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Attracting private investments into rural electrification — A case study on renewable energy based village grids in Indonesia

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ABSTRACT

Renewable energy based village grids (RVGs) are widely considered to be a sustainable solution for rural electrification in non-OECD countries. However, diffusion rates of RVGs are relatively low. We take the viewpoint that, as public resources are scarce, investments from the private sector are essential to scale-up the diffusion. While existing literature mostly focuses on engineering, development and techno-economic aspects, the private sector's perspective remains under-researched. As investment decisions by private investors are mainly based on the risk/return profile of potential projects we — based on literature reviews and field research — investigate the risk and the return aspects of RVGs in Indonesia, a country with one of the largest potentials for RVGs. We find that considering the potential of local, national and international revenue streams, the returns of RVGs can be positive. Regarding the risk aspect, we see that private investors could address many of the existing barriers through their business model. However, the findings also point to the need for government action in order to further improve the risk/return profile and thereby attract private investments for RVGs.

Introduction

Today, about 19% of the global population remains without access to electricity (OECD/IEA, 2011). Access to electricity heavily correlates with economic development, and those people lacking access primarily live in rural areas of non-OECD countries (OECD/IEA, 2011). Providing these rural poor with electricity is a major challenge. The amount of additional electricity generation capacity needed is enormous when aiming to stimulate rural development (Bardouille et al., 2012; Cook, 2011; ESMAP, 2008). At the same time, climate change (being a major threat mainly to the poorest countries) needs to be addressed by decoupling electricity production from CO_2 emissions (Bhattacharyya, 2011; Gallagher et al., 2006; Glemarec et al., 2012; UN AGECC, 2010). Grid extension — the conventional solution for electrification in most countries — is often not feasible or too expensive, especially in very remote areas such as islands as is the case in Indonesia (Blum et al., 2013; Deichmann et al., 2011; Rickerson et al., 2012). In such cases, off-grid renewable energy technologies which produce electricity with a very low climate impact and that fit the requirements of a decentralized context, can well address the challenge of low-carbon electrification (Holland and Derbyshire, 2009; Sovacool and Valentine, 2011; Zerriffi, 2011). In 2011, the Journal *Energy for Sustainable Development* published a special issue on off-grid electrification in non-OECD countries, which discussed rural electrification through renewable energy in a series of sixteen articles and was specifically valuable for our study (for an overview see Bhattacharyya, 2011). Several authors from this special issue (e.g., Bhattacharyya, 2011; Schäfer et al., 2011) as well as other researchers (e.g., Glemarec, 2012; Zerriffi, 2011) recommend further research with regard to scaling up diffusion through private investments. Even though research on rural electrification through renewable energy is increasing, most studies address the engineering, development and techno-economic aspects. The private sector's investment decisions, remain poorly researched (Bhattacharyya, 2011, 2012; Kaundinya et al., 2009).

Renewable energy based rural electrification options are diverse and vary greatly regarding the amount of provided electricity and consequently the potential for allowing for the productive use of electricity. While solar lanterns and household-based stand alone systems such as solar home systems offer lighting and limited access to electricity for household purposes, respectively, their contribution to the productive use of electricity is low (Macharia et al., 2010; Ölz and Beerepoot, 2010). Village grids[1] are widely regarded as more promising in terms of a developmental impact because they allow for the productive use of the generated electricity (Cook, 2011; Kanagawa and Nakata, 2007; Legros et al., 2009; Takada and Charles, 2007). If designed well they can, in terms of reliability, outperform the often unstable national grids in non-OECD countries (Peskett, 2011; Yadoo and Cruickshank, 2012). If village grids are powered by renewable

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[1] Village grids, also referred to as micro- or mini-grids, “provide centralized generation at a local level. They operate at a village or district network level, with loads of up to 500 kW” (OECD/IEA, 2011, p. 16) and connect a few up to several thousand households (Bardouille et al., 2012).

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energy they not only address the poverty, but also the climate change challenge. While the global market for off-grid solutions bringing modern energy to the rural poor has a size of about 35 billion USD p.a., the market potential for RVGs alone is estimated at an annual 4–5 billion USD (2012) (or about 28 million households) and growing by 13% p.a. (Bardouille et al., 2012; Dean et al., 2012). However, despite the advantages of RVGs, the existence of pilot projects (e.g., in Bolivia, Cambodia, India, Indonesia, Nepal, Nigeria, or the Philippines) and the heavy promotion by development agencies, large-scale diffusion has not yet taken place (Bardouille et al., 2012; Roland and Glania, 2011). In this study we focus on RVGs in Indonesia where they are a very suitable form of rural electrification for three reasons[2] (see also the Background on Indonesia's electricity sector, rural electrification and RVGs section). First, the government of Indonesia (GoI) aims to increase the electrification rate from the current 65–70% to beyond 90% by the end of the decade (PT Perusahaan Listrik Negara, 2010; PWC, 2011; Winoto et al., 2012). Second, Indonesia is an island state, making grid extension complicated and expensive. Third, the country has more than sufficient renewable energy resources, e.g., in forms of solar and hydro power. Theoretically, there are three known sources of finance for RVG projects in Indonesia: first, international grants from non-governmental organizations (NGOs) and developmental agencies providing initial capital for RVG projects,[3] second, grants for electrification provided by the federal GoI (Ministry of Energy and Mineral Resources of Indonesia, 2009), and third, private investors (typically local or regional businesses) and village communities which arrange joint financing agreements. Despite these potential sources of finance, little investments have taken place (Bardouille et al., 2012; OECD/IEA, 2011; PWC, 2011). While the first two sources of capital are limited by the specific grants, the private capital is abundant. In order to understand private investment — or the lack thereof — the risk/return profile is essential, as for private financiers/investors, "the risk–return profile of a project is the ultimate determinant of whether to finance or not" (UNEP, 2012, p. 9).

In this paper, we therefore address the question "*what do the current risk/return profiles of RVGs in Indonesia look like and how can they be improved in order to attract private investments*?" We proceed in two steps. First, we investigate the potential returns of different RVG types by comparing costs with revenues. Second, we turn to risks, by analyzing the barriers that drive investment risks (compare Waissbein et al., 2013) and show how investors could make these risks manageable. Both, positive returns as well as manageable risks are prerequisites for attracting private capital (Glemarec, 2012; UNEP, 2012; Waissbein et al., 2013). The role of the government in supporting the formation of such a favorable environment for investment is essential (The World Bank, 2013; Waissbein et al., 2013).

The paper is structured as follows. The Background on Indonesia's electricity sector, rural electrification and RVGs section introduces the context of this study. The Methods section provides an overview of the methods applied. In the Potential returns of RVGs in Indonesia section we identify return sources. The Investment barriers and measures for investors to address them section provides the results of a detailed barrier analysis (that is needed to understand risks) as well as a comprehensive selection of multiple measures to assist investors to address these aforementioned barriers. We then turn to the role of regulation and discuss our findings in the Discussion section with regard to the role of national policy for improving the risk/return profiles of RVGs. We end with the Conclusion section summarizing our findings briefly.

Background on Indonesia's electricity sector, rural electrification and RVGs

The Indonesian State Constitution from 1945 declares that all vital utilities concerning the greater population must be controlled by the state. Since 1985, the electricity sector in Indonesia has been controlled by the state-owned power utility Perusahaan Listrik Negara (PLN). After its formation, PLN became the sole body responsible for the provision of electricity across Indonesia. The Ministry of Energy & Mineral Resources serves as the policy making body and regulator for PLN. However, other ministries within the GoI are also stakeholders providing different governing and support functions. In a bid to boost the capacity of electricity generation and keep up with an estimated 9% annual demand growth (Differ Group, 2012; Permana et al., 2012), the GoI since 2009 has opened up the market of power generation for competition. Small scale independent power producers (IPPs) can now produce electricity, but are required to sell it to PLN for distribution. Only rural cooperatives are allowed to generate and distribute electricity independently of PLN. Fig. 1 shows a schematic of key players in the Indonesian electricity sector and their roles. In order to address climate change and reduce its oil dependency, the GoI has also introduced The Ministerial Decree on Renewable Energy Resources and Conservation (Ministerial Decree No. 002/2004) which aims at increasing the share of renewable energy to 18% by 2025 (Energypedia, 2013).

Despite having significantly developed its generation, transmission and distribution network over the years, the national electricity grid remains significantly strained. The growth in generation capacity has been unable to keep up with the growth in electricity demand. Since 2009, the Java–Bali transmission grid is particularly congested, which has led to "transmission bottlenecks" that often forced PLN to impose rolling blackouts across the two main islands of Java and Sumatra. However, the more remote islands mainly suffer from partial or even complete lack of electricity. With an electrification ratio of about 65%–70%,[4] about 72–84 million of the 242 million Indonesians still do not have access to reliable and affordable electricity services (Asia Sustainable and Alternative Energy Program, 2005; Energypedia, 2013; PT Perusahaan Listrik Negara, 2010; Purwono, 2008; Winoto et al., 2012). Of these 72–84 million people the vast majority, about 60 million, reside in rural areas and almost all live outside of the most densely populated islands[5]: Fig. 2 shows the electrification ratios per province and clearly indicates that the eastern parts of Indonesia particularly are suffering from a lack of access to electricity. Despite these official figures, it has been very difficult to quantify the real progress at the rural village level.

Previous studies suggest that due to the challenging geographical nature of the country, a decentralized off-grid electrification solution is more appropriate than grid extension, in particular for remote and rural villages in mountainous areas and on smaller islands (Blum et al., 2013; Boedoyo and Sugiyono, 2010; Kaundinya et al., 2009; Sovacool and Valentine, 2011). Currently, most village grids are powered by diesel plants: at the end of 2007, 936 decentralized diesel power plants (50 kW–500 kW) with a total capacity of 987 MW were operating in Indonesia (Senoaji, 2008). Diesel generators are a standard rural electrification solution, due to their long track-record, reliability, scalability, availability

[2] Another — non-empirically driven — reason for the choice of Indonesia was the fact that one of the authors is an Indonesian native, which strongly improved the accessibility of data gained in literature reviews and during field trips (see Methods section).

[3] Additionally, international initial capital can potentially be extended by carbon financing (compare Quantitative approach section).

[4] Electrification figures diverge depending on the source and the interpretation of electrification; often electrification ratios reflect general access to electricity, but do not reflect the quantity and quality of the accessed electricity (*Interviews*). In Indonesia a village counts as 'electrified' if at least one location within the villages is connected to PLN's low voltage grid — which includes mainly diesel powered village grids. A clearer indication of the true electrification ratio would be the number of electrified households (see Fig. 2).

[5] Indonesia consists of about 17,508 islands, out of which around 6000 are inhabited (The CIA World Factbook, 2013).