Executive Summary

It has long been claimed that rural electrification greatly improves the quality of life. Lighting alone brings benefits such as increased study time and improved study environment for school children, extended hours for small businesses, and greater security.

But electrification brings more than light. Its second most common use is for television, which brings both entertainment and information. The people who live in rural areas greatly appreciate these benefits and are willing to pay for them at levels more than sufficient to cover the costs. However, the evaluation of these and other benefits (for example, in terms of public goods), as well as of their distribution, has been sparse.

This report reviews recent methodological advances made in measuring the benefits of rural electrification (RE) and commends them. It also notes that the understanding of the techniques shown in project documents is sometimes weak, and quality control for the economic analysis in project documents lacking. This study shows that willingness to pay (WTP) for electricity is high, exceeding the long-run marginal cost of supply.

Hence, in principle, RE investments can have good rates of return and be financially sustainable. But caveats are in order. The first caveat is that attention needs to be paid to ensuring least cost supply, including limiting system losses. Second, continued attention needs to be paid to achieving the right balance between financial sustainability and reaching the poor.

The World Bank has been financing RE for decades in Asia, and it has been expanding such activities in Latin America and Africa. Its support for RE has focused on outputs—building infrastructure and institutions. Yet outcomes have often been missing from project objectives; when present, they are assumed to follow automatically from the outputs. But the connection cannot be taken for granted.

Project design components to ensure that outputs do result in the intended outcomes are rare, though they are increasing. To give this results orientation further impetus, this assessment by the Independent Evaluation Group (IEG) examines anew the costs and benefits of RE for Bank-supported projects in several Regions of the world.

Background to the Study

The World Bank has made loans for power generation, transmission, and distribution since its earliest years. By the 1980s it was lending substantial amounts for expanding coverage into rural areas. However, a 1994 IEG report, *Rural Electrification in Asia*, cast doubt on these investments, arguing that the rates of return were low because many of the claimed benefits were not realized and that the costs of these programs imposed a financial burden on the provider. Since that time, financial reforms have been implemented in a number of countries, and the RE portfolio has seen significant shifts in terms of project objectives and design.

In addition, in response to that IEG report, the Energy Sector Management Assistance Program (ESMAP) carried out a study in the Philippines to quantify a broader range of benefits from RE. Most notably, that study developed a new methodology for measuring the benefits of electric lighting that has been widely adopted in project appraisals,

giving very acceptable rates of return. The main focus of IEG's current study is to review these claims and examine the extent to which changes in the portfolio have addressed earlier concerns regarding the limited poverty impact of lending to RE.

The study analyzed data from a range of sources, including IEG's own analysis of existing data sets for a dozen countries (three energy surveys, nine Demographic and Health Surveys, and two income and expenditure surveys) and a review of Bank and external studies. The analysis unpacks the causal chain from the provision of electricity to the various benefits it is claimed to bring, and quantifies these benefits where possible to address the balance of costs and benefits. The data were used to test the impact of RE on several variables, such as the quantity of lighting used, opening hours of clinics, female health knowledge, and income from home businesses.

The Bank's Portfolio

The Bank's strategy for the energy sector has evolved considerably in the last 15 years. In 1993 two policy papers were published that gave greater emphasis to the role of the private sector and highlighted environmental concerns (World Bank 1993a, 1993b). A 1996 paper discussed the 2 billion poor people around the world lacking access to modern energy services and how the Bank may best meet their needs (World Bank 1996), and a 2001 sector board paper increased the emphasis on both poverty and the environment (World Bank 2001b). How have these strategy changes been reflected in the RE portfolio?

IEG identified 120 Bank-supported projects with RE activities since 1980, falling roughly equally into three categories: dedicated projects (such as Bangladesh Rural Electrification I, II, and III), energy sector projects with RE components (such as the Jordan Energy Development Project), and multisector projects with RE components (such as Brazil's Northeast Rural Poverty Alleviation Projects). A growing number of these projects are in Latin America, where RE is common in multisectoral community-driven development projects, and Sub-Saharan Africa.

Another recent trend is the growth of support for off-grid electrification, usually as a subcomponent of a larger project, as in the Southern Provinces Rural Electrification Project and follow-on Rural Electrification Project in Lao People's Democratic Republic. Most off-grid projects rely on renewable energy technologies, which have also become more prominent in the Bank's lending in the last 15 years.

Three-quarters of RE projects have objectives related to improving energy supply, and the same proportion has objectives related to institutional development. Only 60 percent have the objective of increasing welfare (including environmental benefits), and this objective is mostly stated in general terms, such as improving incomes. Moreover, this objective is most common in the multisectoral projects. Only 7 percent of dedicated RE projects and energy sector projects have an explicit poverty-reduction objective. Hence, poverty has not become a central concern of RE projects, and there is rarely any explicit consideration either of how the poor will be included or of any poor-specific activities. Similarly, although mention of gender in project documents has increased greatly in the last decade, these concerns rarely affect project design.

Where the Bank finances a series of dedicated projects it can make a substantial contribution to increasing RE coverage: in Indonesia coverage rose from 33 percent in 1991 to 85 percent by 2003, with about 45 percent of these additional connections being paid for with Bank financing. In Bangladesh, the number of rural connections grew from practically zero in 1980 to more than 4 million by 2002; 600,000 of these connections were made with Bank financing.

By and large, Bank-supported projects have successfully created the physical infrastructure for RE, although technical problems have often meant high system losses—which have reached as high as 50 percent in Albania and India (Rajasthan). These losses drive a wedge between the cost of generation and the cost of supply, thus undermining financial performance. Many Bank projects

have components to address this problem of system loss, but not all have been successful.

There has been less success with institutional development, with the majority of unsatisfactory projects being rated such for this reason. The poor overall performance of the subsector—with just 68 percent of projects rated satisfactory from 1996 to 2006 (compared with 75 percent for the Bank as a whole)—mainly reflects institutional problems. These problems commonly relate to the lack of financial sustainability of the utility responsible for distribution, as tariffs are set below cost recovery. But the situation is changing; some countries have introduced higher tariffs and others, such as Lao PDR, are on track to do this. But there also remain a number of countries in which financial performance requires further attention.

Who Benefits from Rural Electrification?

It is widely recognized that the larger share of benefits from RE is captured by the non-poor. IEG analysis shows that this continues to be the case, although the gap closes as coverage expands. Two factors underpin this anti-poor pattern in electrification: which communities get connected and which households can afford the connection once the grid is available.

In many countries communities to be connected to the grid are identified on a "least cost" basis, which favors which larger communities nearer to the existing grid, roads, and towns. The Bank has promoted this approach, which is often necessary to secure the financial viability of the RE program, in a number of countries. For example, the recent Peru Rural Electrification Project changed community prioritization from the government's "social criteria" to a least cost approach.

Although this is necessary for the financial health of the service provider, there is a clear trade-off with reaching the more disadvantaged. Hence, some countries include social variables in their eligibility criteria; in Bank-supported projects this has most often been the case for community-driven development projects that target the poorest areas. In other cases, such as the Ghana National Electrification Project, the Bank has acceded to the government's request to ensure geographically equitable coverage. In a small number of cases, RE funds have been used to offset the financial loss incurred by private companies that extend coverage to less advantaged rural areas.

Although off-grid connections can serve remote communities that may not be connected to the grid for some years, they do not necessarily reach the poor better than grid extension does. Bank support to off-grid electrification is typically through a private business model, so social concerns have to be weighed against financial viability.

In most countries, increases in coverage come from extensive growth (extending the grid to new communities) rather than intensive growth (connecting the unconnected in already electrified villages). Once electricity arrives in a village, the connection charge is a hurdle that prevents the poor from connecting to the grid, even though the benefits they would derive—and so their WTP—would exceed the cost of supply.

Even in villages that have been connected for 15–20 years, it is not uncommon for from 20 to 25 percent of households to remain unconnected (for example, in Lao PDR). The absence of credit markets means households cannot borrow to pay the connection charge. Only a very small number of Bank-supported projects have either extended credit to customers (for example, the Second Accelerated Rural Electrification Project in Thailand) or allowed the connection charge to be paid over a number of years. Because the poor do not connect, progressive tariff structures have proved to be regressive subsidy schemes—so better-targeted connection charges would be consistent with the Bank's priority of ensuring that the poor benefit directly.

The same point applies to off-grid schemes, which are more expensive to the consumer than grid electricity. In some countries, the subsidy provided to these schemes is tilted toward the smaller

systems likely to be chosen by poorer households. For example, this is the case with the Philippines Rural Power Project. Also, credit or extended repayment periods for installation costs are more common for off-grid projects than for grid extension.

The poor who do connect benefit from a "lifeline tariff," a low tariff rate—commonly a fixed charge—for consumers who use below a certain level, usually 25 kilowatt hours (kWh) per month. But poor customer information means that many consumers unnecessarily restrict consumption to save money, when in fact it saves them nothing.

The full benefits of providing electricity to the poor are not being realized: first, poorer households are not enabled to connect to the grid, and second, consumers do not get information that allows them to obtain their maximum benefit. Bank-supported projects that claim to have the objective of bringing RE to the poor have typically neglected to include components that would help to achieve this objective.

What Is Electricity Used for in Rural Areas?

The dominant use of electricity in rural households is lighting. All households use it for this purpose, and many use little electricity for anything else. The next most common use is TV. Lighting and TV account for at least 80 percent of rural electricity consumption and thus the bulk of the benefits delivered by electrification. Electricity is rarely used for cooking in rural areas, though East Asia is something of an exception with the use of rice cookers. Fans and irons are also used for a minority of consumption.

The pattern of use has implications for the benefits from RE. The potential benefits to be gained from displacing firewood or kerosene stoves are not realized in the vast majority of cases. Again, consumer education may enable these consumers to achieve a greater range of benefits.

Electricity is also used in community facilities—notably for the cold chain for vaccines, though this does not appear to affect immunization rates. A positive impact of RE on service provision comes from the greater willingness of health and education workers to stay in communities that have electricity.

The lack of large-scale productive uses for rural electricity remains a constraint on the financial viability of RE because of low load factors resulting from consumption being heavily concentrated in the evening peak hours.

RE does not drive industrial development, but it can provide an impetus to home businesses, even though few households use electricity for productive purposes. IEG's analysis shows that the number of enterprises grows as a result of electrification and that these enterprises operate for more hours. There is, therefore, a positive impact on household income. However, the broader literature has found these effects to be less than expected, except when there has been a specific program to promote productive uses of electricity. This is, then, another example of how an additional project component can help achieve the welfare objective.

Benefits of Rural Electrification

IEG's review endorses the approaches advocated in the ESMAP study (2003) for measuring the benefits of lighting and TV; this involves measuring them as WTP for lumens (a measure of the quantity or intensity of lighting) in the case of lighting and hours of TV. There is a caveat that the shape of the demand curve matters (although the evidence as to its shape is still thin) and that assuming a linear demand curve, as in some studies, most likely results in an overestimation of project benefits. In one notable case, the claimed economic rate of return of 60 percent fell to 12 percent in IEG's recalculation.

It is also evident that some authors of project economic analyses have a weak grasp of the methodology, so the Bank's economic analysis does not match the quality of the available analytic work. Quality control mechanisms are not in place to stop weak analysis appearing in Board documents. But this view must be balanced with the observation that some project documents, such as that for

the Peru Rural Electrification Project, are best practice examples of cost-benefit analysis.

The ESMAP approach yields a WTP of around $0.10–0.40 per kWh for lighting and TV alone. This figure is already well in excess of the average long-run supply cost, which is usually in the range of $0.05–0.12 kWh.

This study also considers education benefits (as did the ESMAP study) and health and fertility benefits. More studies are required to better understand these channels. Other benefits are harder to quantify. But many of them are most likely internalized by the household and so reflected in the WTP. The exceptions are public good benefits, such as street lighting, which increases security, and the so-called "global benefits" of reduced carbon dioxide emissions, where applicable. Including these benefits means the benefit for an average household consuming 30–40 kWh a month is about $60 per month per household. This level is sufficient to ensure an adequate rate of return for most grid-extension schemes.

Off-grid schemes fare less well because they have higher costs but lower benefits. Benefits are further reduced by technical issues, including supply problems. The economic rationale for funding off-grid components alongside grid extension when the latter has the higher economic rate of return is far from clear. Such a decision might be justified on social grounds, but the case is far from proven, especially when much lower subsidies would be required to reach the poor who are unconnected in electrified villages. An alternative argument to support these investments is that these are mostly small-scale programs to enable learning by doing, which, together with general cost reductions and technological developments, will eventually make off-grid electricity more competitive.

Lessons Learned

It is difficult to generalize about RE, because both costs and benefits are context specific. However, some broad statements can be made.

- RE investments can generate sufficient benefits for the investment to be warranted from an economic standpoint—and they often have.
- The value of these benefits to households is above the average long-run supply cost, so cost-recovery tariff levels are achievable, even if politically unpopular in countries with a history of low tariffs.
- Analysis of feasible tariff levels can be informed by good quality economic analysis of the sort pioneered by the Philippines ESMAP study. But the quality analysis of that study is not uniformly replicated, as the quality of project-level analysis is uneven, with apparent weak quality control.
- The evidence base remains weak for many of the claimed benefits of RE. Tailor-made surveys, designed to test these benefits, need to be built into a greater number of Bank projects and designed to allow rigorous testing of the impact of electrification.
- Countries with low coverage rates—now mostly in Africa—still have to make investments in generation, transmission, and distribution, which implies relatively high average supply costs and low coverage, increasing slowly by extensive growth for some years to come. The principal challenge is to balance financial sustainability with growing coverage, requiring efficiency by limiting system losses. Grid connections will grow slowly, so many areas may be eligible for off-grid connections, but the logistics of maintaining technical quality will be challenging.
- Some countries in Asia and Latin America are reaching the limits of grid extension. Further increases in coverage require intensive growth, which requires instruments designed for that purpose, or off-grid schemes, which need design improvements if they are to be financially sustainable.
- There are project design options that have been uncommon but that would enhance project benefits. These include financing schemes for connection charges, consumer education, and support for productive uses.