



Original research article

Rethinking the sustainability and institutional governance of electricity access and mini-grids: Electricity as a common pool resource



Lorenz Gollwitzer^a, David Ockwell^{b,*}, Ben Muok^c, Adrian Ely^d, Helene Ahlborg^e

^a SPRU (Science Policy Research Unit), School of Business Management and Economics, University of Sussex, UK

^b Department of Geography, ESRC STEPS Centre, Sussex Energy Group and Tyndall Centre for Climate Change Research, School of Global Studies, University of Sussex, UK

^c Centre for Research Innovation and Technology, Jaramogi Oginga Odinga University of Science and Technology (JOUST), Kenya

^d SPRU (Science Policy Research Unit), ESRC STEPS Centre, Sussex Energy Group, School of Business Management and Economics, University of Sussex, UK

^e Division of Environmental Systems Analysis, Department of Technology Management and Economics, Chalmers University of Technology, Sweden

ARTICLE INFO

Keywords:

Energy access

CPRs

Mini-grids

ABSTRACT

Rural mini-grids are viewed as a key technology for providing access to electricity to the billion or more people that lack it by 2030 (in line with the UN's Sustainable Energy for All commitment). But at present no model for the sustainable management of rural mini-grids exists, which contributes to high failure rates. This paper makes a number of contributions. First, it explores how electricity in mini-grids might be understood as a Common Pool Resource (CPR), opening up potential to learn from the extensive literature on institutional characteristics of sustainable CPR management in the natural resource management literature. Second, it refines Agrawal's (2001) overarching framework of enabling conditions for sustainable CPR management institutions to develop a framework applicable to rural mini-grid management in developing countries. Thirdly, the utility of this refined framework is demonstrated by applying it to analyse data from 27 semi-structured interviews with actors with expertise in mini-grid development and management in Kenya and 2 field visits to rural mini-grids there. This contributes a nuanced basis for future application of CPR theory to mini-grids and a systematic analysis of institutional challenges and possible solutions, which have hitherto received limited attention in the energy and development literature.

1. Introduction

Over one billion people lack access to electricity – a vital precursor of many aspects of human and economic development [1]. In sub-Saharan Africa around two in every three people lack access, with electrification rates below 25% in some countries [2]. The UN's "Sustainable Energy for All" (SE4ALL) initiative (supported by Sustainable Development Goal 7) aims to solve this problem by 2030. But this aim is plagued by problems in practice. In this paper, we focus on developing sustainable institutions for managing the use of a key technology, mini-grids, which are estimated as needing to provide 45% of the connections required to achieve SE4ALL by 2030, the majority in remote rural locations [3].

Despite their promise, managing mini-grids in ways that can provide electricity access to poor people poses considerable technical, economic, socio-cultural and political challenges, with failure rates evaluated as being as high as 50–100% [4,5]. Part of the reason for this

failure can be due to inappropriate equipment installation and/or inadequate maintenance; it can also relate to financial issues (e.g. tariffs being set too low). A persistent problem also, however, relates to collective over consumption of electricity, which in turn leads to equipment degradation and failure, indicating the presence of socio-cultural and institutional management dimensions to mini-grid failure (explored in more detail in Section 5) as much as technical or financial reasons [4,5]. Whilst, as Section 2 demonstrates, the engineering and economic challenges relating to energy access in developing countries are relatively well researched, the socio-cultural and political challenges have received very little attention to date.¹ In this paper, we focus on the institutional aspects of managing mini-grids, which cut across all of the above challenges, but in particular cast analytic attention on the socio-cultural and political dimensions of energy access. We demonstrate how insights from the broad literature on common pool resource (CPR) management (which mostly focuses on natural resources) can shed light on how to sustainably manage a man-made resource, electricity in mini-

* Corresponding author.

E-mail addresses: L.Gollwitzer@sussex.ac.uk (L. Gollwitzer), d.ockwell@sussex.ac.uk (D. Ockwell), a.v.ely@sussex.ac.uk (A. Ely), helene.ahlborg@chalmers.se (H. Ahlborg).

¹ Note, it is not our intention to imply that high mini-grid failure rates are purely the result of a lack of sustainable management models and that technical and financial problems do not also contribute to failure, rather we wish to explore the former in a research field previously dominated by a focus on the latter.

grids. There are examples of scholars who have proposed that mini-grids are CPRs [4–7]. As demonstrated in Section 2, however, there is, to date, no systematic examination of the relevance, and applicability to mini-grids, of the well-developed literature (reviewed below) on the ‘enabling conditions’ under which institutions will emerge that support sustainable management of CPRs.

Our core question is whether CPR theory can assist in analysing the enabling conditions that characterise institutions capable of sustainably managing mini-grids for pro-poor electricity access in developing countries. After reviewing relevant literature on energy and development and useful strands of the CPR literature, the paper makes its first contribution by analysing the conditions under which mini-grids display the characteristics of CPRs and hence how CPR theory might be relevant. We highlight similarities between electricity in a mini-grid and water in irrigation systems (the subject of a large part of the CPR literature) using the hydraulic analogy to explain the behaviour of electricity in closed circuits. The paper then makes its second contribution by developing a refined, mini-grid specific, analytical framework of enabling conditions for the sustainable management of CPRs (based on Agrawal [8]). The potential utility of this refined framework is then tested by applying it to analyse empirical data from 27 expert interviews and 2 site visits to mini-grids in rural Kenya. This provides a nuanced basis for future research. Our intention is not to produce overarching prescriptions for solving the complex problems that relate to managing rural mini-grids in developing countries. Rather, it is to develop and evaluate the usefulness of a new analytic, theoretically grounded approach with potential to inform future research and practice focussed on overcoming the high levels of failure observed in relation to rural mini-grids in developing countries.

2. Relevance of CPR theory for mini-grids

This paper engages with the CPR management literature made famous by Hardin’s [9] “Tragedy of the Commons” and Ostrom’s [10] later Nobel prize winning work, which demonstrated how social institutions can form and achieve sustainable management of CPRs, thus avoiding Hardin’s earlier hypothesized “tragedy”. We apply Ostrom’s and later authors’ insights on sustainable CPR management to local electricity provision in the form of mini-grids. This is motivated by recognition of the sophisticated body of theoretical and empirical work in the CPR and collective action field, compared to a lack of any well-developed institutional approaches within the energy access literature. Rather than starting from scratch, we want to see what we can learn from this work that, arguably, deals with systems similar to decentralized, collective electricity provision via mini-grids.

The existing energy access literature has, to date, been dominated by a focus on the financial and technological dimensions, with attendant disciplinary domination by economics and engineering, with insufficient focus on socio-cultural and political dimensions [11] – what Ockwell and Byrne [12] describe as the “scholarly deficit” in energy access research.

As a result, we know a lot about financial dimensions of mini-grids and rural electrification more broadly, such as: relative costs and benefits of technological options [e.g. [13,14]]; willingness and ability to pay [e.g. [15]]; and the nature and appropriateness of different financing mechanisms for infrastructure [e.g. [16]]. We also know much about: technology selection methods [e.g. [17]]; applicability of technologies to specific physical contexts [e.g. [18,19]]; spatial mapping of technological applicability and least-cost scenarios [e.g. [20]]; improving technological efficiency [e.g. [21]]; technology adoption, e.g. the energy ladder [e.g. [22]]; and scenario modeling [e.g. [23]].

A handful of recent contributions have begun to grapple with political economy dimensions of energy access more broadly (as opposed to mini-grids specifically) [e.g. [24,25–31]]. And recent years have witnessed what might be described as a nascent “socio-cultural turn” [12] in energy access research, with a number of contributions

operationalizing insights from the socio-technical transitions literature [32–39] and social anthropology [40–42]. These contributions have cast analytic light on a range of socio-cultural aspects of energy access, including understanding the social, cultural, gendered and, inevitably, political dimensions of electrification and the implications of involving potential users in the design, development and implementation of rural electrification projects. A number of recent contributions also operationalize insights from innovation studies, introducing an emphasis on indigenous capability building, albeit more at a firm/industry than community level [43–47]. There have also been recent attempts to bridge the fields of socio-technical transitions and innovation studies [see [12,48]]. More explicitly focussed on sustainable mini-grid management, a wider literature also exists (mostly focusing on Indian experiences) which analyses enabling conditions for sustainable management of mini-grids, emphasizing, for example, the important role that village energy committees and other local institutions have played, as well as the broader importance of community participation [e.g. [49–51]].

Despite this recent socio-cultural turn and the emerging literature on the politics of energy access, however, (and excluding the two working papers that preceded the current journal article - [see 56,57]) only four pieces of grey literature to date (two working papers and two doctoral theses, no peer reviewed journal articles) have explicitly engaged with institutional insights from the collective action literature [4,5,7,52]. Of these, only three recognize the relevance of work in that literature on understanding enabling conditions for sustainable CPR management and all three of these demonstrate only a partial engagement with this work. Maier [5] uses a CPR perspective to analyse reasons for successes and failures of 27 community-based micro hydro mini-grids in Northern Pakistan. He finds that communities have established institutions and various rules of use, concluding that they are able to govern the use and ensure the maintenance of the plants in ways that often function better than state- or private-based models. In most cases, the projects that failed experienced external pressures, e.g. the arrival of the national grid. Maier does not venture beyond treating electricity as a CPR, identifying CPR attributes and describing resulting management challenges. There is no systematic application of theories of collective action or reference to overarching enabling conditions through which institutions and transferable approaches may be developed, although, given the importance of rules Maier identifies, the use of enabling conditions as an analytical tool would have been appropriate.

Greacen [4] also suggests that electricity in community-based micro hydro mini-grids, in this case 59 projects in Thailand, can be treated as a CPR. Rather than elaborating on the manner in which experiences from other instances of collective action could be used to overcome identified challenges, however, he suggests a technological fix that could be used to address the problems: current limiters, which technically limit the maximum current that can be drawn by each household. Again, there is no attempt at a theoretical expansion of the collective action literature. Furthermore, this focus on technical fixes ignores potential institutional considerations that might still persist, e.g. managing distribution among users during seasonal demand that exceeds generating capacity.

In an analysis of the economic impacts of 5 community-based micro hydro mini-grids in rural Kenya, Kirubi [7] also studies some aspects of collective action. He focuses on the contested effect of heterogeneity of user groups on the sustainability of collective action and finds that heterogeneity of resource users increases chances of long-term success. This analysis only represents one small sub-section of a thesis more broadly concerned with the impact of electricity access on rural development and only engages with one of the 33 enabling conditions identified in Agrawal’s [8] theoretical framework that we refine and test further below. There is therefore no precedent in the peer-reviewed or grey literature for applying a comprehensive theoretical framework of enabling conditions for collective action to the issue of sustainably

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