased spending as a result of household electrification. Some authors treat increased spending as a proxy for increased income (hence framing it as a positive outcome), whilst others consider expenditure relative to income, meaning that the poverty impact of increased expenditure depends on what additional money is spent on. Impacts in terms of overall household finances are explored in Section 7.3. Where increased expenditure implies purchases that improve quality of life it can be considered to be a positive outcome (provided that unaffordable debt is not incurred). Where increased expenditure results from increased prices for essential goods and services, it can be considered to be a negative outcome. Increased spending on electricity itself may be a bad thing if the energy service provided is poor.

None of the reviewed studies report on the impact of different levels of household electricity access on household expenditure. Treating electrification as a binary variable, Khandker et al (2009a) find that electrification can increase per capita expenditure by 9% in Bangladesh. The same author finds an 18% increase in India (Khandker et al, 2012), with non-food expenditure increasing much more sharply than food expenditure, although Van de Walle et al (2013) find a much less marked increase (7%) in their Indian study.

The mechanisms by which **enterprise** electricity access might affect household expenditure are either through increases in household income (dealt with in the previous section) or through increased availability of electricity-enabled goods and services in the community on which a household may choose to spend money. No evidence was found in the literature to elucidate the potential poverty impacts of this second causal link. The field research component of this study, given its focus on productive use of electricity, did not seek to investigate changes in household expenditure patterns as a result of improved electricity access but rather focused on household income.

> ***The benefits of electricity access in reducing energy costs and so enabling transfer of expenditure to other goods and services is not disputed in the literature. However, higher levels of electricity access are sometimes found to increase overall spending. This may be seen as a positive or negative outcome, depending on whether this additional spending confers benefits to poor people or represents an extra drain. The research element of this study did not, in the context of focusing on productive electricity use, look at changes in household expenditure patterns.***

7.3. Household Finances and Poverty Rates

In many cases, the literature does not succeed in drawing links between the impacts on productive uses detailed in Section 6 and specific poverty impacts. In general, the literature that analyses both household income and expenditure concludes that the increase in income that results from electrification is greater than the increase in expenditure, for example Khandker et al (2009a) and Khandker et al (2012). This means that there is net additional money for the household.

However, electricity access is not always found to result in an improved financial situation for households. Cook et al (2005) indicate that access to electricity <u>increased</u> spending in their China and Thailand case studies but did not increase income, particularly of poor people. This outcome is problematic if it reduces poor peoples' resilience to shocks, increases debt or adversely affects their capability to make longer-term investments.

Only one reviewed paper looks at the impact of electricity access on poverty rates and finds that the poverty rate in India declines by 13.3% as a result of access to electrification (Khandker et al, 2012).

Because the field research component of this study did not seek to investigate household expenditure or household assets, no conclusions could be drawn regarding the effect of improved electricity access on household finances in the areas studied. This study has not defined and measured poverty rates in the communities studied.

The literature reports divergent impacts of electricity access on household finances. One reviewed paper reported a positive impact on poverty rates.

7.4. Health and Education

Health and education impacts were not included in the literature review, however improved education is widely seen that a common benefit of household electricity access. Electric lighting makes it much easier for learners to study outside of daylight hours, for example allowing children to spend more time doing homework. Improved electricity supply in the wider community may also enable education benefits through improved school facilities and the attraction of teachers to communities where electricity access is available.

Household respondents were asked as part of the field research if the education available to their children had improved in the period since programme implementation. (Given its focus on productive uses levels of electricity access for community uses such as schools and health clinics were not assessed). Overall, 62% of Beneficiary Households, but only 32% of Non-Beneficiary Households, with children felt that the education available to them had improved. However, in Kenya, 78% of Beneficiaries and 69% of Non-Beneficiaries reported an improvement while in India these figures are 51% and 2%. More than 90% of the Kenyan respondents (whether or not beneficiaries of the programme) who had noticed a positive change felt that this was in whole or in part attributable to improved electricity access. Contrastingly, only 75% of Indian beneficiaries (and no non-beneficiaries) who had noticed a positive change attributed this at least in part to electricity access.

Given the narrow band of electricity access tiers found, (most respondents achieving Tier 0 or Tier 1) it was impossible to draw firm conclusions about the level of household electricity access needed to produce an improvement in education.

Positive health impacts of electricity access may be direct results of fuel switching (e.g. the avoidance of indoor air pollution from kerosene or wick lamps or reduction of the fuel collection burden) or the results of improved healthcare enabled by electricity access for clinics and hospitals. Less direct impacts might include the attraction of skilled healthcare workers to communities where electricity access is available.

The field research did not seek to establish the health impacts of household electricity use in the case study communities[36], but household respondents were asked if the health services available to them had improved since electricity access became available.

Overall, around 24% of survey respondents who were beneficiaries of household electricity access felt that the health care available to them had improved since the electricity access programme implementation. Amongst non-beneficiaries, the rate was only 16%. Respondents in Kenya were much more likely to report improvements (35 - 40% for beneficiaries and non-beneficiaries alike) than respondents in India (13% for beneficiaries and 0% for non-beneficiaries). In each country, more than 80% of beneficiaries and non-beneficiaries alike who reported an improvement in healthcare attributed it in whole or in part to improved electricity access.

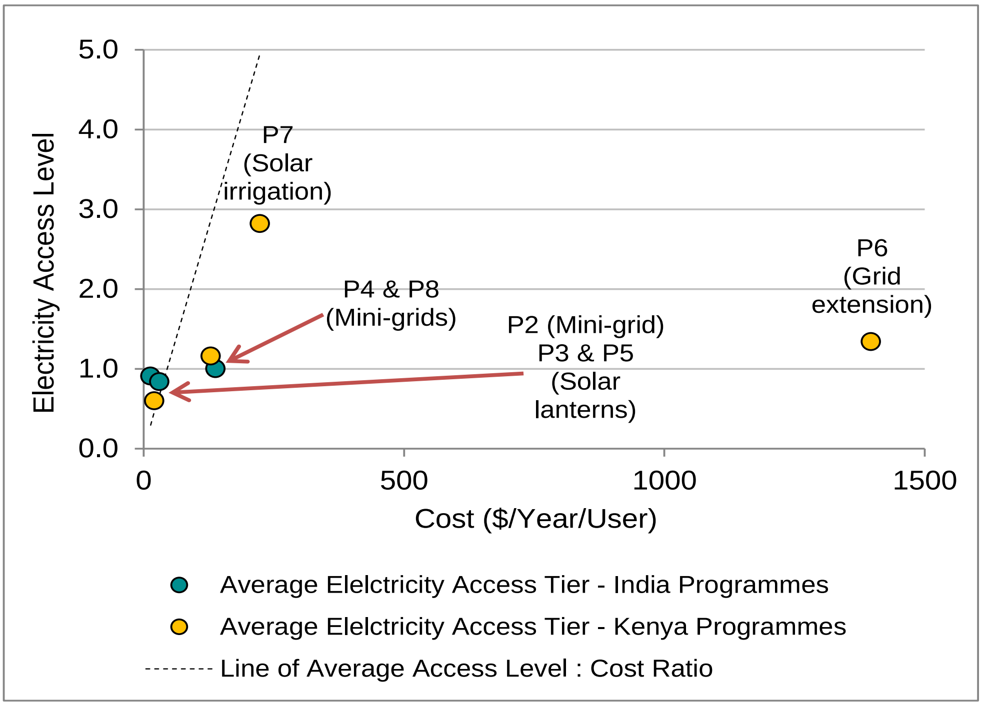
Electricity access seems to have had a significant positive impact on the quality of education available to children of households surveyed during the field research, especially in India. Positive impacts in terms of healthcare appear to have been less widespread, although survey respondents widely agree that those improvements that have taken place can be attributed at least in part to improved electricity access. These improvements may well have come through electricity access becoming available to health and education facilities (not assessed as part of this study) rather than productive use.

[36] Beyond investigating the health and safety risks associated with peoples' electricity supplies as required by the Global Tracking Framework.

8. Value for Money

By comparing average through-life costs[37,38] in terms of $/user/year for each of the programmes[39] with the average level of access[40] they achieve, it is possible to arrive at some broad observations regarding the relative value for money provided by the various means of electricity provision:

Figure 16: Average Electricity Access Level vs Cost (including Grid Extension Programme)



[37] This is cost of provision, not the cost paid by the user

[38] It should be noted that these costs are not directly comparable as:

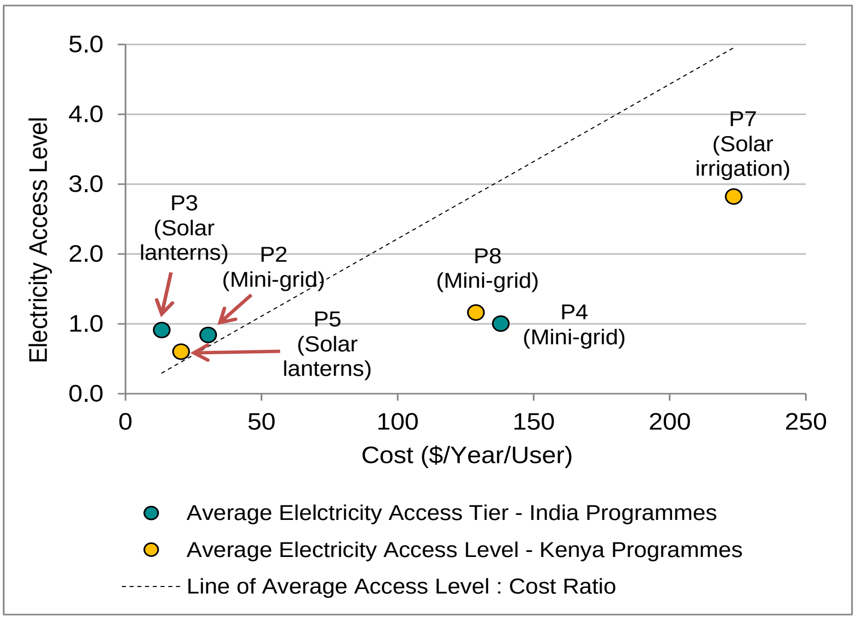
- Programme development and ongoing overhead/administration costs, and the impact these have on average through life cost per user, will be very much affected by the scale at which the programme has been implemented
- Mini-grid and grid extension costs in particular (but also though to a lesser extent costs of other forms of electricity) are highly location specific, being affected by geography (distance from the existing grid system), local topography, availability of primary energy resources for generation, size and population density of the community served. Thus it is highly unlikely that, for instance, the costs of a mini-grid installed in one location would reflect those in another
- The electricity access levels also represent a combination of household and productive use tiers – which are not strictly comparable, as demonstrated by the solar pumping systems provided by the CAFOD programme in Kajiado, which provide a relatively high level of access to electricity for motive power, but none other productive or other household uses.

[39] Community-specific costs for the RGGVY grid extension programme were not available and average "cost-of-service" figures for the grid system in West Bengal (see Tariff Order 2011-12 and 2012-13, West Bengal Electricity Regulatory Commission, 1st December 2012), which encompass both urban and rural areas, were not judged to provide a useful comparator with the rural community electricity access programmes which form the focus of this study.

[40] Arrived at by simple averaging of the average household and average productive use access level reported by programme beneficiaries.

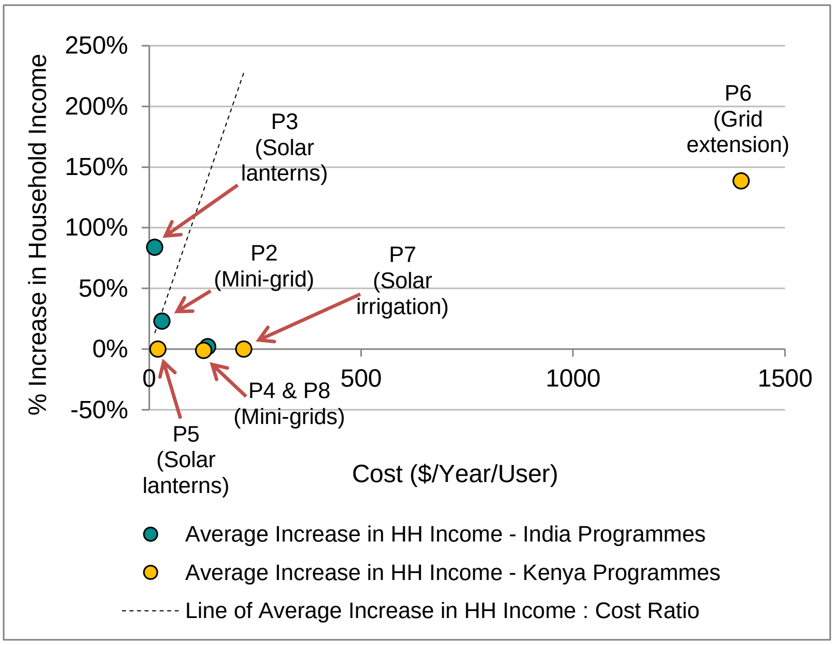
An initial observation is that while the grid extension programme achieves a higher level of access than most of the others, it is also substantially more costly, lying well below the line of average access level to cost ratio. If this data point is removed the relative positions of the other programmes can be seen more clearly:

Figure 17: Average Electricity Access Level vs Cost (excluding Grid Extension Programme)



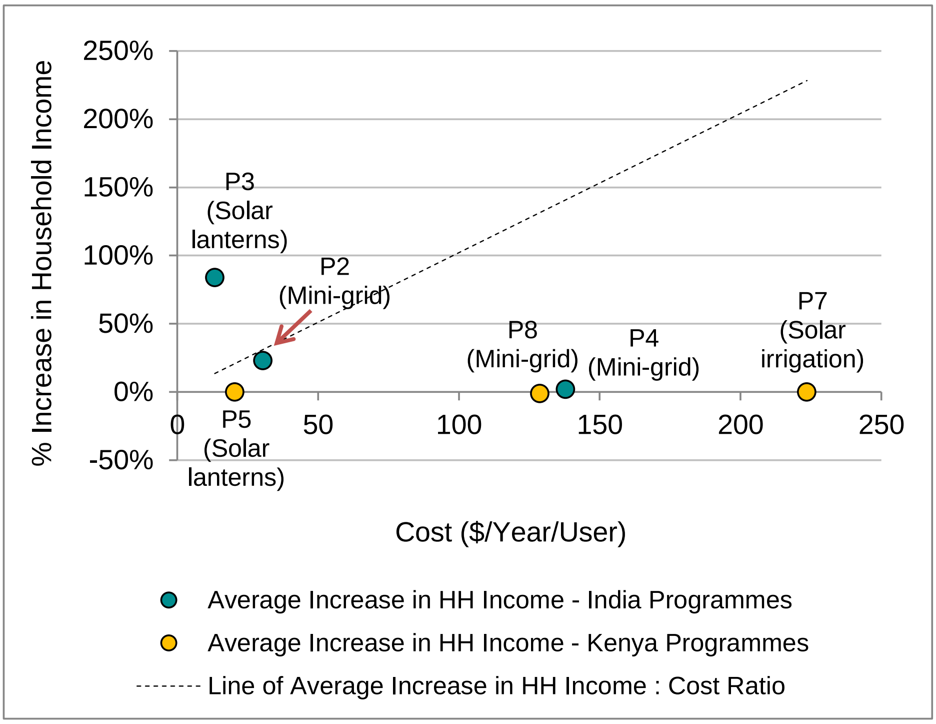
From this it would appear that those programmes providing relatively low levels of access (the two solar lantern and one mini-grid programmes), nevertheless provide relatively strong value in terms of the cost of providing this access. Recognizing that electricity access is not an end in itself, but a means to enable poverty reduction, the costs of the various programmes have also been plotted against the average percentage increase in beneficiary household incomes:

Figure 18: Average Increase in Household Income vs Cost (including Grid Extension Programme)



Here again the grid extension programme is an outlier, being the only programme in Kenya for which a substantial increase in household income was seen, but at significant cost. Looking more closely at the other programmes:

Figure 19: Average Increase in Household Income vs Cost (excluding Grid Extension Programme)



It would appear that in these terms also, it is the programmes which have provided the lowest levels of access, but have done so most economically which have delivered the best value.

9. Factors Affecting Provision, Take Up and Use of Electricity for Productive Purposes

Most authors agree that electricity is a necessary but not sufficient condition for increased income generation and poverty reduction. Evidence from the World Bank in the 1990s showed that, despite intense electrification activity in developing countries during the 70s and early 80s, connection rates and consumption remained low and electricity was rarely used for productive activities and that in general electrification had delivered low economic returns, low cost recovery and little evidence of an impact on industrial development, income generation and poverty eradication (IEG, 1994). More recent studies have provided inconclusive evidence regarding the impacts of electricity access. A recent literature review (Pueyo et al 2013) of “The evidence of benefits for poor people of increased renewable electricity capacity”, for instance, concluded that even once households and businesses are given the opportunity to connect to the grid or purchase off-grid systems connection rates and final use may remain disappointingly low. Similarly Attigah and Mayer-Tasch (2013), as part of the report “Productive use of energy- PRODUSE”, found the literature on productive use impacts of electrification programmes to be generally inconclusive, indicating that access to and use of electricity by medium and small enterprises “does not automatically lead to intended development results such as increased productivity, profits and income”. The literature review carried out as part of this current study has also found inconsistent and inconclusive results.

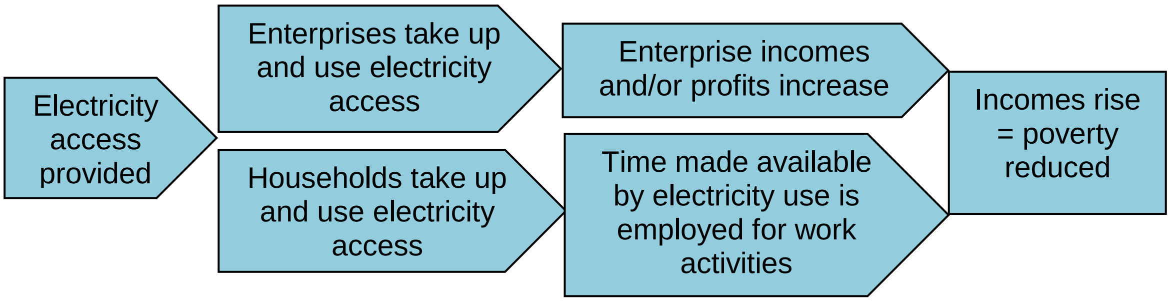
Against this background, one possible hypothesis has been that different levels of electricity access provide different outcomes, but that the bulk of the literature in treating electricity access as a binary, and ignoring the potentially differential impacts of different levels of access, has drawn disparate conclusions. This hypothesis has been one of the focuses of this current study but our conclusion has been that even recognising the potential for different levels of access to have different effects there does not appear to be a simple relationship between access and its impacts (see Sections 6 and 7). Thus our review of the relevant literature has concluded that “A coherent relationship between different levels of access to electricity and poverty reduction, defined in income terms, could not be proved” and the field research undertaken has similarly failed to reveal a consistent relationship between levels of electricity access and its impacts in terms of either productive activity or poverty reduction.

This supports the consensus prevailing in the literature that the impacts of electricity access are highly country- and context-specific (Attigah and Mayer-Tasch 2013), dependent not only on the level of access provided but also on pre-existing conditions in the areas to be electrified and on a number of other factors. Throughout the current study we have sought to explore these factors and the effects they have on the extent to which electricity access impacts on productive activity and poverty.

9.1. Interaction between Causal Chain & Facilitating/ Constraining Factors

The causal chain between electricity access and poverty reduction is highly complex, with multiple pathways. At the simplest level, however, it may be envisaged as:

Figure 20: Causal Chain



Numerous factors may intervene at each of the steps along this chain. Thus, for example:

- Uncertainty in the regulatory environment might hinder provision of electricity access;
- The (in)ability to access finance for connection, wiring, or productive equipment might discourage or encourage households and enterprises to take up and use electricity productively;
- Enterprises making use of electricity may, nevertheless, be unable to increase production (and hence revenues) due to difficulties accessing other inputs;
- Individuals may be unable to make use of time made available by electricity use due to lack of employment opportunities and/or lack of skills needed to engage in productive activities;
- In the absence of access to wider markets, increased production by those enterprises with electricity, or increased working time by individuals, may simply reduce the opportunities available for non-electrified firms or reduce prices and/or wages, leading to no overall increase in incomes or poverty reduction.

These and other factors have been explored as part of this current study, through the literature review, the examination of the regulatory and policy frameworks in India and Kenya, the discussions with stakeholders involved in electricity access provisions and with both the implementing agencies and participants in the selected electricity access programmes, and through questions included in the surveys of enterprises and households in the selected communities. The study has thus drawn together a holistic picture, from a number of perspectives, of the accompanying factors needed to enable electricity access at varying levels to support poverty reduction.

9.2. Enabling/Constraining Factors Identified

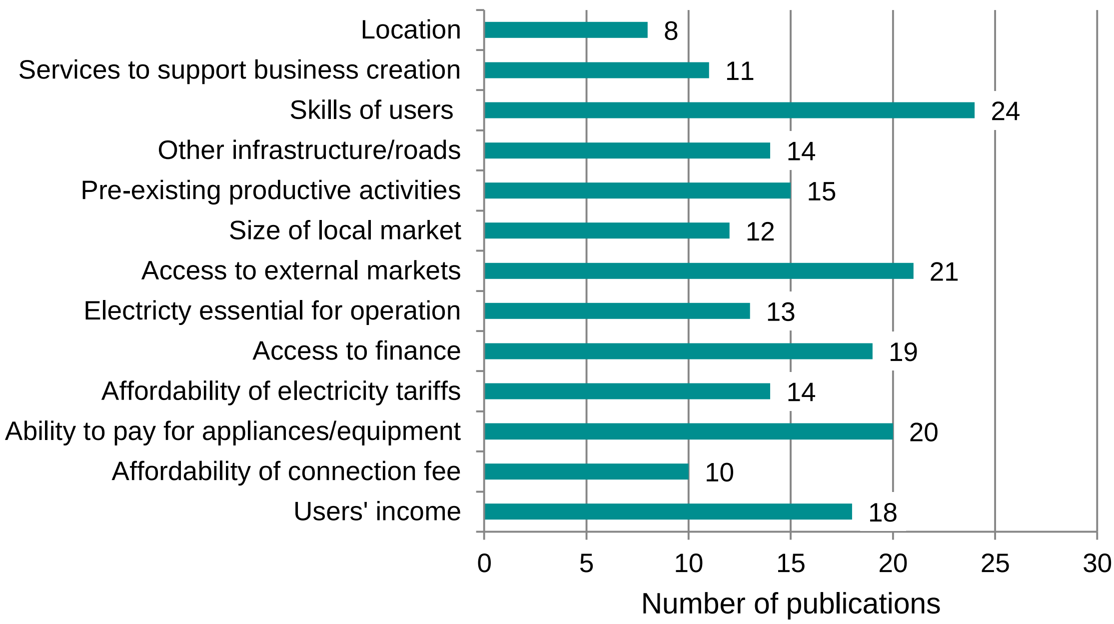
The literature is clear that pre-existing conditions in areas to be electrified play a big role in the number and magnitude of positive impacts, with those most economically developed being most likely to use electricity for income generation. In particular:

- access to markets;
- pre-existing industry;
- access to finance and resources
- knowledge and skills
- sufficiency, duration, reliability and quality of electricity access[41]

are seen as being key to achieving positive impacts on proverty through productive use of electricity.

Figure 21 shows the number of publications reviewed as part of the current study which identify specific factors, linked to the conditions described above, that allow benefits from access to electricity for productive uses to be felt.

Figure 21: Enabling/constraining factors of electricity impacts



These publications highlight that access to electricity needs to be accompanied by adequate users' skills; access to markets and other resources; and that users must have sufficient income and/or access to finance to enable them to pay for

[41] In the context of this study these have been treated as attributes driving the assessment of the level of access provided rather than as enabling/constraining factors.

connection, electricity and appliances and equipment for productive use, if economic benefits from access are to be achieved.

Insofar as the literature distinguishes (or enables the reviewer to distinguish) between different levels of electricity access, Table 5 summarises the identified enabling/constraining factors reported by the studies reviewed according to the assumed tier of electricity access that they refer to. As will be seen, access to finance is identified as a key facilitator across all levels of electricity access and access to business support services is regarded as critical across the range from Tier 2 to 4. Access to skills and markets appear to be most relevant to enabling the benefits of lower levels of electricity access, possibly reflecting that these levels of access are most frequently provided in smaller, rural, communities where these factors are most likely to be lacking. Conversely, the presence of pre-existing productive activities and complementary infrastructure is seen as being of most importance in relation to the higher levels of electricity access, perhaps because electricity at these higher levels is more often made available to larger more economically active communities (where skills and markets are more likely to be available).

Table 5: Enabling/Constraining Factors Identified in Relation to Different Levels of Electricity Access

Tier	N^{o} Papers	Access to Markets	Skills	Access to Finance	Business Support Services	Pre-existing Productive Activities	Complementary Infrastructure
1	3						
2	12						
3	6						
4	6						
5	1	Income increases through businesses favour rich/middle income households					

The Case Studies undertaken in Kenya and India as part of this study provided supporting evidence of the effects of many of the factors discussed above, while also identifying a number of additional factors. While the literature review focused primarily on barriers to productive use and poverty reduction from electricity access once available, the case studies also provided information on the perceived barriers to provision of access in these countries. Factors affecting provision, take up and use and impact of electricity access identified through the policy/regulatory review and provider and programme stakeholder discussions include:

	Literature	Kenya	India
Appropriate (off-grid) policy and regulatory provisions		✓	✓
Community engagement		✓	
Quality/performance of electricity supply and equipment	✓	✓	✓
Costs and Access to Finance	✓	✓	✓
Knowledge and Skills	✓	✓	
Access to Markets	✓	✓	✓
Pre-existing Industry	✓		✓
Infrastructure and security	✓	✓	✓
Access to Other Resources		✓	✓

In Kenya the main influencing factors identified through stakeholder discussions were costs (upfront and ongoing) and skills and capacity. Focus groups in electricity access beneficiary communities also identified access to markets as a significant factor in securing benefits from access. In India, the lack of provision for productive uses under existing electricity access programmes is seen as a major policy-related barrier to provision. It was also observed that factors other than electricity, such as enterprises' access to infrastructure, markets and raw materials, exerted a strong influence on the rate of take up and productive use of electricity access.

In addition, households and enterprises in electricity access programme beneficiary and non-beneficiary communities were asked about the factors affecting their decisions whether or not to take up and use electricity. Their answers were analysed to give a picture of users' perceptions of the factors influencing productive use of electricity:

Table 6: Enabling/Constraining Factors Identified in Literature and by Survey Respondents[42]

		Rank				
		Literature - Number of Publications	Kenya		India	
			HH	SME	HH	SME
	Availability of electricity access options		4	10	7	7
	Electricity essential for operation / Adequacy of other energy access options	9	6	11	5	6
Electricity Supply Characteristics	Capacity of supply		11	12	4	**2**
	Duration/availability		14	8	**2**	4
	Reliability		7	4	**3**	**3**
	Quality of supply		8	7	6	**1**
	Time/effort to secure/operate/maintain supply		10	13	14	13
	Health and Safety		12	15	10	8
	Legality		13	14	12	14
	Location	13				
	Other infrastructure/roads	7				
	Pre-existing productive activities	6				
Access to Markets	Demand for enterprise's product/service			9		
	Size of local market	10				
	Access to external markets	2				
Knowledge, Skills & Capabilities	Knowledge/awareness		4	4	9	5
	Skills of Users	1				
	Services to support business creation	11				
Costs and Access to Finance	Users' income	5				
	Upfront costs / connection fees	12	8	6	**1**	9
	Ongoing costs /electricity tariffs	7	**2**	**2**	11	12
	Cost/availability of appliances/equipment	3	**3**	**3**	13	11
	Access to finance	4	**1**	**1**	8	10

[42] Figures in the first column of this table represent the ranking of the number of publications in the literature reviewed (1 = highest number of publications, 13 = lowest number of publications) identifying each enabling/constraining factor. (For the actual number of publications, see Figure 21 in Annex 1, the Literature Review report.) This ranking does not address the level of importance attributed to the various factors in the literature.

For users in Kenya, cost and access to finance are the most influential factors, whereas in India these are (with the single exception of up-front costs for households) apparently less important. Conversely households and SMEs in India place greater importance on the capacity, availability, reliability and quality of the electricity supply, but those in Kenya put these behind cost and other factors. Very little weight is placed in either country on the time and effort needed to support access, or on the health and safety benefits or legality of the supply. In both countries availability and adequacy of electricity access options relative to other energy options, knowledge of the electricity access options and the skills and capabilities to make productive use of electricity are seen as influential. Demand for products and services also came through as a factor in Kenya[43], but was not rated particularly highly by survey respondents. (The existence of complementary infrastructure and presence of pre-existing industry were not issues raised in the survey, so no conclusions can be reached on these factors).

Each of these factors, and the mechanisms through which they may affect the causal chain between provision of electricity, its productive use and poverty reduction, are discussed in greater detail below.

9.2.1. Policy & Regulation

Energy policy and regulation can directly assist or hinder provision of electricity access and affect how straightforward it is for potential users to take up access (particularly connection to the main grid). In addition the wider legal and regulatory framework may affect users' ability to make productive use of electricity. While examination of policy/regulatory effects was not a focus of the literature review, each of the country case studies included a review of the national policy/regulatory framework, and policy/regulatory issues flagged by stakeholders.

To date, policy support for the productive use of electricity has seemed to exist more in theory than in practice in both India and Kenya. The lack of provision for productive uses under existing electricity access programmes is seen as a major policy-related barrier to the provision of electricity access.

Several stakeholders in Kenya saw the failure of existing legislation and policies to make appropriate provision for development of mini-grids in rural areas as a barrier to access provision. Much of this concern related to arrangements for tariff-setting and approval, which developers did not feel adequately reflect the high costs of electricity provision in remote rural areas (see Section 9.2.4 below). Clearly if developers are not allowed to charge tariffs which enable cost-recovery this will constrain access provision. Conversely, higher tariffs may discourage take up and use of electricity, particularly if productive users are competing in markets with subsidised grid-provided electricity. In this context, Kenyan stakeholders noted that while the current Energy Act and feed-in-tariff policy recognise that some rural areas

[43] This question was not included for India, so no conclusion can be reached from its omission from the factor ranking.

may not be viable for electrification on a purely commercial basis they fail to make explicit provisions to facilitate planning and encourage investment in the off-grid areas or to establish a model for investment in off-grid solutions from the Rural Electrification Programme Fund. (While a higher tariff for off-grid solar is offered, this tariff is not considered sufficient to enable rapid uptake of this energy source.)

Developers of small scale electricity access projects in Kenya also felt that the permitting and licensing process was unwieldy (consistent with the assessment against the RISE[44] framework that Kenya performs only moderately in relation to the time and cost to secure mini-grid licenses and for connections to the grid). One specific factor identified by Kenyan stakeholders as a disincentive to mini-grid development is the lack of regulatory provision in the event the national grid extends into an area where a mini-grid has been established. This is a risk which will inevitably discourage other mini-grid developments and drive up the costs of those which do proceed.

Stakeholders in India also perceived a failure of policy and regulation to adequately support off-grid electricity access in rural areas, although in several ways India appears to offer a more favourable environment than Kenya. In India, mini-grid developers are able to operate in designated rural areas without licence and are free to set tariffs without the need to involve the regulator. However, the issue of cross-subsidisation related to rural grid and off-grid electricity is more pronounced in India, where rural grid tariffs are actively cross-subsidised (being cheaper than urban tariffs). In India, the majority of village centres are electrified (even if the supply does not reach many people or adequately meet needs), meaning that off-grid enterprises are very often competing with grid-connected businesses for the same markets. The artificial discrepancy between energy costs for on- and off-grid rural enterprises is an important disincentive for both the provision of off-grid electricity access and the productive use of off-grid electricity access once available.

In India, both on- and off-grid electrification programmes receive government subsidy to assist with upfront costs. However, the lack of subsidy support during the operational phase of rural electricity access projects often presents a barrier to the provision of access; a redistribution of subsidy support across both upfront and ongoing costs would improve project viability and potentially improve affordability for electricity service users.

Each national regulatory and policy environment will be different, but the examples of Kenya and India demonstrate the importance of having a clear and transparent framework, including explicit and equitable provision for off-grid access, if unnecessary barriers to electricity access provision and productive use are not to be created.

[44] Readiness for Investment in Sustainable Energy framework developed by the World Bank Group as part of Sustainable Energy for All (SE4All) as a guide to the key policy and regulatory elements needed to create a an enabling environment for provision of electricity access.

9.2.2. Community Engagement

Community engagement is recognised as a vital requirement for success of off-grid projects (though not specifically identified in the literature review as an enabling/constraining factor on productive use and poverty reduction). For instance in relation to the Solar Transitions Energy Centre in Kenya, the energy centre's status as a community-owned asset, and the resulting sense of responsibility most local people feel for its success, were seen as key factors in the take-up of services, and in both this and the Kenyan CAFOD Community Solar PV Project, community empowerment and unity and cooperation fostered among community members, were seen as significant non-quantifiable benefits from the project.

In a similar vein, a number of programmes in India, such as the Mlinda Foundation programme included in this study, make use of community organisations such as Joint Liability or Self-Help Groups as vehicles for financing electricity access provision and promoting entrepreneurial development. National- and state-level electrification programmes have recognised the value of community engagement for enabling impacts and delivering efficiency, finding that local electricity distribution via franchisees with closer links to the community is an effective way to deliver new connections.

However, some of those involved in provision of electricity in Kenya also saw the need for community-specific engagement as creating a barrier to scale-up of electricity access. They identified the requirement for time (and money) to be spent in negotiating with communities in relation to relatively small projects as representing a significant transaction cost. They also saw the need to re-create community relationships for each project as hindering scale-up and replication of similar projects nationally. Any means that could be found to overcome this barrier (for instance by establishing models for community engagement, perhaps with some form of regulatory or government endorsement, which could be adopted by project developers) might ease private sector provision of mini-grid access.

9.2.3. Quality/performance of electricity supply and equipment

A further issue identified by many as a barrier to poverty reduction through productive use of electricity is the quality and performance of equipment.

Much of the discussion in this area relates to electricity generating and distribution equipment and hence to the reliability and quality of electricity supplied. Thus, Watson et al (2012) highlight low quality equipment and installation of SHSs and poor performance and unreliability of grid electricity as one of the major barriers to increased use of modern energy services. Similarly Pueyo et al (2013) identify quality and reliability of supply as widely and consistently reported factors facilitating increased connection rates and use, and comment that, particularly for productive activities, availability and reliability are more important than price as energy costs are usually only a small percentage of total production costs and industry can face high costs as a result of voltage drops or blackouts. Other studies (Khandker et al, 2012; Kooijman van Dijk and Clancy, 2010; Kooijman van Dijk, 2012; Maleko, 2005) also recognise that the quality of the electricity supply plays a major role because reliability and predictability are crucial for impact on income with blackouts or fluctuating voltage potentially causing damage to appliances and products and forcing enterprises to stop operation. Khandker et al (2012), estimates that increasing the average availability of electricity at the village level by one hour increases the rate of household adoption by 2.7 percent and electricity consumption by 14.4 percent, while unscheduled outages leading to production losses have been quantified by some papers as reaching between 3 and 7% of total sales in African countries and Goedhuys and Sleuwaegen (2010) note that electricity supply interruptions are considered as the major constraint to the growth of businesses by most of the high growth industries in 6 out of 11 countries studied.

For the current study capacity, availability, reliability and quality of electricity access were incorporated into the assessment of the level of access. In Kenya, the assessed level of access for households appears to be driven almost entirely by capacity and availability (and affordability), with reliability and quality having less effect. For enterprises capacity, availability and affordability remain the dominant drivers of the level of access, but reliability and quality are more influential, setting the access level in up to 17% of cases (depending on the application). This may be reflected in the views of Kenyan users who did not in general rank the characteristics of the access particularly highly in the factors on which they decided whether or not to take up and use electricity access. Despite this, a number of stakeholders commented on the effects of access characteristics on take up and use of electricity – community members in Machakos saw the reliability of the grid-supply as one of the factors supporting economic growth, while those in Mageta Island felt that limitations on the power available from the mini-grid had restricted its productive use.

In India, the assessed level of access for households appears to be driven largely by low capacity and poor affordability (46% and 37% respectively), with a much smaller proportion limited by the duration or the quality of electricity supply. For enterprises, poor capacity and duration were equally important driving factors, accounting for 93% of all application tier assessments. Quality and health and safety were the constraining factors in a minority of cases. Despite its lack of prominence as an influencing factor in the access tier assessments, a large proportion of Indian electricity users, both households and enterprises, reported the reliability of the electricity supply as an influencing factor when deciding whether to take up electricity access (households) or to make productive use of electricity access (enterprises). Quality of supply was generally felt to be important, as were duration/availability and capacity - but more so by enterprises than by households. Capacity was highlighted as important by participants in the focus groups for the two mini-grid programmes (Husk Power Systems and Mlinda Foundation) and the Lighting a Billion Lives solar lantern programme. Duration and reliability problems were cited as problematic constraints by both the grid extension and mini-grid programme beneficiary communities.

Less focus has been placed on the availability and quality of electrical appliances which can be put to productive use. It would seem clear that this must be a factor in the take up and use of electricity and hence securing poverty reduction benefits, and there are references to this in the literature, but it is not brought out as a major influence, and where lack of such appliances is noted it is largely in the context of difficulties in financing their purchase. Nor was this an issue raised by stakeholders or users in Kenya or India.

9.2.4. Costs and Access to Finance

The literature strongly reports high upfront costs as one of the main barriers to increased electricity demand and this demand-side economic barrier is normally linked to a lack of access to finance (Watson et al, 2012). Pueyo et al (2013) similarly note that the literature strongly and consistently reports financial barriers to increased connection and use and in particular barriers related to income of users and upfront costs of electricity, including unaffordable connection fees or purchase price of home systems, house wiring and electrical appliances. If people cannot afford appliances linked with productive uses, energy access will not make a difference. Electricity tariffs are less frequently reported as a barrier to initial connection and increased use.

Stakeholders in Kenya and India concurred with the literature in seeing cost and access to finance as critical in enabling or restricting access to and productive use of electricity. For users in communities surveyed in Kenya, cost (of electricity and productive equipment) and access to finance were identified as the most influential factors in their decision to take up and make productive use of available access, whereas in India these are (with the single exception of up-front costs for households) apparently less important.

In relation to provision, Kenyan stakeholders highlighted the high capital and ongoing running costs resulting from relatively large distances between households in rural areas and the need to engineer off-grid (mini-grid) systems to provide reliable supplies, with power storage and/or back-up being needed for renewable energy plants (solar and wind). In the northern parts of Kenya in particular, not only are population densities low but many are also nomadic. This was identified by a bilateral donor as a major complication (and economic factor) making it difficult to provide electricity.

The high capital and operational costs of off-grid electricity provision act as disincentives both to the provider (who fears that prices may come under regulatory and/or market pressure and that costs may not therefore be recoverable) and to users. In this context, off-grid providers saw regulatory pressure to charge below-cost-recovery tariffs (see Section 9.2.1) and implicit competition with grid access (which may be more expensive to provide for the specific community, but which benefits from both explicit subsidies and the cross-subsidisation inherent in grid systems so that charges to users are lower) as barriers to provision. From the users' perspective, those involved in extension of the grid to Kola in Machakos County regarded the low “lifeline” tariff (which applies to the first 50 kWh/month consumption) as one of the main factors encouraging the take up and use of electricity. Conversely, the relatively high cost to end users of mini-grid electricity was identified as the main factor discouraging take-up of access and productive use of electricity from the Access:Energy project on Mageta Island.

Greater levels of government support in the form of grants are available for developers of electricity access programmes in India, meaning that the high upfront cost of provision is less of a barrier. Indian stakeholders rather highlighted the challenging economics of off-grid electrification on an operational basis, with little or no support given after construction has been completed and a more severe discrepancy between rural on- and off-grid tariffs resulting from cross-subsidisation of grid electricity. When passed on to end-users through high off-grid tariffs, the ongoing cost of electricity is problematic for the poorest users, although stakeholders were optimistic that the current downwards trend in the cost of off-grid electricity provision will extend into the future.

Access to credit can ease income constraints as shown by evidence that bank proximity leads to more investment in motorised pumps and grain mills (Barnes and Binswanger, 1986). This is one reason why the financial position of existing businesses is seen as a key enabler and why areas which are more economically developed are found to gain greater benefits from electricity access. However, while the ability to secure funding for investment is critical to the productive use of electricity, it will not be sufficient to allow enterprises and incomes to grow if the underlying cost of the electricity is such that it does not enable them to compete in accessing wider markets, as discussed in Section 9.2.1.

Suitable credit facilities are also seen as vital enablers of both provision and productive use of electricity in Kenya. Developers saw lack of access to credit and the high rates charged by commercial banks as limiting private sector expansion of electricity access projects/ programmes and also suggested that inability to access finance restricts local communities' involvement in projects and their ability to take up and make productive use of electricity access. It was noted that availability of loan facilities from Kenya Power encouraged take up of electricity from the grid, but similar facilities are not available for off-grid projects.

For small enterprises in India, credit may be easier to come by thanks to initiatives such as the Credit Guarantee Scheme (CGS) for Medium and Small Enterprises which offer credit with relaxed guarantee requirements. However, for many rural enterprises, access to credit still remains a significant barrier to investment in electricity access and the equipment needed to use electricity productively.

9.2.5. Knowledge, Skills and Capabilities

The possession of appropriate skills and capabilities is a vital factor in securing benefits across the causal chain between electricity access and poverty reduction.

In the first instance, low skill levels and capacity act as a barrier to local people securing economic benefits through involvement in electricity provision, as entrepreneurs selling or leasing pico-PV devices or through employment by mini-grid enterprises. Watson et al (2012), for instance, identify low technical capacity to adequately maintain and operate energy systems, in particular low skill levels and knowledge amongst end users and local technicians in the case of off-grid solutions, as one of the major barriers to increased use of modern energy services among the world's poorest people. Stakeholders interviewed in Kenya as part of the current study noted that local communities are often unable to benefit from the income-generating potential of off-grid electricity systems. In areas where off-grid power plants have been set up, the community's limited technical and financial capacity restricts their involvement in the project. Operation and maintenance jobs that could be done by local people are sourced elsewhere because the skills do not exist locally.

Knowledge of the benefits and possible productive uses of electricity is also a key factor in the take up of electricity access, and potential users need not only to be aware of how electricity can be used but also have the skills to operate and maintain electrical machinery. As Pueyo et al (2013) note, if businesses and individuals have insufficient knowledge about what for and how to operate electrical equipment this will act as a barrier to take up and use, and it will also constrain the employment of those who have more time available as a result of electricity access. In Kenya, government and donor agencies, project implementers, research institutions and academia consulted as part of the current study expressed the view that one reason for the limited take up of electricity for productive uses in many areas is low awareness of potential income generating activities and lack of training and knowhow about the kind of activities that could profitably make use of available electricity. This also ranked high in the factors identified by users in both Kenya and India as influencing their decisions whether to take up and use electricity access productively.

In India, the stakeholders consulted were more concerned about the lack of vocational skills among rural communities, which is as much of a 'missing piece of the puzzle' as the lack of electricity access. The uptake of new electricity-enabled income generating activities in poor rural communities can only take place if people also possess the skills that go alongside those activities.

Finally, there is a need for entrepreneurial skills to identify new opportunities created by electricity access, create new enterprises and find and access markets for the new products and services provided. This is one of the reasons why the evidence indicates that areas which are more economically developed, with a pool of skilled entrepreneurs capable of innovating and reaching new markets, are most likely to use electricity for income generation.

Without this full range of knowledge and skills, communities where electricity access is made available are unlikely to be able to secure the benefits of productive use of this electricity.

9.2.6. Access to Markets & Employment

Demand for the products and services provided using electricity is one of the most widely identified factors affecting both productive use of electricity and the impact of such use on economic activity and poverty. Evidence from the literature shows that areas most likely to use electricity for income generation are those with a significant and growing local market with demand for non-basic goods or with the proximity, infrastructure, communications links and skills needed to access external markets. As an example, those involved in the extension of the grid to Kola in Machakos

County, Kenya saw ready access to markets in the area as a factor in enabling economic use of electricity and a facilitator of benefits achieved by individuals.

In the absence of such access to markets, demand in rural areas is often constrained and unable to absorb additional production, leading to market saturation with new and newly electrified enterprises simply competing with existing and un-electrified firms for the same overall “pool” of value. This is reflected in Kooijman van Dijk and Clancy’s (2010) finding of very small changes in incomes to entrepreneurs and reduced profits per enterprise due to market saturation, and a later study by the same author which showed impacts of rural electricity supply on poverty reduction in terms of income generation in India to be small for the typical rural entrepreneur who owns a small scale enterprise targeting the local market (Kooijman van Dijk, 2012). Similarly while Peters et al (2011), found that electricity-reliant firms created after electrification, which use more electric appliances and have better market access because they offer new products to final consumers and intermediate products to other enterprises, prospered they found no positive impacts of electrification for firms created before grid access. They attribute this to crowding out effects among competing traditional manufacturers, with job losses and decreased profits, and the drain on existing businesses as local consumers’ purchasing power is diverted to new electricity-reliant manufacturers.

There are parallels in the effects of electricity access for households and individuals. Electricity can increase the productivity of unpaid household work and enable longer income-generating working hours, increasing (mostly female) labour supply and potentially leading to more employment and improved incomes. As discussed under Section 6.2.2, a shift in time use (for women in particular) is the most strongly reported impact of access to electricity in the literature, and this effect was also reported anecdotally for some of the programmes looked at as part of this study. However the survey data did not bear this out, finding similar or higher levels of employment, and higher increases in employment, amongst those who had not benefitted from improved household electricity access than those who had. This is consistent with the literature which indicates that the consequences of freeing time for productive activities have been mixed and often gendered.

Here again the effects of constraints on access to markets can be detected. Time freed up by electrification can only be used for productive activities if suitable employment options are available. If the local employment market cannot absorb the additional labour made available by electrification people will not, whatever their wishes, be able to use this time on income-earning activities. Developing countries often have a large labour surplus and therefore an increase in labour supply is not likely to directly increase employment though the literature reviewed seems to indicate some increase in casual and self-employment, which is not subject to the same constraints as formal employment (van de Walle et al, 2013). Women may gain the most time from electricity access, but they also suffer greater constraints on access to employment markets both for social reasons and because the demands of their reproductive roles and unpaid care work still tend to confine them to the home or the immediate neighbourhood, and hence are less likely to be able to make use of this time to gain paid employment. In the absence of access to wider markets, additional available labour is likely to simply drive down wages and the prices of goods and services produced informally are also likely to fall. Thus even those able to use additional time productively may well not see any increase in incomes.

Unless new value can be brought into the electrified area by selling products outside the area (or at least by providing products and services which were previously sourced from outside the area) and thereby generating increased revenues and employment, the overall economic benefit to the community will be limited to any savings achieved by replacing relatively expensive forms of energy previously used with more economical electricity access.

9.2.7. Pre-existing Industry

The evidence in relation to the need for pre-existing industry to make use of, and hence benefit from, electricity access is less definitive. A number of studies covered in the literature review identify such industry as a prerequisite for achieving economic benefits from electricity access, particularly higher levels of access. It is argued that in the presence of pre-existing productive activities, local industry and agricultural businesses can provide a significant, relatively steady initial demand for electricity and contribute to an important share of its initial costs, thus making access provision more economic and affordable. Established enterprises are also more likely to be able to finance electricity access and investment in productive equipment, and can provide a pool of the entrepreneurial and technical skills needed to take advantage of electricity availability. Such enterprises may also be better-positioned to move to the scale of production which it is argued Peters et al (2011) is needed to make investments in electricity and electricity-using machinery economic.

However, there is also some contrary evidence. Peters et al (2011) found that electricity-reliant firms created after electrification performed better than pre-electrification firms, with no positive impacts of electrification for pre-existing firms and profits from (pre-existing) connected firms in the access region being lower than their matched counterparts in the non-access region (though the difference was not significantly different from zero). The same author also found crowding out effects among competing traditional manufacturers, with job losses and decreased profits.

In the research undertaken for this present study, stakeholders in India highlighted the advantages offered by the presence of pre-existing industry when considering provision of electricity access. Pre-existing enterprises and productive activities do not face such severe challenges as newly-initiated activities in terms of training and skills development, market linkages and access to finance; hence they do not require the same level of support effort from the programme developer or assistance provider. The importance of pre-existing industry was not flagged as an issue by stakeholders in Kenya. This may reflect a greater focus by the Kenyan stakeholders on smaller off-grid communities and lower levels of access for which pre-existing industry may be less relevant.

Overall it would appear to be that the pre-existence of enterprises with the capacity to take advantage of electricity access should facilitate benefits from that access, but that in the absence of the other conditions (in particular access to markets) needed to support increased overall production and sales, there may be no overall net benefit, with existing firms simply being out-competed by new enterprises, and non-electrified businesses being crowded out.

9.2.8. Infrastructure & Security

Weak transport and telecommunication infrastructure links are one of the most widely reported constraints to achieving the poverty reduction and income generation potential of electricity in the literature, with infrastructure inadequacies often seen as limiting access to markets.

The need for infrastructure to support productive use of electricity access was highlighted in the Kenyan context by the cases of the CAFOD Community Solar PV Project, Kajiado, where lack of a proper road network was flagged as a factor constraining uptake and productive use of electricity, and the grid extension to Kola in Machakos Country, where strong communication links were seen as one of the enablers for economic growth from the project.

Stakeholders in Kenya also identified poor infrastructure as an obstacle to provision of electricity making transport (particularly of sensitive equipment) difficult and expensive. Security, too, was regarded as an issue in some remote areas of Kenya with arrangements needing to be made to protect both generating plants themselves and for transport of fuels and equipment. Cases of vehicles being stuck and people hired to secure the equipment for extended periods were reported. This increases costs and is believed to have limited the development of projects in remote areas.

Many of the stakeholders consulted in India felt that lack of infrastructure was the biggest hurdle facing the use of electricity access for productive purposes. When basic facilities like roads, transport and communication are missing, people may not be able to access electricity nor the technology needed to make use of it, and enterprises may struggle to obtain the inputs they need (raw materials, information) or reach buyers for their goods or services.

9.2.9. Access to Other Resources

The existing literature does not, in general, identify access to resources (other than finance and skilled human resources) as a constraint on productive use of electricity. However the effects of lack of such access were clearly illustrated during the current study by the case of the Access:Energy mini-grid project on Mageta Island in Kenya where, despite improved electricity access, enterprise revenues and profits and household incomes were found to have fallen under increasing pressure on resources. Mageta Island is an area dependent on fishing where fish stocks are coming under pressure and residents report having to travel further to catch fish, with the area where they can fish being limited by the border with Uganda, and fishing bans being increasingly imposed in order to conserve stocks. In this situation there appears to have been if anything a negative relationship between increase in electricity access and changes in enterprise revenues and profits (possibly because enterprises have made decisions to secure electricity access which they have then been unable to use productively in the face of falling fish stocks and community prosperity).

9.3. Integrated Development Programmes

Given the wide recognition in the literature of the need for electricity access to be accompanied by other enabling factors if the potential for productive use and poverty reduction are to be realized, it is unsurprising that a number of authors recommend the combination of electricity access programmes with wider rural-development programs incorporating, for example:

- Improvements to roads and other transport and communication links
- Capacity building and training in relevant productive skills
- Awareness raising regarding potential productive uses of electricity and their benefits
- Business support services and facilitation of market systems development
- Financial services and access to credit for electricity connection and to purchase productive electrical equipment

The PRODUSE Manual (Bruderle et al, 2011), in particular, provides guidance on designing and implementing activities that complement electrification projects and promoting productive uses.

It is also suggested that integration of electricity access and market creation and other development policies is required at national level as well, with consideration being given, for instance, to the compatibility of programs to provide electricity to rural communities with policies that strengthen agricultural value chains and trade policies that facilitate access to external markets and prevent flooding of local markets with subsidised imported crops.

While there is a consensus on the rationale for integrating electricity access and other development programmes, studies that look at the impact of such integration are rare. One example is Kirubi's 2009 study of a community-based mini-grid in Kenya which in spite of its high unreliability was found to have delivered significant positive impacts on income levels of the community. This was attributed to the combination of the mini-grid's construction with the facilitation of access to markets and provision of roads, schools, markets and business services, including facilitating access to credit fund and providing training on product design and marketing, book keeping and self-organising.

The current study looked at two cases in Kenya where electricity access was being provided as part of a wider development initiative:

- The Ikisaya Energy Centre (Solar Transitions project) not only recharges lanterns, phones etc., but also provides printing and photocopying services and a communications centre through which community members can access employment opportunities and keep in touch with wider political, economic and social events.
- The CAFOD Community Solar PV Project included energy access for schools and health centres, and eight community-based ICT centres, and alongside the solar water pumping systems which this study looked at most closely support was also provided to women youth groups to set up businesses based around greenhouse horticulture.

(None of the case studies in India embedded electricity access within a wider initiative.)

It is not possible to draw any firm conclusions from just these two cases, but initial impressions are that in the case of the Solar Transitions Energy Centre the level and form of electricity access was insufficient to support productive activities, and the linked development initiatives were not specifically targeted at overcoming barriers to productive uses and that the economic impact of the project has been limited (though community members report non-economic benefits). The improved electricity access provided to micro-enterprises through the CAFOD Community Solar PV Project would appear to have had some effect in supporting growth of productive use and economic activity, but it is impossible to judge to what extent this relates to the type of electricity access provision, and to what it extent it is a result of linkage to wider capacity building, business support and assistance with accessing markets.

10. Conclusions

Neither the literature review nor the field research undertaken for this study demonstrate a clear, unambiguous, relationship between level of electricity access and poverty reduction. Instead, our research has reinforced messages from the literature regarding the importance of combining electricity access with other enabling factors (such as access to skills, markets and finance) if poverty reduction impacts are to be achieved.

While there is some evidence of positive relationships between level of electricity access and increases in enterprise revenues, profits and employment, it has not been possible to identify any relationship between level of access and poverty reduction. The three programmes studied where we saw the greatest increases in household income included both grid extension programmes, but also one of the solar lantern programmes.

We conclude that electricity solutions which provide relatively low-level access may offer the greatest value in terms of poverty impact, but above all that electricity access provision should be matched to the particular needs of communities and linked to access to markets skills and finance. Our full conclusions from the study are set out below.

10.1. Impacts of Electricity Access

Most literature agrees that electricity access is necessary for poverty reduction, primarily through:

- improved productivity or output of enterprises using electricity for their activities; and/or
- freeing up time for paid work, which would increase labour supply.

However, the relationships between electricity access, productive uses and poverty outcomes identified in the literature are not straightforward, pointing at high country- and context-specificity of impacts[45]. Even though productive uses of electricity are seen as having the highest potential to reduce poverty, robust evidence is scarce as regards impacts of electricity on the creation of enterprises or the improved performance of existing ones[46]. Similarly, the consistency and strength with which poverty impacts of increased electricity use were reported varies, with employment, time allocation and education outcomes more persuasively reported than total hours of paid work and health.

One possibility, which formed a central focus of this current study, has been that different levels of electricity access provide different outcomes, but that the bulk of the literature, in treating electricity access as a binary and ignoring the potentially differential impacts of different levels of access, has drawn disparate conclusions.

[45] Attigah and Mayer-Tasch (2013)

[46] Pueyo et al (2013)

However, even when estimates of the level of electricity access[47] being considered had (where possible) been assigned to the various studies covered in the literature review, a coherent relationship between different levels of access to electricity, its productive use and poverty reduction (defined in income terms) could not be proved.

The field research undertaken as part of this study has allowed direct examination of relationships between level of electricity access, productive use and poverty impacts, using primary data derived from surveys of households and enterprises in communities included[48] in eight electricity access programmes in Kenya and India. This detailed research similarly failed to reveal a consistent relationship between levels of electricity access and its impacts in terms of either productive activity or poverty reduction, thus supporting the conclusion from the literature review that - even accounting for different levels of access - any relationship is not straightforward[49].

Productive Use Impacts

The strongest evidence provided by the field research for the impacts of productive uses of electricity relates to employment, creation of new enterprises and enterprise financial performance (revenues and profits). However, whilst some relationships appear to exist, other related factors that might be expected to behave similarly do not display relationships at all. In addition, findings are frequently inconsistent between the two countries, and between programmes and communities within each country. Specific potential impacts identified through the literature review and further explored through the field research are discussed below.

Creation of Enterprises **-** The bulk of the literature finds that electricity access enables enterprise creation. Our research in India appeared to support this finding, with 3 times as many enterprises being created in those communities which had benefitted from improved electricity access. (Only half of the new enterprises in the beneficiary communities were themselves receivers of improved electricity access suggesting that the any relationship may be indirect rather than direct.) In Kenya, however, no difference in the level of enterprise creation between beneficiary and non-beneficiary communities was apparent. No patterns were found in either country when comparing the level of electricity access for productive use provided under each programme and the proportion of beneficiary enterprises created post-programme.

Employment and Time Use – The literature strongly, though not unanimously, reports increased employment, particularly amongst women, as a result of shifts in time enabled by electricity access. Our research did not bear this out, finding similar or higher levels of employment, and higher increases in employment, particularly amongst women, for those who had <u>not</u> benefitted from improved household

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[47] Against the six tiers of access defined by the Global Tracking Framework

[48] In each case a beneficiary and non-beneficiary community pair were surveyed

[49] In reaching this conclusion it is recognised that limitations on data collection, and the narrow range of electricity access levels found across the programmes mean that relationships could exist which have not been revealed

electricity access than those who had. In the literature, more of the papers indicating higher, rather than lower, levels of access report increased employment as an impact and our research also indicated a possible positive relationship between level of electricity access for productive use and increases in employment.

Enterprise Revenue and Profit - Most studies in the literature find that changes in income and profits following electrification are small (and in some cases negative), suggesting that electrification is a necessary but not sufficient condition for enterprise success. The findings of our research bore this out, with very different impacts in the two countries and between different programmes. In India both average current revenues and change in revenues were similar between beneficiary and non-beneficiary enterprises, while in Kenya the surveyed beneficiary enterprises enjoyed revenues that were on average more than twice those of non-beneficiary enterprises and average increases in revenues were also higher for beneficiaries. In both countries, beneficiary enterprise average profits are 20 – 25% higher than those of non-beneficiary enterprises, but there is no consistent pattern in the increases in profits since programme implementation between those enterprises who had received electricity access and those who had not. If only those enterprises which have received improved access are considered, there appears to be a loose positive relationship between average increase in electricity access tier and average increases in revenue and profits. However, it is the Lighting a Billion Lives solar lantern programme in India which appears to have had the greatest impact on enterprise financial performance, despite the relatively low level of electricity access it provides - apparently because the local fishing community were able to make use of the additional working hours made possible by solar lanterns to increase activities (such as mending fishing nets) for which there was a ready market.

Poverty Impacts

The literature is inconsistent as regards the household income generation and poverty reduction potential of electricity, with some studies reporting positive impacts while others (which tend to be of higher quality) report minimal or non-existent impacts. The literature tends to report increases in expenditure as a result of improved electricity access. Depending on the context, this may be seen as a good thing (e.g. an increase in purchasing power) or a bad thing (increased pressure on household finances).The literature reports divergent impacts in this respect, with some authors reporting incomes increasing more than expenditure and others reporting the opposite.

Across the samples surveyed both average household income and increases in household income were significantly higher for beneficiary households compared with non-beneficiary households. Because of the narrow range of levels of electricity access levels across the programmes it is not possible to determine whether any relationship exists between the average access tier provided by a programme and the household income of its beneficiaries. While some of the programmes display convincing correlation between household electricity access level and household income, amongst other programmes the relationship is less clear, and sometimes the data even points towards a relationship that is contradictory to expectations.

Electricity access seems to have had a significant positive impact on the quality of education available to children of households surveyed during the field research, especially in India. Positive impacts in terms of healthcare appear to have been less widespread, although survey respondents widely agree that those improvements that have taken place can be attributed at least in part to improved electricity access.

Overall

Neither the literature review nor the field research components of this study have demonstrated a decisive link between the level of electricity access achieved by households and enterprises and productive use or poverty indicators. Instead, the sometimes contradictory and counter-intuitive findings affirm that the mechanisms by which electricity access enables poverty reduction are numerous and complex and are influenced by many other factors beyond electricity access. The observation that the impacts felt by notionally similar communities supplied by similar electricity access technologies vary so significantly between India and Kenya is evidence for this complexity and the part that is played by various enabling and constraining factors.

10.2. Value for Money

From the evidence of the case studies examined in this study, it would appear to be the lower level, off-grid, electricity access solutions which provide the greater value for money in terms of both access tier achieved and increase in beneficiary household incomes.

10.3. Enabling / Constraining Factors

Most authors agree that electricity is a necessary but not sufficient condition for increased income generation and poverty reduction. The literature on impacts of electrification programmes is inconclusive and the prevailing consensus is that impacts are highly country- and context-specific, being dependent not only on the level of access provided but also on pre-existing conditions in the areas to be electrified and on a number of other factors.

The research carried out as part of this study has served to confirm that variability and inconsistencies in the observed impacts of electricity access provision are not simply an effect of the different levels of access provided, but that even accounting for such differences, the socio-economic context and presence (or absence) of a number of critical enabling factors (or barriers) strongly affect the extent to which looked for benefits of electricity can be achieved.

The factors most strongly reported in the literature reviewed are:

- sufficiency, duration, reliability and quality of electricity access
- access to finance and resources
- knowledge and skills
- access to markets (including employment markets);

- pre-existing industry.

To these the policy/regulatory reviews, stakeholder discussions and field research carried out as part of this study would add:

- appropriate (off-grid) policy and regulatory provisions
- community engagement
- infrastructure and security

Policy and regulation – It is generally accepted that a clear, transparent and equitable regulatory environment is a prerequisite for effective provision and take-up of electricity access. In India and Kenya stakeholders saw lack of policy focus on provision of electricity for productive use (relative to basic household provision) and on off-grid access as a barrier. Much of this concern centred on arrangements for tariff-setting and subsidisation of electricity access. In Kenya mini-grid developers felt they were prevented from charging full cost-recovery tariffs and in both countries it was considered that subsidy arrangements do not adequately reflect the high costs of electricity provision in remote rural areas or sufficiently recognise the cross-subsidisation effects implicit in a grid system, whereby urban customers subsidize those living in remote areas. In India explicit subsidies provided to grid-supplied customers were seen as a barrier, leaving enterprises using off-grid electricity competing at a disadvantage to nearby grid-supplied communities.

Unwieldy and bureaucratic licensing processes (noted by stakeholders in Kenya) form a barrier to development of smaller-scale projects and to growth of productive uses, while lack of information on future extension of the grid system and lack of regulatory provision in the event the national grid extends into an area where a mini-grid has been established also acts as a disincentive to mini-grid development.

Community Engagement – Community engagement is recognised as a vital requirement for success of off-grid projects, helping communities to feel ownership and responsibility for a community asset, and facilitating financing of electricity access projects on a community basis. However, the need for community-specific engagement, and the time and costs involved can (as in Kenya) as create a barrier to scale-up and replication of electricity access projects nationally.

Supply and Equipment Quality – Poor performance of grid, off-grid and standalone systems is widely reported in the literature as one of the main barriers to productive use of electricity. In the context of this study this has largely been covered through the assessment of the levels of access provided for each of the programmes studied. In line with the literature, access levels were found to be well below those which might have been expected due to issues with capacity, availability, reliability and quality. Users, particularly enterprises, also reported these issues as prominent factors in their decisions on take up and use of electricity. While availability and quality of electrical appliances which can be put to productive use might also be expected to factor, this does not represent a major theme in the literature and was not an issue raised by stakeholders or users in Kenya or India.

Costs and Access to Finance – Cost and access to finance, both for electricity itself and for the wiring and equipment needed to use it productively, are strongly identified in the literature as factors driving (or preventing) its take up and use. This view was echoed by stakeholders and users, particularly in Kenya. In relation to provision, Kenyan stakeholders highlighted the high capital and ongoing running costs resulting from relatively large distances between households in rural areas and the need to engineer off-grid (mini-grid) systems to provide reliable supplies, while users identified costs in general and the relative costs of grid and off-grid electricity as key factors in their decisions. This is seen in both countries as being exacerbated by inequitable support regimes which favour grid over off-grid supply and fail to counterbalance the inbuilt cross-subsidy between urban and rural areas inherent in grid systems, with the effect that smaller off-grid communities are competing on unequal terms with nearby grid-supplied communities. Suitable credit facilities are seen as vital enablers of both provision and productive use of electricity in Kenya. In India credit is more easily available to small enterprises, but it remains a significant barrier to investment in electricity access and particularly the equipment needed to use electricity productively.

Knowledge & Skills **-** The possession of appropriate skills and capabilities is vital to securing benefits across the causal chain between electricity access and poverty reduction. Low skill levels and capacity act as a barrier to local people securing economic benefits through involvement in electricity provision. Knowledge of the benefits and possible productive uses of electricity is also a key factor in the take up of electricity access, and potential users need to be aware of how electricity and also have the skills to operate and maintain electrical machinery. In Kenya, one reason given for the limited take up of electricity for productive uses in many areas is low awareness of potential income generating activities that can use electricity, and in both India and Kenya lack of vocational skills among rural communities is seen as critical. The uptake of new electricity-enabled income generating activities in poor rural communities can only take place if people also possess the skills that go alongside those activities. Finally, there is a need for entrepreneurial skills to identify new opportunities created by electricity access, create new enterprises and find and access markets for the new products and services provided. Without this full range of knowledge and skills, communities where electricity access is made available are unlikely to be able to secure the benefits of productive use of this electricity.

Access to markets **-** Demand for the products and services provided with electricity is one of the most widely identified factors affecting both productive use of electricity and the impact of such use on economic activity and poverty. This consensus in the literature was echoed by the views of stakeholders in India and Kenya. In the absence of adequate access to markets, demand in rural areas is often constrained and unable to absorb additional production, leading to market saturation with new and newly electrified enterprises simply competing with existing and un-electrified firms for the same overall “pool” of value. Employment markets can, in many ways, be seen as a special case of this effect. Time freed up by electrification can only be used for productive activities if suitable employment is available. If the local employment market cannot absorb the additional labour made available by electrification people will not, whatever their wishes, be able to use this time on income-earning activities. In the absence of access to wider markets, additional available labour is likely to simply drive down wages and the prices of goods and services produced informally are also likely to fall. Thus even those able to use additional time productively may well not see any increase in incomes. Unless new value can be brought into the electrified area by selling products the overall economic benefit to the community will be limited to any savings achieved by replacing relatively expensive forms of energy previously used with more economical electricity access.

Pre-existing Industry **-** A number of studies identify pre-existing industry as a prerequisite for achieving economic benefits from electricity access, particularly higher levels of access. However, there is also some contrary evidence, with pre-existing firms performing poorly and being out-competed by firms created after electrification (Peters et al, 2011). In this present study, stakeholders in India highlighted the advantages offered by the presence of pre-existing industry but it was not flagged as an issue by stakeholders in Kenya. Overall it seems likely that pre-existing enterprises may provide a pool of skills finance and other resources needed to secure benefits from electricity access, but that this may be a community effect rather than advantaging individual enterprises. Furthermore, the importance of the presence of pre-existing industry and productive uses will depend very much on the context. In the absence of the other conditions (in particular access to markets) needed to support increased overall production and sales, there may be no overall net benefit, with existing firms simply being out-competed by new enterprises, and non-electrified businesses being crowded out.

Infrastructure & Security **-** Weak transport and telecommunication infrastructure links are one of the most widely reported constraints to achieving the poverty reduction and income generation potential of electricity in the literature, with infrastructure inadequacies often seen as limiting access to markets. In both Kenya and India stakeholders saw lack of adequate infrastructure as one of the biggest hurdles facing the use of electricity access for productive purposes and in Kenya lack of security was also highlighted as an obstacle to energy access provision, though no specific quantitative data was gathered to support this view.

Other Resources **–** The need for access to resources other than finance and skills to support productive use of electricity access has not been the focus of great attention in the literature. However, one of the cases considered as part of this study (the Access:Energy mini-grid project on Mageta Island in Kenya) provides a vivid illustration - despite improved electricity access, enterprise revenues and profits and household incomes were found to have fallen under increasing pressure on resources.

11. Recommendations to Policy Makers and Programme Developers

While there is widespread acceptance of the need for electricity to support productive uses (and contribute to poverty reduction), in practice policies, support and the majority of programmes continue to focus on providing the minimal levels of access needed for household lighting and small appliances. Priority must be placed on electricity access for productive use alongside basic household access.

Improvements in levels of electricity access are central to economic and social development, but the context in which electricity is provided is equally important. The different experiences of communities we have looked at demonstrate how vital it is that programme developers consider the context in communities they are seeking to serve – what productive activities already take place, what opportunities and resources exist to expand these activities, and where markets for products and services will be found - and seek to align electricity access provision with this context. One size does not fit all!

Levels of electricity access provided should be matched to potential productive uses. Even lighting-only programmes can impact on poverty (as we saw in the Lighting a Billion Lives Programme in India) if other factors are available for a product which can be made simply by extending working hours. However, income-generating activities that only require electricity for lighting are limited and often low value-adding. Enterprises that need energy for motive uses (pumping, refrigeration, milling, etc.) require power inputs at a higher level than many off-grid programmes typically provide. In the extreme, provision of access which does not recognise the community's social and economic context may fail to bring any benefits and can even act as a burden on the community.

Not only capacity but also hours of supply, unexpected supply interruptions and voltage irregularities can significantly affect the value that enterprises are able to obtain from electricity access. The relative importance of these characteristics depends enormously on likely productive uses, so it is vital that these uses are considered and factored in to the design of access programmes.

This study has reinforced the consensus that electricity for productive use must be combined with other factors to achieve poverty reduction. Electricity access provision should be combined with wider development efforts aimed at tackling the barriers to enterprise development that would otherwise constrain productive use of electricity and hinder poverty reduction - poor infrastructure, inaccessible markets, skills shortages and lack of access to credit and finance:

- To secure benefits of electricity access, people need to be aware of the productive uses to which it can be put. They need to have the technical skills and capabilities to be involved in the provision itself, to operate and maintain electrical equipment and to engage in productive activities using electricity. Alongside technical skills, business capabilities are needed to grow enterprises and access markets.

- If electricity access is to have positive impact, communities must be able to gain access to markets for the goods and services it enables them to produce. This requires both adequate physical infrastructure (roads, communications etc.), and the less tangible market systems links through which goods and services can be traded.

- Access to finance is also needed if developers are to provide electricity and potential users are to take up access and to pay for wiring and equipment – provision of appropriate financial facilities to meet all of these needs should be a priority for both policy makers and programme designers.

Integration of electricity access and market creation policies should take place at the national as well as the programme level. As an example, programmes providing electricity to rural communities dependent on agriculture should be compatible with industrial policies that strengthen the value chain of agricultural products and trade policies that facilitate access to external markets and prevent flooding of the local markets with subsidised imported crops.

As the case studies we have looked at demonstrate, the impacts of electricity access can be significantly gendered. While access can benefit women, relieving their domestic burdens and enabling them to participate in economic activities, there is also evidence that women may be disadvantaged in making productive use of access and there may even be negative impacts in terms of employment and wages. It is therefore vital that policy makers and electricity access programmes consider gendered impacts at the design stage, and incorporate measures to ensure that benefits accrue to both male and female beneficiaries.

Programme Recommendations

1. Programme developers should seek to match access provision with the productive activities, resources and markets available to communities

2. Electricity access provision should be combined with measures to tackle other barriers to enterprise development and poverty reduction such as:
    - Raising awareness of potential productive uses of electricity
    - Building skills and capabilities
    - Improving transport and communications links
    - Developing market systems for goods produced by use of electricity
    - Providing access to finance (for electricity services, wiring and appliances)

3. Potentially gendered impacts of electricity access should be recognised and measures taken to ensure that women benefit and do not suffer negative impacts, particularly in terms of employment and wages.

It is imperative that the duration and reliability of grid electricity supplies for rural enterprises are improved. Policy and regulation can promote investments in generation, load balancing, transmission and distribution and protect rural users from bearing the brunt of grid supply outages. India's policy of installing or retro-fitting separate feeders for agricultural and non-agricultural users is an example of a successful initiative, enabling improved duration of supply to rural households and enterprises.

However, off-grid solutions (including mini-grids) provide the most appropriate and cost effective means of electricity access provision for many smaller and more remote communities and should be prioritised alongside grid extension in national and local policies and plans, with specific, concrete, regulatory provisions made to address their particular characteristics and requirements.

Though they can be the most cost-effective solution for a particular community, the remoteness of many of these communities, relatively large distances between households, initially low demand levels, and the need for power storage and/or back-up generation to ensure reliable access, mean that mini-grids will generally be more costly to both build and operate than grid access provision to larger communities. For this reason, mini-grid operators must be allowed to charge tariffs that make business models viable <u>or</u> be provided with support under Feed in Tariff or similar schemes. Any support schemes should recognise not only the higher capital costs but also the ongoing operational costs faced by those running such schemes.

Many of those living in rural areas subsist on low incomes and some form of financial support may be needed to bring electricity access within their reach. Those connected to a national grid system will benefit from implicit subsidization of their access (through standard national tariffs through which urban dwellers effectively cover some of the additional cost of provision to smaller, scattered communities) and often also explicit subsidies (through life-line tariffs and other support schemes, as seen in both India and Kenya). It is recommended that similar financial support is provided to off-grid electricity access to enable these smaller communities to benefit also. This is particularly important in relation to access for productive uses, since the availability of subsidies (both implicit and explicit) to grid customers when equivalent support is not available to off-grid users, serves to suppress productive use of electricity in off-grid communities, since they will be competing in markets for goods and services with those in larger grid-supplied communities. It should be emphasised that the call is not for an overall increase in levels of subsidy but that financial support to electricity provision should be deployed more strategically and equitably.

Clarity and openness in relation to plans for national grid expansion will reduce risks perceived by mini-grid and other off-grid electricity providers, and so has the potential to increase investment and bring down off-grid electricity costs. Provision should also be made within regulatory frameworks to deal with the position of any previously established mini-grids within an area into which the national grid is extended.

More generally, streamlining and clarity of the consenting process will enable developers and particularly developers of smaller schemes to bring electricity access to more communities more swiftly and economically. This is, of course, an aim of all regulatory authorities, but there it remains an issue flagged by stakeholders in, for instance, Kenya and there may be lessons to be learned for experience in India where regulation does not appear to be an obstacle.

Smooth and straightforward processes for securing connections to both grid and mini-grid systems, and other business requirements (such as business registration) are equally important to support the growth of enterprises able to make productive use of electricity.

Development of “standard” models for community engagement, perhaps with some form of regulatory or government endorsement, which could be adopted by project developers, could reduce what is currently seen by developers (at least in Kenya) as a barrier to scale-up and replication of similar projects on a national scale and so foster private sector provision of mini-grid access.

Finally it is important that policy makers and programme developers work together to avoid creating a proliferation of potentially conflicting programmes and support arrangements which share the same space and can create inefficiencies. Consolidation of different programmes may encourage better focus and allow electricity and productive uses to be more effectively linked.

Policy Recommendations

1. Electricity access for productive use must be prioritised in policies and programmes alongside basic electricity access for households.

2. Policies and plans for electricity access should be linked to those in other areas of livelihood creation and income generation, such as industrial and agricultural development.

3. Policy interventions that tackle barriers faced by rural communities with respect to access to markets, poor infrastructure, resource supply and inadequate skills, should be coordinated with electricity access provision.

4. Livelihood improvements may be achieved through relatively low levels of access, and policy makers should encourage a range of electricity solutions to meet the various needs of different communities. The reliability and availability of grid-supplied electricity access must be improved, but the need for off-grid solutions should also be recognised and specific policy and regulatory measures developed to support them.

5. Mini-grid operators should be permitted to charge tariffs that cover costs and make business models viable while financial support arrangements should be re-balanced to recognise the higher costs faced by off-grid providers and the cross-subsidies inherent in grid systems and so ensure that off-grid communities can compete on equitable terms in markets.

Policy Recommendations

6. Clear, streamlined consent processes will enable developers of smaller schemes to bring electricity access to more communities more swiftly and economically, while smooth and straightforward connection arrangements and general business regulation will foster productive use and enterprise growth.

7. Clear, publicly available plans for grid expansion and regulatory provision for mini-grids in areas into which the grid expands will reduce risks faced by developers and bring down costs.

8. Permitting and licensing procedures should be rationalised and streamlined to minimise barriers faced by off-grid developers.

9. Development of "standard" models for community engagement could reduce a barrier to scale-up and replication of similar projects on a national scale and so foster private sector provision of mini-grid access.

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