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Barriers to Successful Implementation of Renewables-based Rural Electrification

Among the various options for off-grid rural electrification, renewables-based off-grid electrification holds particular promise due to the double dividends it offers: reduction of poverty and of greenhouse gas emissions. Notably, off-grid renewable energy systems can be suitable for applications in remote rural areas where energy consumers are dispersed and have low demand. However, these double dividends are not fully captured if productive uses of electricity are not also put in place, through additional planning and investment.

Barriers to implementing renewables-based rural electrification include both entry and project continuation barriers that have so far led to project performance below expectations. The most important lessons from our barriers analysis are firstly the need for proper information about renewable energy to decision-makers, as well as about least-cost options and development-environment double dividends to be had from these technologies. Secondly, there is a need to tailor electrification efforts to communities' needs and capacities.

Why does rural electrification matter?

With about 1.6 billion people having no access to electricity, promoting rural electrification is an important developmental goal for many countries. The reasons are obvious: firstly, levels of human development and per capita energy use are positively interrelated.

Secondly, gaps in electricity access often lie along given fault lines (notably ethnic ones – e. g. in Latin America, it is often indigenous communities that are still left without electricity access, be this in remote areas of the Andes, in the southern Mexican states of Oaxaca and Chiapas, or elsewhere) – reinforcing the marginalisation of these groups. Therefore, rural electrification is an important approach for promoting integration.

This paper focuses on why many past rural electrification efforts have run into difficulties – outlining the key barriers to successful rural electrification. The focus is on renewables-based rural electrification, which has gained some popularity among development practitioners for its double dividends (poverty reduction – greenhouse gas [GHG] emissions avoidance). The findings are based on specific field research by the authors in various countries on the success factors of rural electrification; on the authors' involvement in the financing and technical assistance for rural electrification projects; and on an additional literature review.

Reference is made to the experience of various countries. Examples from China and India are of particular interest because here, renewables-based rural electrification will be of special relevance, due to the sheer size of their rural population and current growth rates. Moreover, both countries have important experiences to share on renewables-based electrification.

Rural electrification options: The case for renewables-based off grid systems

In many areas of developing countries, renewables-based off-grid electrification will be the best approach for the promotion of rural electrification and poverty reduction. Costs of electrification either through grid extension or stand alone systems are largely determined by:

- distance from the grid;
- total number of households to be served;
- expected electricity consumption per household;
- fuel and fuel transport costs (i. e. in the case of diesel);
- renewable resource availability;
- ability to operate and maintain electricity solution (i. e. whether system maintenance is provided through local training or outside experts);
- equipment costs.

Evidence based on cross-country experience shows that in rural communities that are far from the grid, dispersed, and have low electricity demand, off-grid systems are often the economically most viable option in the long-term. Renewables-based off-grid systems offer additional advantages: they use locally-available resources to provide energy, making it frequently the least-cost option for basic energy services in the long-term. Most systems currently used are solar, wind, biomass or micro-hydro. Moreover, renewables-based rural electrification avoids both the local (health-threatening) and global (greenhouse-gas) emissions connected with diesel-based off-grid electrification, and have therefore attracted increased interest as well as funding from mechanisms such as the Global Environment Facility (GEF).

Isolated areas that have managed to acquire electricity have in many cases relied on diesel generators – notably because diesel power is a well-known and tried technology with good average reliability. Yet, the trend might shift away from the use of diesel systems for off-grid electrification due to heightened awareness about the negative implications of electrifying with diesel. These include harmful emissions, high costs of fuel transport and vulnerability to price fluctuations.

Alternative energy solutions that rely on locally available resources are less costly and less exposed to external price shocks. The funds thus saved could therefore, with the right incentives and a leadership committed to social progress, be spent on developmental purposes rather than on fuel.

Key types of barriers to renewables-based rural electrification

There are some barriers to the increased inclusion of alternative energy technologies for rural electrification solutions. These barriers are in terms of entry or in terms of continuation. Entry barriers are those that prevent investors or government entities from selecting renewable technologies to implement projects. They can be based on initial high costs of the technologies, or in terms of lack of familiarity with the technology. Continuation barriers are those that prevent alternative energy technologies in rural areas from achieving expected goals or from continuing to provide electricity both in terms of quantity in a given area or of expanding to other areas. Examples of these continuation barriers are maintenance problems and lack of follow-up programs.

Key entry barriers include the following:

Unsuitable financing mechanisms: A lack of funds or late / badly-timed disbursement of funds in rural electrification efforts has frequently led to half-finished or low-quality components prone to breakdown. This is partly explained by the fact that off-grid solutions in developing countries often have to involve small companies that are prepared to serve small rural markets; evidently, the lower the average firm size, the more easily it gets into financial difficulties and the less the likelihood of it having access to private funding at favorable terms. Financial capacity-building is in order here, as are (in select cases) custom-tailored subsidy programs for such firms. In particular, low-interest loans are useful in securing investment in rural power projects. Also, since rural electrification technologies have lifetimes of 20 years or longer and the initial investment in technology is costly, financing options should also provide long loan repayment periods. In China, for example, the State Council managed to arrange 20 year loan repayment periods with banks for rural electrification.

Moreover, responding to users' capacity and willingness to pay is essential. High costs of electrification will otherwise serve as an excuse not to provide service. In fact, the capacity and willingness to pay of consumers may surprise project developers – likely even more so once communities are educated about the benefits of having electricity services, about the quality of energy when compared to fuels such as kerosene, about cost-saving opportunities and increased productivity (especially for small businesses). Capacity- and willingness-to-pay calculations will thus help public authorities gauge the need for electricity consumption subsidies, and their size.

Thus, one important aspect of sustainable financing for rural electrification programs is of course the collection of payment from users. These fees make it possible to operate and maintain systems, and to provide returns on construction investment. The design of a reliable fee-collection program is thus necessary to motivate power companies to supply services. For instance, in China's rural electrification there are typically two stages involved: a) individual households pay for interior wiring and metering and b) village committees are formed to pay for line constructions and substations, appoint (rotating) technicians to read meters and to solve some technical issues, and after construction collect payment fees. It is clear, however, that not all users are able to pay for electricity services. Thus, as also seen in the case of China, some of the services provided to poorer households have a lower fee or are free.

Information barriers: Lack of access to information has been manifested by end users and decision-makers alike. In India, for example, knowledge about various renewable energy technologies has at times proved a considerable barrier in the implementation of renewable energy technology programs. Policy makers are not always aware about the costs and savings of alternative energy technologies and residential and commercial sectors also have low awareness levels. There is also lack of knowledge on appropriate policies that are required for the penetration of renewable energy technologies.

However, this is not only the case in India. Other developing countries are further behind in terms of their awareness about the potential and benefits of using alternative energy options for isolated rural customers. Thus, an important barrier to overcome when establishing alternative energy solutions in areas with available resources is the dissemination of information among decision/policy makers and final users of energy technologies.

Lack of complementary investments: Electricity access by itself is of little use. As anywhere in the world, rural populations of developing countries do not value electricity access per se but the services that this electricity can provide. Hence, rural electrification efforts have frequently been limited in improving people's lives where such complementary investments were lacking – leading to limited political or financial support for rural electrification programs.

The key types of productive uses of electricity in rural areas of developing countries include: 1. Hard infrastructure (i. e. electric pumps for water supply such as domestic use and irrigation and enabling rural access to communication services such as telephone and internet); 2. Social infrastructure (i. e. modern education tools such as video for local schools and modern treatment facilities for health centers); 3. Domestic uses (i. e. electrical grain milling and electrical sewing); 4. Production of goods (i. e. preservation such as through canning of locally-produced food for sale or export); 5. Small-scale local service industry (i. e. light and refrigerators for small grocery shops and light and cooking facilities, and basic comfort needed for small-scale tourist facilities); and 6. Communal services (i. e. radio broadcasting).

Thus, managers of rural electrification programs should integrate from the start a component for the promotion of productive uses of electricity in the target areas – as well as the financing and technical assistance needed to kick-start such productive uses. Private firms and Non-governmental Organizations (NGOs) may prove important partners here: private firms may be buyers for new or additional goods produced by a newly-electrified community; and NGOs already present in the community or region may be most aware of e. g. what electrical equipment is most urgently needed in the local health center.

Institutional and decision-making barriers: There are several barriers within institutions which, together with the continuity of certain behavioral patterns, lead to limitations on the way decisions are taken. One of these barriers is *time limitations*: provision of electricity often becomes the urgent priority of governments (e. g. during election time when the pressure mounts to deliver on basic services) and decisions are thus made to provide the service with immediacy. Thus, pressured with time, decision-makers often choose technologies that are customary and do not require periods of data acquisition or experimentation. In this way (as identified earlier), *lack of resource data and information about technologies* become limiting factors to rational decision making. Another barrier to the selection of renewable technologies is *access difficulties:* conventional technologies that require fewer field visits to rough (geographically or prone to conflict) areas prior to project development are also more attractive to project developers. Lastly, another barrier to decision-making is the *unawareness of human capacity*: as much as the rhetoric praises community involvement in electrification projects, this is often not followed in practice. Often, developers believe that electricity solutions should only be based in the hands of the experts (as they will actually know how to handle the equipment appropriately). In practice, including community members in planning and implementation of electrification projects is complicated because it requires time and information (i. e. for community consultation) and previous investment in institutional strengthening in the field, in education and training, and in trust-building.

Along with the selection of appropriate technology, electrification projects need to be supported by strong institutions and the involvement of community members in the decision making process. Local businesses should be contacted to understand their experiences in the area, for example in terms of payment collection for services or in terms of user behavior. Furthermore, industry coordination and long-term agreements with local sellers can ensure that replacement equipment is sold for the life-time of the systems installed. In the decision-making process it is important to focus on the demands of the users, the power needs, the final uses of the electricity, rather than only on supply-side questions. In addition not only energy experts should participate in making decisions. Energy provision is a precondition for delivery improvements in many other sectors of development (such as agriculture, education, health, etc.). Multi-disciplinary teams are needed in order to ensure that these linkages are implemented.

Inappropriate technology choices / cultural barriers: Project design has frequently lacked careful consideration of local resources, local capacity, and an appropriate technology options characterization. There has been a poor effort to select technologies that will most fit the needs of the communities in question and to train these communities on the operation and required maintenance of the equipment. When appropriate community education is missing, communities themselves may then see the equipment provided as a destroyer of their traditional cultures.

Barriers relating to inappropriate technologies should be addressed through adequate capacity building by financing institutions or technical assistance agencies for the running, maintenance and repair of the systems. In selecting appropriate technologies, appropriate system standards and codes must also be selected to ensure equipment compatibility, proper operation, and to keep costs down. An example of appropriate technology and a rural electrification program is that of China, where the government took the role of providing construction materials, such as steel, to selected demonstration sites. Small hydropower turbines were manufactured locally and provincial governments funded the training of local technicians in system design and operation. In addition to past practices, China has continued to adapt inexpensive technologies and local materials and has taken advantage of local human resources.

Lack of follow-up and abandonment of projects: Lastly, an obvious but often overlooked barrier to the success of rural electrification through renewable power is project abandonment and lack of project follow-up. In some cases (and there are clear examples of this across the world), development institutions, NGOs, or government institutions implement energy projects that later fail once the programs run out of funds or once the government institutions disengage.

Aside from monitoring the equipment for preventive maintenance and repairs, the level of satisfaction of customers should also be monitored. Thus, communities will continue to feel included in their own energy solutions and necessary changes may be made before they escalate into frustration that may lead to abandonment of the project by the community itself.

Conclusions and recommendations

Renewable electricity can have double dividends since it fulfills basic needs and since it reduces the impacts of otherwise polluting energy sources. Although the local and single project impact of emission reductions is minor, the global, multi-project, and long-term impact of the prevented emissions can be immense if 1.6 billion people are to acquire electricity within the next decades. For this reason it is important to strengthen institutions and enable decision-makers to make more informed decisions on electrification projects. These informed decisions must be based on real data (detailed renewable resource maps) which are currently lacking in many developing countries. Similarly, decision-making requires training in renewable technologies and the access to appropriate and relatively simple tools and methodologies to determine the best electricity solution in an area. It will still be the case that in some areas renewables are not the best alternative, but the decision should be made on a project by project basis and not as status quo procedure. As mentioned before, however, careful attention must also be paid during project operation. Follow-up and proper maintenance are crucial to project success and to the future implementation of similar projects.

Yet, even if the barriers to the successful implementation of renewable energy electrification in rural areas are overcome, providing electricity through renewables does not fully take advantage of the double-dividend benefits mentioned earlier if productive uses of electricity are not sought as well. Such productive uses include the enabling of social services such as improved educational and health facilities; or income generating activities (through enabling electricity-dependent small business ventures such as e. g. cooling systems that have helped isolated southern Mexican fishing communities to export their catch). These productive uses do not necessarily appear simultaneously with the access to electricity but must be envisioned and additional investments are often necessary to achieve them. Such additional investment and planning could well multiply the poverty-reduction benefits of rural electrification.

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