

Brief supporting Evidence Report 31

**THE EVIDENCE OF BENEFITS FOR POOR
PEOPLE OF INCREASED RENEWABLE
ELECTRICITY CAPACITY: LITERATURE
REVIEW**

Pro-Poor Electricity Provision

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September 2013

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The material has been funded by UK aid from the UK Government, however the views expressed do not necessarily reflect the UK Government's official policies.

AG Level 2 Output ID: 130

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First published by the Institute of Development Studies in September 2013
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Background

Lack of access to electricity is seen as a major constraint to economic growth and increased welfare in developing countries. The latest update by the IEA (2012) shows that in 2010 nearly 1.3 billion people did not have access to electricity, which is close to one-fifth of the global population. This deficit is due to a combination of political and institutional problems and the economics of expanding grid infrastructure or providing off-grid solutions to remote, poor and sparsely populated areas.

After an intense activity during the 70s and early 80s, electricity provision slipped down the list of priorities for donors and governments, following the World Bank's position. This change in direction was largely due to the disappointing results of many electrification programmes that had delivered low economic returns, low-cost recovery and little evidence of an impact on income generation and poverty eradication. However, since the late 90s until today electrification has come back to the development agenda as a key element of poverty reduction strategies and low-carbon development. Many rural electrification projects use the Millennium Development Goals as their main justification, although often without robust evidence to back it up.

DFID is involved in this renewed interest in electrification as a means to poverty reduction through its participation in the International Climate Fund (ICF) and is particularly interested in maximising the poverty impact of investments in renewable electricity capacity. This review aims at supporting donors' planning of investments in renewable electricity capacity to maximise their impact for the poor. It identifies the evidence that links electricity generation capacity to benefits for the poor, as well as the policy interventions that can maximise this relationship.

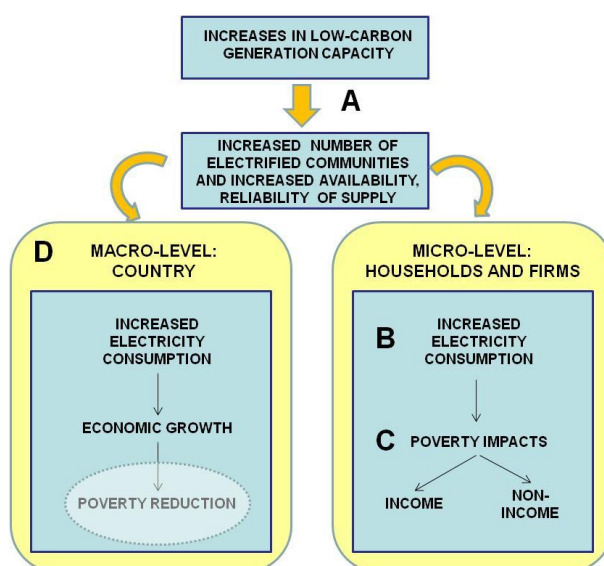
Method

The review begins by elucidating a theory to break down the causal chain between additional renewable electricity generation capacity and poverty impacts in four stages or links, which can be formulated as four research questions:

- a) What is the link between increased renewable electricity capacity and higher availability and reliability of supply?
- b) What is the link between increased availability and reliability of electricity and actual connection and use by the poor?
- c) What is the link between electricity consumption and poverty impacts?
- d) What is the link between electricity consumption and economic growth at the macro level? The causal chain is illustrated in Figure 1.

A structured review, following the realist approach, focused on developing countries and covering academic and grey literature was conducted according to a detailed search protocol including five sets of search terms related to interventions, uses, poverty outcomes, geography and low-carbon technologies. Retrieved publications were systematically reviewed and included in the study according to a detailed set of criteria related to their relevance to the four research questions. Each paper was assessed in terms of the quality of the evidence provided on the basis of explicit quality evaluation criteria. A total of 143 papers were deemed relevant and of sufficient quality to respond to our research questions. Most reviewed literature concentrates on link C of the causal chain, whereas technical literature dealing with link A was particularly thin. The literature was synthesised into a single narrative giving a higher weight to the best quality publications.

Figure 1 Causal chain of poverty impacts of electricity generation capacity



Results

Even though there is a large body of literature analysing links B, C and D of the causal chain, their quality and methodological approach is highly uneven (only 32 per cent of studies are considered as high quality). There are particularly significant gaps in the technical literature on link A of the causal chain and literature on link C that can demonstrate causality from electricity consumption to income-related impacts. The literature has been thoroughly classified according to transparent quality criteria, with the main conclusions derived from high-quality literature, reinforced with evidence presented by moderate and low-quality literature. The main outcomes of the review for each of the links of the causal chain are summarised below:

A. What is the relationship between increased renewable electricity capacity and higher availability and reliability of supply?

The potential additional generation capacity in a grid electricity system to increase the number of electricity consumers, the consumption of existing consumers or to improve the reliability of their supply depends on a number of factors, including:

- The type of low-carbon generation (e.g. intermittent vs. dispatchable)
- The location of the plant in relation to centres of demand
- The layout, capacity and reliability properties of any network which links the new generation project to centres of demand
- The distribution of demand through the day/week/year
- The statistics of available renewable resources at different times of day/week/year
- Changes in the number of consumers, including not only legal network extension but also illegal connections (which are common in developing countries).

Power system reliability analysis in developing countries can predict the expected impact of additional capacity on reliability of supply and final consumption taking these data into account. The literature in international journals and conferences on power system reliability analysis methods specialised to developing countries is very limited. It points at data availability as a main difficulty to undertake power systems analysis in developing countries.

Even if additional renewable generation capacity improves quantity and reliability of electricity supply, this may still not reach the poor. Increases in connection rates can either come from intensification (increase the percentage of electrified population inside electrified communities) or extensification (increase the percentage of population living in electrified communities) strategies. The final impact of these strategies on the poor depends on whether they are mostly located in electrified or unelectrified communities. If extensification strategies are followed, the selection of communities to be provided with increased access usually follows economic imperatives, prioritising the more densely populated, closer to the grid, with a high average community income and productive potential and access to roads. A minority of rural electrification projects have explicitly targeted the most deprived areas or rolled out electrification following geographical balance criteria. Political and institutional barriers also play an important role in determining who gets access to electricity. In some cases, corruption and the behaviour of vested interests, as well as a lack of political will to extending energy services to sparsely populated rural areas are behind low access rates for the poor.

B. What is the relationship between increased availability and reliability of electricity and actual connection and use by the poor?

Evidence shows 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.

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. Electricity tariffs are less frequently reported as a barrier to initial connection and increased use. Electricity is price inelastic, even if the own price elasticity is consistently negative and significant, as expected. Besides, several papers find good evidence of willingness to pay for an improved service, suggesting that heavily subsidised tariffs that make utilities unviable are often unnecessary. Evidence also suggests that subsidised tariffs often benefit the better off, who are able to connect and purchase appliances, therefore perverting public service solidarity mechanisms.

The quality and reliability of supply and the capacity of the utility to cope with subscription applications are also widely and consistently reported factors facilitating increased connection rates and use. 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 could face high costs as a result of voltage drops or blackouts. Bad quality of service is often linked to the financial weakness of utilities or managing cooperatives caused by unsustainable subsidised tariffs or poor management. In the case of SHS it is often due to poor maintenance of the systems, due to lack of training or to maintenance not being a priority in electrification programmes.

Lack of productive uses is frequently reported as the reason for low electricity consumption. Electricity is still mainly used for lighting, which is concentrated in a few hours of the early evening, instead of productive uses more evenly spread throughout the day. On one side, this jeopardises the financial sustainability of electrification projects and on another side it limits the income generation effect expected.

Behavioural barriers are less frequently reported by the literature and are mostly included in qualitative research. These include the lack of control over monthly electricity bills, as opposed to kerosene, where households can pay as they consume

and quickly react to price changes. Often households want to avoid large monthly bills and consume less than their optimal amount. In some other cases, lack of understanding of flat tariffs makes them consume less than what they are actually paying for. Other behavioural barriers refer to insufficient knowledge about the usage and operation of electrical equipment in businesses and households and about the economic and productive benefits of electricity, as well as deeply engrained habits of using specific energy sources for cooking and lighting. As a result, poor households tend to keep on using traditional sources of energy such as firewood, kerosene and candles after they have been connected to the grid.

C. What is the relationship between electricity consumption and poverty impacts?

The benefits of electricity for the poor depend on how much and what for it is used. Direct and short-term non-income benefits for households are more strongly and consistently reported than income-related outcomes that depend not only on electricity but also on a number of factors jointly enabling its productive use. A compilation of quantitative estimates of several income and non-income impacts of electricity for households is provided in the main text.

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. This impact is caused by an increase in household productivity through the use of electricity, which releases female time from domestic tasks such as collecting fuel, fetching water and cooking, to market work and also to education and entertainment. There is also robust evidence of positive impacts for women's empowerment, understood as their participation in household decisions, independence and intolerance of male abuse. Men's employment does not consistently increase.

Improvements in education are widely and consistently reported, with homogeneous measurements, mainly: years of schooling completed, study time and school enrolment. Impacts are generally higher for girls than boys, probably as they need to perform less household tasks with the introduction of electricity.

Evidence is weak regarding health and environmental improvements facilitated by the use of electricity.

Evidence shows that richer households benefit more than poorer ones from the use of electricity. This is explained because electrification benefits happen through multiple channels and poorer households can only benefit from lighting, while richer households can use more diverse energy services.

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. Rural electrification projects on their own rarely deliver income generation activities because lighting and TV are the most widespread uses. Most authors agree that electricity is a necessary but not sufficient condition for income generation and poverty reduction. The pre-existing conditions in the area to be electrified play a big role in the number and magnitude of positive impacts to be expected. Areas most likely to benefit are those more economically developed, with access to new markets or a large local purchasing market, a solid pre-existing industry, access to resources and skilled entrepreneurs capable of innovating and reaching new markets. Additionally, businesses not only need access to electricity to improve their performance, but a sufficient and reliable service. Where these preconditions do not exist, integrated development programmes should address the existing gaps through, for example, improved roads and telecommunications, access to credit to purchase

end-use technologies, business services, training programmes and professional support for enterprise creation, business promotion and development, demonstration projects of the use of electricity appliances for irrigation and for industries, and technical assistance in converting enterprises to electricity.

Some authors have estimated the monetary benefits of electricity consumption on the basis of willingness to pay for the services it provides and cost of labour for the time it saves in domestic tasks. The World Bank (2008b) in particular has estimated benefits that would allow to break even supply costs within one to three years, hence justifying investments in rural electrification. However, this justification is provided with the caveat that estimated benefits are not cashable and hence do not contribute to the user's ability to repay connection costs.

D. What is the relationship between electricity consumption and economic growth at the macro level?

The empirical literature about the relationship between electricity consumption and economic growth has focused on two main related questions. A large number of studies analyse the direction of causality between economic growth and electricity consumption. A smaller number of studies measure the size of the potential impact of electrification on economic growth, based on the assumption that causality runs from electricity consumption to economic growth.

Four possible hypotheses on causality are found in the literature:

1. No causality or '*neutrality hypothesis*': The analysis cannot find causality in any direction between economic growth and electricity consumption
2. Causality from economic growth to electricity consumption or '*conservation hypothesis*'
3. Causality from electricity consumption and economic growth or '*growth hypothesis*'
4. Bidirectional causality or '*feedback hypothesis*', economic growth leads to electricity consumption and vice versa.

The finding of the report is that the evidence regarding the causal direction is extremely mixed. Most studies suggest that there is some causality; only around 14 per cent of estimates support no causality or '*neutrality hypothesis*'. However, the direction of causality is less clear. Around one third of estimates support the '*growth hypothesis*' where electricity consumption increases growth. Around 53 per cent of observations suggest other types of causality; bidirectional causality (30.38 per cent) or causality running from economic growth to electricity consumption (22.78 per cent). This heterogeneity of outcomes is not only explained by the country of study but also by the study design, including variable definitions, sample period or methodology used.

We look also at the size of the impact of electricity consumption on growth for those studies that estimate or assume a direct causality, and that report elasticities that can be compared across studies. The random effects estimate of the overall effect is positive and statistically significant, suggesting that a 1 per cent increase on electricity consumption leads to an increase of 0.17 per cent of the GDP. This is a substantial effect, however, subject to the caveat about the direction of causality.

Overall and looking at the reviewed evidence, the answer to the link between electricity consumption and economic growth remains largely inconclusive.

Policy implications

Policies to increase the quantity and reliability of electricity available for final users as a result of increased renewable generation capacity

Our review of the technical evidence of impacts on final consumption of increased renewable generation capacity in developing countries was rather limited. However, some relevant recommendations for the design of policies to increase access for the poor point at the need to consider the host country's electricity systems as a whole when planning investments in on-grid renewable energy capacity, as these will not have a significant impact for the poor if they are located far from poor people's centres of demand, are linked to them through low capacity and unreliable transmission and distribution networks or if the availability of renewable energy resource does not match the distribution of demand through the day/week/year. It is recommended that power system reliability analysis is undertaken in developing countries as part of investments planning to predict the expected impact of additional capacity.

In addition to technical aspects, the political economy of access to electricity in the host country should be well understood to better plan which communities are more likely to gain access as a result of donors' investments in additional generation capacity.

Policies to increase electricity connection rates and use

- Subsidies or liberal credit should be provided to cover upfront costs (including connection costs, house wiring and electrical equipment), which are considered as very important barriers to connection and use. These subsidies should be specifically designed to target the poor, for example through subsidised connection rates for late connectors, which usually include the poorest.
- Electrification strategies based on intensification (increasing connection rates in already electrified communities) could be much more cost-effective than extensification strategies, involving extending the grid to reach additional communities.
- Subsidised tariffs are often not necessary, as evidence shows that there is willingness to pay and they have been found to benefit the better off (those who can connect and buy appliances). If required to lower project risks at the start, they could have a phase-out period, aiming at financial sustainability in the long term.
- Tariffs should guarantee the financial health of operation and maintenance activities of the utility. They should also cover the potential expansion of generation capacity. Capacity development for efficient management of utilities and local cooperatives is also necessary. Only then, utilities will be able to provide a high-quality service to a large number of consumers in the long term.
- The effects of privatisation of the power sector for the poor are not conclusive. It may increase tariffs and not expand the grid to rural areas, but it may also improve quality and reliability, expand networks and liberate public finances to support rural electrification.
- Interventions are required to increase the control of consumers over their monthly bill, as evidence shows that poorly understood payment schemes are a barrier to higher consumption by the poor. This can be done through individual meters and pre-payment schemes.

- Interventions that promote productive uses of electricity are likely to deliver higher consumption rates.
- Consumer education can stimulate demand, ensure that consumers derive maximum benefit at least cost and increase the lifetime of individual off-grid systems.

Policies to improve the poverty impacts of electricity use

Several estimates of the expected household benefits from the use of electricity are provided in Tables 3 and 4. They could be used by policymakers to undertake cost benefit analysis of their investments in access to electricity. Other policy recommendations to improve the poverty impact of electricity for households include:

- Policies that facilitate increased access to electricity appliances through microcredits, free distribution or favourable payment conditions.
- Gender-targeted policies to promote uses that improve the quality of life of women and girls, by reducing the drudgery of household tasks and the time spent on domestic activities. Household dynamics need to be taken into account as purchase and use of appliances is influenced by the decision-making power of the different family members.

Two main policies can be put in place to encourage productive uses for electricity.

- A set of criteria could be developed to prioritise rural areas with the highest potential to use electricity for income-generating activities. These would include communities with a large internal market and easy access to external markets; a pre-existing diverse and growing productive sector including agriculture, manufacture and services; a set of infrastructures conducive for business development, such as road and telecommunications networks; and easy and reliable access to exploitable resources such as agriculture and tourism.
- Alternatively, more deprived areas with lower economic potential can be targeted but electrification should be integrated with other development programmes that contribute to create the appropriate environment for productive activities. This could include support to purchase productive equipment and to develop the skills to efficiently use it; infrastructures (particularly roads and telecommunications) and social skills to access external markets; or support for the creation of businesses.

The diversity of impacts of electricity for income generation, depending on productive activity and location of the businesses implies that a one-size-fits-all methodology that would try to predict the productive impact of electricity would be likely to deliver misleading results.

Policies to improve the macro-impact of electricity consumption on economic growth

The policy implications resulting from a review of the impact of electricity consumption on economic growth are not obvious and do not facilitate the adoption of specific electrification policies. Perhaps the most important element that transpires from our results is the need for electrification projects to not assume the 'growth' hypothesis that electricity consumption causes growth, and consider that some reverse causality is also possible.

Recommendations

This review has identified the links of the causal chain that determine the occurrence and size of poverty impacts from increased renewable electricity capacity. We recommend that these elements are taken into account by donors when planning investments in generation capacity that maximise their poverty impact. To facilitate the introduction of poverty considerations in planning exercises we propose the use of a methodology for ex-ante evaluation based on the results of our review, which is summarised in Figure 2.

Our results can also contribute to improving the design of ex-post impact evaluations of the poverty impacts of electrification projects. We suggest contributions at three stages of the impact evaluation: posing the right research question; developing a robust evaluation strategy through selection of treatment and control groups; and designing the baseline and endline surveys to include all the appropriate criteria and indicators for the selection of treatment and control groups and the assessment of impacts.

Both the ex-ante and ex-post evaluation methodologies will be further developed as part of IDS work on pro-poor access to electricity funded by DFID's Accountable Grant to the programme on Strengthening Evidence-based Policy.