Renewable Energy 34 (2009) 1774–1781

Contents lists available at ScienceDirect

Renewable Energy

journal homepage: www.elsevier.com/locate/renene

Systems analyses and the sustainable transfer of renewable energy technologies: A focus on remote areas of Africa

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ARTICLE INFO

Article history:
Received 25 June 2008
Accepted 13 October 2008
Available online 25 January 2009

Keywords:
Sustainability science
Sustainable development
Technology management
Technology assessment
Technology transfer
Sustainability indicators

ABSTRACT

Sustainable energy provision is regarded as one of the most significant challenges facing the realm of development, especially in Africa where large proportions of the population still lack access to energy services. Although there have been much efforts to address these problems with renewable energy technologies, there have also been substantial failures and problems. The Intermediate Technology Development Group (ITDG) has developed a manual that seeks to address these implementation issues. The Renewable Energy for Sustainable Rural Livelihoods workgroup has also developed such a framework, termed SURE, which is a multi-criteria decision analysis modelling tool. Both of these frameworks rely heavily on the Sustainable Livelihoods Approach and emphasise the need to rigorously analyse the sub-systems where technologies are to be introduced. These two frameworks have been integrated and assessed in terms of their applicability for the South African rural renewable energy landscape through a Delphi study conducted with several experts in the energy sector. The results indicate that the integrated framework is suitable for the South African context, with additions to the ITDG and SURE frameworks suggested. Finally the paper highlights a potential concern in the South African renewable energy industry in that technology assessment methods that are utilised in practise do not incorporate the concepts of sustainability science adequately; this must be addressed through further case study research efforts.

1. Introduction

In light of the almost universal acceptance of the Millennium Development Goals (MDGs) [1], the growing awareness of climate change [2], and an increasing concern of an oil peak as oil prices continue in a general upward direction [3], the search for renewable energy (RE) has become increasingly important [4]. Especially in rural areas of Africa, where the bulk of the continent's poor still find themselves, the potential of RE to address the challenges of energy poverty and meeting the 2015 targets of the MDGs, has been highlighted [5]. In South Africa, for example, the national government views RE as a means to reach its constitutional commitments made through the mechanism of human rights in terms of access to electricity for all citizens [6], whilst alleviating the perceived enormous costs involved with utility-based grid provision in rural areas [7]. Also, a target of 10,000 GWh of energy to be produced from renewables by 2013, has been set [8].

Despite this enormous drive for renewable energy, literature suggests that renewable energy projects are rather prone to failure, especially in remote areas [9]. The international experience of the World Bank Group [10] highlights the fact that the interaction between society and renewable energy technology is one of the critical factors of success that needs to be actively managed if sustainable energy development is to be achieved. Some of the prevailing challenges listed include: "…perceived financial and political risks, insufficient institutional capacity to implement projects, weak or inadequate regulatory frameworks, and limited understanding of what is feasible on the ground". An in-depth study of renewable energy models in Southern Africa confirms this realisation [11], and highlights that socio-political factors are on par with economic and technical aspects when it comes to the sustainability of renewable energy projects. These, and other studies [12], suggest that there are truly significant challenges to transferring renewable energy to rural areas. A holistic, integrated approach to rural renewable energy delivery is subsequently needed. Identifying what such an approach may look like was the

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doi:10.1016/j.renene.2008.10.012

purpose of a literature study. The primary objective of this paper is to identify a framework of such an approach. The paper further evaluates the framework through a Delphi methodology that engaged experts from across the South African renewable energy landscape.

2. Decision-making frameworks to facilitate the sustainable transfer of renewable energy technologies (RETs) in rural areas

A comprehensive literature review of rural development, and the role of renewable energy for such development, is summarised elsewhere [13]. The literature review concludes that the integration of renewable energy into the rural development paradigm is of great importance to the sustainability of technology transfer in particular, and sustainable development in rural settings in general. A rural energy implementation framework should therefore not only be based on the lessons learned from the failures of previous rural energy projects [12], but should also incorporate the current theories found within rural development thinking [14].

The "Energy for Sustainable Rural Livelihoods" manual of the Intermediate Technology Development Group (ITDG) [15] is such a framework. As the product of practical experience in technology related development, the manual serves in pragmatically integrating all spheres of the rural developmental process in a very flexible, people-based manner. As such, the social and institutional spheres of sustainable development receive a great deal of attention, not for a moment relegating them to anything less than the technological, ecological and economic spheres.

The social sphere primarily focuses on using participatory techniques to gain indigenous knowledge as well as to determine the possible impacts of technology choices. It also places people and their needs in the centre of the rural renewable energy process. The institutional sphere is mainly concerned with the creation of supportive institutions. This is not restricted to any level of government or organisation, but is a cross-cutting call for meaningful institutional transformation in the face of the need for rural energy. The choice of technology is a product of the careful analyses of demand and supply, required and available skills, and the standards and quality control measures in place.

Another framework is based on a multi-criteria decision-support system that utilises a large amount of technical and non-technical information collected in a variety of ways to determine the most appropriate energy choice [16]. The software used by the Sustainable Rural Energy Decision-Support System (SUREDSS) was developed by the Renewable Energy for Sustainable Rural Livelihoods (RESURL) project, which is funded by the UK Department for International Development (DFID) [17]. SURE was tested in a remote Colombian rural community, who were already making use of a diesel generator, but required additional energy.

2.1. Structure of the introduced frameworks

The discussion of the proposed frameworks for rural energy provision needs to first address the characteristics, similarities and differences between the two frameworks, after which they will be combined into one framework. The flowcharts of Figs. 1 and 2 are useful as basis for this discussion.

The analyses methods that the ITDG manual and the SURE tool utilise are not vastly different. However, there are two important differences between the approaches, which are made clear by the two diagrams. The first is that all of the analyses of the SURE tool fed into a computer model that eventually derives an appropriate technology choice. In other words a hierarchy is established with technology occupying the top position when it comes to sustainable energy provision for rural communities. This, however, brings

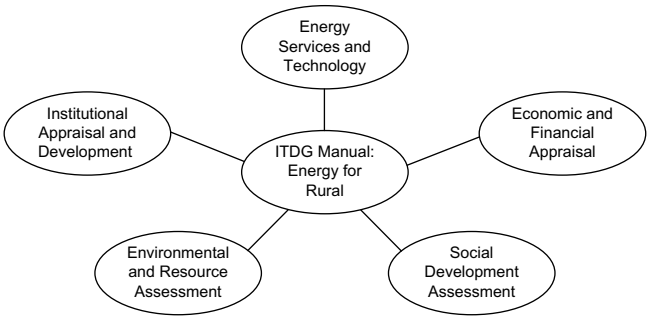

Fig. 1. The ITDG manual framework.

about the second important difference. Whereas the ITDG manual has a whole section/chapter devoted to institutional analysis and development, this is noticeably absent from the SURE system of analysis. The ITDG manual partly addresses this problem by focusing on the development of, for example, institutions in addition to their analysis. What their experience has taught them is that rural energy is not just about technology choice, but also about development.

In essence, it is about the balance between a choice and a strategy, where the former is the result of the SURE decision-support system and the latter the result of the ITDG manual. Although the SURE decision-support system does not provide an appropriate "strategy" for the implementation of rural energy technology, it does enhance the chances of success of the strategy produced by the ITDG manual. This is achieved by promoting the technology that is sure to be the best option for the community concerned. The rest of the strategy surrounding this technology can now be developed, in partnership with the community, around this technology.

Fig. 3 illustrates how the two different approaches may be reconciled by integrating the SURE tool in the ITDG manual. The decision-support provided by SURE greatly enhances the efficiency of the ITDG manual by providing a more robust technology choice system without undermining the other four spheres in terms of their contribution to the strategy. The functional detail of the two systems will be discussed in the broad framework of the different stages of a project, allowing for an increased understanding of the interaction between these two.

Table 1 provides a summary of the abovementioned methods, analyses and frameworks, allowing one to gain a more thorough understanding of the eventual product or integrated framework that is being proposed for further evaluation. As may be observed, a major part of this overall framework revolves around comprehensive analyses, allowing for the proper assessment of all major areas of the context where a technology will be introduced. Much of the analyses are reliant on the communities themselves and requires their continued involvement, since the analyses methods are technologically neutral and aim to deliver a solution that is acceptable to the community. The implementation and monitoring and evaluation stages are also created in such a way that they are community led and motivated, which not only has sustainable technology implementation, but also empowerment in mind. The details of how the analyses may be executed, and associated indicators calculated, are provided elsewhere [13].

3. Research design and methodology

The Delphi technique was selected for the study. The versatility of the technique to produce generalisable results [18] was the main basis for the selection. The Delphi technique is also particularly well suited to situations where those with the expert knowledge on the particular problem are geographically dispersed, as is the current