Energy Policy 121 (2018) 25–34

Contents lists available at ScienceDirect

Energy Policy

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

Exploring household energy transitions in rural Zambia from the user perspective

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ARTICLE INFO

Keywords:
Solar mini-grids
Rural electrification
Service design
User journey mapping
Zambia

ABSTRACT

Renewable energy mini-grids are expected to play a major role in pursuit of universal access to modern energy services, particularly in rural Africa where grid extension is technically or financially unviable. In doing so, they will contribute greatly to a shift in household and community energy use from reliance on traditional fuels to more modern energy services. However, such a shift is a complex and uncertain process, with mini-grids often struggling to achieve sustainability after initial project funding ends. This paper draws on service design approaches to understand challenges associated with adoption of electricity services from the user perspective. By developing a user journey map, our study explores users' experience associated with connecting to and using electricity services from a 60 kW solar mini-grid in Mpanta, a small rural fishing community in northern Zambia. Our study finds that poor expectation management and limited integration of local socioeconomic dynamics in mini-grid service design, including their impact on affordability, has led to a slow and partial shift in household energy use. Better incorporation of the user perspective in the design, implementation and evaluation of mini-grids can help to identify potential barriers to adoption of electricity services and adapt it to the local context.

1. Introduction

Renewable energy mini-grids are expected to play a major role in the pursuit of universal access to modern energy services, particularly in areas where grid extension is technically or financially unviable (IRENA, 2015; Szabó et al., 2011). The International Energy Agency (IEA) has estimated that nearly 60% of the additional generation required to achieve universal access to electricity in Africa will need to come from off-grid solutions (IEA et al., 2010). Of the roughly 315 million rural Africans that the IEA envisions gaining electricity access by 2040, about 140 million would be served by mini-grids (IEA, 2014).

Such large-scale diffusion of mini-grid technology would contribute greatly to a shift in household energy use from dependence on traditional fuels – particularly kerosene and candles for lighting – to the use of electricity services for lighting and powering electrical appliances (Sokona et al., 2012). Yet such a shift is not a given. Diffusion of new technologies and fuels is a socio-technical process (Geels, 2002; Ahlborg and Sjöstedt, 2015; Ulsrud et al., 2015), whereby adoption of new technological hardware and associated services shapes and is shaped by existing norms, practices and infrastructure (Eder et al., 2015; Stephenson et al., 2015; Rogers, 2003). Meanwhile, across the world, fuel and stove use often continues even when electricity services are accessed, debunking the myth of an energy ladder where people follow a linear transition from sole dependence on traditional energy sources to sole use of modern energy services (Cheng and Urpelainen, 2014; Masera and Navia, 1997; van der Kroon et al., 2013).

One potential way to ensure renewable energy mini-grids and the services they provide are more effective in contributing to changing the ways in which households use energy is to design them in tandem with the user (Lambe and Atteridge, 2012; Norman, 2013). Such an approach can help to ensure services better meet their needs, desires and expectations. Despite this, research and practice focusing on the user perspective of mini-grid service adoption remains limited (Schillebeeck et al., 2012; Hirmer and Cruickshank, 2014). This paper contributes to filling that gap by exploring how the adoption of a new energy service – electricity from mini-grids – is shaped by users of that service and their context.

For our analysis, we draw on participatory, user-centred and service design literatures to identify key components associated with understanding user experience over time. In our methodology, we apply user journey mapping methods from service design to identify how and why people remain on or fall off the electricity service adoption pathway after getting connected. User journey mapping has been used to analyse user experiences of a variety of products and services, from cookstove

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https://doi.org/10.1016/j.enpol.2018.06.005
Received 15 January 2018; Received in revised form 13 May 2018; Accepted 2 June 2018
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adoption (Jürisoo et al., 2018) to cruise ship experiences (Norton and Pine, 2013) to use of library services (Marquez et al., 2015). Our study is the first application of user journey mapping to analyse user experiences of renewable energy mini-grids.

We focus our analysis on the 60 kW solar mini-grid in Mpanta, a small community situated on the shores of Lake Bangweulu in northern Zambia. The Mpanta solar mini-grid was a pilot project led by the Rural Electrification Authority and funded by the United Nations Industrial Development Organization and the Global Environment Facility aimed at demonstrating the technical and financial viability of renewable energy mini-grids for rural electrification; part of an attempt by the Zambian government to increase rural electrification rates from 3% in 2008 to 51% in 2030 (Grøn and Chisonga, 2014).

The paper is structured as follows. Section 2 reviews the literature on understanding the user perspective in the design of mini-grid services. Section 3 introduces the case study and explains the research methods used. Section 4 visualizes and describes the user journey of different community members in Mpanta with respect to accessing electricity services from the solar mini-grid. Section 5 discusses the implications of these user journeys on household energy transitions and Section 6 concludes.

2. Understanding the user perspective in mini-grid service design

In this section, we conceptualize adoption of new mini-grids and the services they provide as a process of socio-technical change. From this perspective, we illustrate the importance of understanding the mini-grid service user and the context within which they use that service. We then show how participatory, user-centred and service design approaches can help to do this.

2.1. Adoption of mini-grids services as socio-technical change

Renewable energy mini-grids involve small-scale power generation (as little as 10 kW or as much as 10 MW)[1] and a distribution grid that can provide national grid- quality service to a limited number of customers in a concentrated area, without having to connect to the national grid (Franz et al., 2014). They are typically established in rural areas without access to the national electricity, but where there is an adequate density of households and an available source of renewable energy, such as solar, wind or hydropower. In this sense, mini-grids are often viewed as a “third alternative to rural electrification, coming between the option of large-scale grid extension and pico-scale stand-alone solutions like solar home systems (SHS) or solar lanterns” (Pedersen, 2016, p. 570). Although the precise quality and quantity of electricity services provided by renewable energy mini-grids depends upon how the system is designed, they typically aim to provide services similar to those provided by the national grid: electricity for lighting, powering electrical appliances and entertainment systems, charging battery-powered devices and driving machinery (Alstone et al., 2015; Yadoo and Cruickshank, 2012). In some cases, renewable energy mini-grids are run by national electricity utilities, which often have years of experience running decentralized diesel-powered electricity networks in rural areas. But in other cases, mini-grids are developed by private enterprises or local cooperative groups (Johnson and Muhoza, 2016; Tenenbaum et al., 2014).

Despite the high expectations around the role of mini-grids in contributing to increase energy access in sub-Saharan Africa, there is still limited uptake of mini-grids in the region (IRENA, 2016; Johnson and Muhoza, 2016). Those that have been installed often face considerable challenges in sustaining their operations (Draeck and Kottász, 2017). Debates around how to improve mini-grid electricity services have typically centred around technological design, institutional set-up and financial viability (Pedersen, 2016; Schillebeeck et al., 2012; Hirmer and Cruickshank, 2014). However, this perspective neglects the importance of socio-cultural context on how new technology is diffused and how new services are adopted.

We conceptualize the diffusion of renewable energy mini-grid technology and adoption of its associated electricity services as a dynamic process of forming of a new socio-technical system, or socio-technical change (Ahlborg and Sjöstedt, 2015; Geels, 2002), whereby the use of new technologies and services shapes and is shaped by the local social context in which it is used (Ulsrud et al., 2015). We believe this conceptualization is valuable for understanding the process of change in community-level energy systems for three reasons.

Firstly, it helps us to better understand the complexity of mini-grid technology diffusion and electricity service adoption. Adoption of mini-grid electricity services comes hand-in-hand with the adoption of new technologies and devices that utilise that service and also a range of modified or new practices – watching TV, reading into the night, refrigerating food – that result from incorporating the new energy service into the existing household system (Stephenson et al., 2015).

Secondly, the socio-technical perspective helps us to appreciate that adoption of a new electricity service as a dynamic process, rather than a static, binary state based upon initial acceptance or first use of the service (Kowsari and Zerriffi, 2011). A user may use electricity for powering their radio and dry cell batteries for powering their torch, or a user may use electricity services one day and not the next. Hence, we need to consider adoption in terms of sustained use over time, particularly if we want to ascertain the benefits of adoption.

Lastly, a socio-technical approach expands the range of factors we consider as influencing technology diffusion and service adoption to include social context. Of course, new mini-grid technologies and services will only be adopted if they provide relative advantages over existing technologies and services and are financial viable from the users’ perspective (Eder et al., 2015). But new technologies are not widely adopted just because they harness technical principles, but also if their form and function are aligned to fit with dominant norms, practices and routines (Stephenson et al., 2015).

2.2. Understanding the mini-grid service user

The question then remains how to design mini-grid technology and associated electricity services in such a way that minimizes the socio-technical barriers to diffusion and adoption. Sustained adoption of technologies and services associated with using electricity from renewable energy mini-grids requires significant behaviour change on the part of the user, the extent of which is heavily determined by expectations and experience (Lambe and Atteridge, 2012; Shyu, 2013), cognitive biases (Hobman et al., 2016; Frederiks et al., 2015) and social values and context (Faiers et al., 2007; Lutzenhiser, 1993). Given these complex aspects shaping technology and service adoption, achieving adoption must start with a good understanding of user needs and the context within which users will make decisions about accessing and using that technology or service (Norman, 2013). As Ritter et al. (2014), p.50) succinctly put it, designing a product or service is about “considering particular people doing particular tasks in a particular context”. Drawing on participatory, user-centred and service design approaches, we identify three components associated with understanding the user perspective in mini-grid service adoption, which formed the basis of our analysis: user experience, user journey and touch points.

Early participatory design efforts – linked to efforts in Scandinavia to democratize the workplace – emerged in the 1980s as an approach to engaging with the user, based on the assertion that “those affected by a design should have a say in the design process” (Bjögvinsson et al., 2012). The participatory design process provides an interactive space for participants – designers and users – to reflect on product or service functionality and the context within which it would be used (Simonsen

[1] In some cases, mini-grids with as little as 1–10 kW of generation capacity are referred to as “micro-grids” or “nano-grids”.

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