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"Small is beautiful!? Evaluating the sustainability of small-scale renewable energy projects in developing countries"

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Abstract

Access to sustainable and affordable energy services is a crucial factor to reduce poverty in developing countries. Especially small-scale and community-based renewable energy projects are recognized as an important form of development assistance to reach the energy poor. The WISIONS program run by the Wuppertal Institute has supported numerous of such innovative small-scale energy projects via its Sustainable Energy Project Support (SEPS) scheme since 2004. This paper presents the first step in the effort to evaluate cross-sectional energy development interventions at the local level, gather evidence on their effectiveness and measure their sustainability.

Keywords: community-based projects, renewable energy, evaluation, sustainability

Introduction

Today about 1.3 billion people still lack access to clean, affordable and reliable energy services to meet their basic energy needs (IEA/OECD, 2011). Renewable energy sources are expected to play a key role in increasing and improving access to energy in developing countries offering clean electricity, heating, cooking and lighting solutions to people and communities, who so far depend on traditional energy sources and/or expensive fossil fuels. This is especially true, since technological innovations and cost reductions in the last ten years have made renewable energies more competitive to traditional fuels (REN21, 2012). Nevertheless, these technologies still face a broad range of social, economic and structural challenges, requiring not only the development of new capacities and tools but also new ways of understanding and fostering technological innovation to accomplish widespread dissemination. The SEPS scheme (Sustainable Energy Project Support) of the WISIONS initiative addresses these issues by supporting innovative approaches and capacity development to respond to energy needs at the local level. Since 2004, a total of 64 projects around the world have been selected for SEPS support. These projects focus on different energy related needs, technologies and implementation concepts.

Although most of these projects could be completed successfully it is important to assess their sustainability some years after the initial project activities have been completed. The need for such an evaluation of development projects is recognized throughout the international community and reflects in the increasing attention the subject receives in publications of donor organizations and research institutions (e.g. Baker, 2000, ESMAP, 2003; Mansuri & Rao, 2003; Späth, 2004; FASID, 2008; UNDP, 2009; World Bank/IEG, 2012). According to Baker (2000) ex-post evaluations can help to answer the question of 'what works and why' and therewith guide improvements of project designs and practices by identifying success factors and explain failure. While many evaluations focus on one discrete project at a time the present evaluation was applied to a group of cross-sectional projects in terms of technologies, needs and regions. Studies by the Japan International Cooperation agency (JICA) (2010), FAO (2010), World Bank (2008), or Linn (2012) have shown that by evaluating a number of projects which have been implemented with a common framework, but under diverse contextual factors, can provide recommendations which are relevant across projects boundaries.

Research Objectives

The main objective of this paper is to evaluate the mid-term sustainability of small-scale renewable energy projects ex-post implementation. The key research questions addressed are (1) *Sustainability*: Whether or not the energy services and structures could be sustained over an extended period of time after the initial project activities were completed? (2) *Suitability*: What has been working as expected? What has changed from the original design and why? Which problems and challenges have occurred?

Thus, the analysis is focused on extracting information on performance and credible evidence on the effectiveness or inefficiency of different project components and designs. Moreover the aim is to explore if specific influencing factors, difficulties and/or necessary changes that had to be made can be regionally linked, are technology specific, universal or only particular to single projects. The results can (a) be used to effectively determine the future needs of the "WISIONS for sustainability" program and improve the quality of future projects (b) provide stakeholders with information on the major factors that influence the achievement or non-achievement of sustainability in small scale renewable energy projects in developing countries and (c) help other organization to learn from the experience and therewith avoid replication of poor project designs and practices.

Methods

The evaluation was designed as a semi-structured in-depth survey with the organizations that implemented and monitored the initial project activities. The survey approach was chosen as it is time effective and particularly suitable to address questions regarding how innovation occurs, why certain decisions are made, and why some processes work better than others (Baker, 2000). As the projects are worldwide distributed, on-site evaluation was considered to be too time and cost-intensive. Although there are inevitably limitations of the chosen approach, namely the problems to quantify and generalize the results, it is possible to provide an interpretation of the processes and impacts that have a high level of probability (Späth, 2004). Most of the supported small-scale energy programs focus on providing development assistance through the supply of electricity or other energy services to stimulate economic productivity and enhance quality of life. To measure these components this evaluation focuses not only on quantifiable evidence, such as the number of installations or number of beneficiaries, but also on qualitative aspects, such as impacts on society, awareness raising or network development. The data drawn from the interviews and additional documentation including progress and final reports from the original project phases were examined using statistical methods as well as content analysis tools. The analysis and the presentation of results concentrate on four categories (a) technical viability, (b) interactions with political level, (c) socio-economic development and (d) replication and dissemination.

Results

The evaluation sample consisted of 40 projects, which have been supported by the SEPS scheme of the WISIONS initiative in the period between 2004 and 2008. The response rate to the survey was 65% (26 projects), of which 23 projects were suitable for the evaluation. In the remaining 3 cases no information on the status of the projects was available.

The evaluation has shown that with 78% of the 23 projects the majority of the implemented small scale renewable energy interventions were successful, meaning that more than 50% of the original technical components and/or services were functioning 2-7 years after their first introduction. Of these 48% were fully functioning and 30% were largely operational, with only some installations or structures not functioning. Further 13% of the former projects were only functioning to limited extent, for example in one case out of 13 biogas digesters only three were still running. While 9% of the projects failed completely. In the group of cases that failed or are only operational to limited extent, technologies that utilize biomass as renewable fuel source represented the largest cluster. Whereas all projects that aimed to meet the need of preparing food with less energy inputs utilizing technologies like improved cook stoves and solar cookers are still fully operational.

Table 1: Overview projects and status.

	Technology	Need/Application	Country	Status 2012
1	Micro-hydro power	Electrification	Brazil	Fully operational
2	Solar PV	Electrification & Lighting	Namibia	Fully operational
3	Pico-hydro power	Electrification & Lighting	Philippines	Fully operational
4	Improved cook stoves	Food preparation	Laos	Fully operational
5	Biogas	Food preparation	India	Fully operational
6	Improved cook stoves	Food preparation	China	Fully operational
7	Biogas	Food preparation & heating	Jordan	Fully operational
8	Efficient pumps	Irrigation	India	Fully operational
9	Solar PV & efficiency improvement	Lighting	Mauritius	Fully operational
10	Solar PV	Lighting	Kenya	Fully operational
11	Efficiency improvement	Lighting	Mexico	Fully operational
12	Wind power	Electrification	Peru	Mostly operational
13	Solar cookers & improved cook stoves	Food preparation	Guatemala	Mostly operational
14	Biogas	Food preparation	Latin America	Mostly operational
15	Solar cookers	Food preparation	Nepal	Mostly operational
16	Solar PV & Wind power	Irrigation	Tanzania	Mostly operational
17	Efficient lanterns	Lighting	Sri Lanka	Mostly operational
18	Solar bakery	Commercial food preparation	Cameroon	Mostly operational (2011)
19	Liquid biofuel Jatropha	Irrigation	India	Not functioning
20	Biomass gasification	Productive use	India	Not functioning
21	Biogas	Electrification	Sri Lanka	Only functioning to a limited extent
22	Solar PV & Micro-hydro power	Electrification	Peru	Only functioning to a limited extent
23	Liquid biofuel Jatropha	Irrigation	Nepal	Only functioning to a limited extent

Technical viability

The evaluated projects indicate that the technical viability of the applied concepts strongly depend on two factors: (1) The reliability of the technical components (hardware) and (2) the availability of knowledge, expertise and skills (software) required during the whole lifecycle of the hardware, i.e. from their selection or design, through their construction and installation up to their operation and maintenance. In many cases (43% of evaluated projects) main technical components have been fulfilling the expected functions without major difficulties. However, the use of reliable technical components does not necessarily ensure sustainable operation of the concepts. Gaps in the 'software' factors may lead to difficulties or even to failure. Two notable examples are:

a) Improper use of the PV systems led to damage of some components in Namibia (no. 2), thus stronger emphasis on training of users was given on follow up activities to correct this issue.

b) The lack of empirically validated knowledge on the applicability of Jatropha led to very low supply of seeds in the project in Nepal (no. 23) and to the failure of the plantation in India (no. 19). On the other hand, the availability of adequate knowledge and skills seems to be crucial for responding to difficulties that emerge in the practical implementation. Adaption of the applied technology, major repairs or selection of new components were reported in 47% of the projects that are mostly or fully operational.

Interactions with political level

Between local projects and the policy level strong mutual influences exist. The evaluation results emphasize the importance of the following two forms of interaction: (1) the direct 'negative' effect national infrastructure developments can have on local projects and (2) the 'positive' effects small energy projects can have on national energy regulations.

(1) National programs for grid extension had severe impacts on four projects evaluated (17%). They resulted for the most part in the abandonment of the affected projects, as households with new connections to the national grid dropped the commitment to the decentralized energy systems. This is especially true for technologies that are not cost competitive with the electricity prices and the service quality (24-hour power supply) of the grid.

(2) Successful projects, if sufficiently communicated to the political level, can influence renewable energy regulations. To influence national regulations, the introduced technologies have to be cost-effective in relation to alternative energy regimes (e.g. kerosene, diesel generator, grid extension to remote areas) and/or their potential in the country must be proven. Although direct causal relationships are hard to detect, it can be stated, that two projects (no. 9 in Mauritius and no. 2 in Namibia), in some way or another, stimulated the decision to introduce support schemes –like feed-in-tariff or cheap loans– to foster the dissemination of the respective technologies.

Socio-economic development

The evaluation results indicate on the one hand the services and jobs already planned and established during the implementation phase still exist. On the other hand project concepts hardly triggered the generation of additional economic activities. In addition, the survey revealed that all on-going projects have socio-economic benefits for the local population. Benefits most mentioned were expenditure reductions of up to 40% on firewood (improved cook stove projects), higher income through increased agricultural productivity (irrigation projects), as well as better living conditions due to access to basic electricity services, clean water and lighting (electrification and lighting projects). Further, the results also show clearly that no productive use should be expected from small-scale (up to several hundred Watts per household) electrification projects. The principal use of these electricity technologies is for communication (mobile phone, radio, TV) and lighting.

Replicability and Dissemination

Small scale energy projects can to be understood as a first step in a process of the wider dissemination of renewable energy technologies. If they are successful and sustainable it is important that steps are taken to achieve increasing coverage. At the time the reviewed projects started their replication potential was considered to be high and most of the projects had developed concepts for local or regional dissemination. The findings of the evaluation show that the dissemination strategies have been generally suitable as in 78% of the cases the awareness and interest regarding renewable energy technologies could be increased. Furthermore it was possible to replicate either the technology or the management model in 40% of the cases. The evaluation data reveals that there are two factors that strongly influence the potential for replication. On the one hand replication depended on continuing involvement of the implementing organization. In all replicated cases the organizations continued to actively support the technology and were connected to or present in the region. On the other hand the high up-front investment of renewable energy systems was often mentioned as central barrier for replication. Meaning that donor funding or other forms of subsidies were needed for the replication in all but one case. This shows that although a system is successful and accepted by the users replication hardly happens on its own but that several conditions need to be in place before replication is possible. These conditions include long-term commitment within the implementing organization, strategies with an explicit focus on replication as well as availability of medium- to long-term funding.

Besides lacking finance options, other barriers mentioned are the low level of motivation of potential producers/users, problematic logistics in remote areas as well as the lack of local capacity to manufacture and install the technology properly.

Discussion

Comparing the findings of the evaluation of the small-scale renewable energy projects with other multi-project evaluations, several parallels but also certain dissimilarities can be discovered. Regarding the sustainability of the projects the results are comparable with an evaluation of 139 projects supported by the KfW bank (2011), where 79% of the projects were categorized as successful. While in a study from the JICA (2011) the success rate was slightly higher with 87%. The main reasons for failure identified by the later study were financial issues like insufficient budget for operation and maintenance and decline in demand (JICA, 2011). This could not be confirmed, by the evaluation of the projects supported by WISIONS, although funding has been identified as critical factor for the replication potential.

Our findings indicate that the most common reason for failure is the application of unsuitable technologies, driven by two main factors: The reliability of the technical components and the availability of adequate knowhow and skills. This observation is in line with the findings from an evaluation of rural electrification projects by the World Bank (2008), which acknowledged problems resulting from lack of technical capacity in rural areas and the logistical difficulties of servicing equipment as one of the major issues.

In terms of socio-economic development the World Bank evaluation found that electrification may bring the chance for small business activities but the overall impact of renewable energy technologies on productive activities was limited (World Bank, 2008). These results are confirmed by the present evaluation. More over the results suggest that not only electrification measures but interventions ‘only’ addressing energy issues can hardly trigger additional economic activities.

With focus on the replicability the presented results are supported by a study of Linn (2012) on the scaling up of development projects in Tadzhikistan. Long-term perspective and a proactive approach from the implementing organization have as well been identified as essential. Linn describes this as “stick-with-it mentality” (Linn, 2012).

The findings of the present evaluation indicate that in small-scale energy projects it is not only the reliability of the technology that defines the sustainability of a project. The availability of adequate knowledge and skills can strongly influence the technical viability of a concept. These ‘soft’ components are already crucial in the conceptualization and pre-development of the project (e.g. evaluating the suitability of a technology for the given ecological context), during implementation (e.g. ensuring quality of components and installation) and for the operation after project closing (e.g. ensuring adequate use and maintenance).

Moreover, the results show the influence that the political context can bear. It can improve the performance of a project (e.g. ensuring revenues in form of subsidized tariffs) and also close opportunities for some project concepts (e.g. through grid extension). First findings of other influencing factors -like involvement of local actors and the management model- indicate that in order to ensure long-term provision of clean energy service, the technical solutions should be appropriately embedded in the socio-cultural, political and ecological context.

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