ARTICLE

An Integrated Framework for Rural Electrification: Adopting a User-Centric Approach to Business Model Development

Simon J.D. Schillebeeck, Priti Parikh, Rahul Bansal, Gerard George
Civil, Environmental & Geomatic Engineering, University College London

Abstract
Rural electrification (RE) has gained prominence over the past two decades as an effective means for improving living conditions. This growth has largely been driven by socio-economic and political imperatives to improve rural livelihood and by technological innovation. Based on a content analysis of 232 scholarly articles, the literature is categorized into four focal lenses: technology, institutional, viability and user-centric. We find that the first two dominate the RE debate. The viability lens has been used less frequently, whilst the user-centric lens began to engage scholars as late as 2007. We provide an overview of the technological, institutional and viability lenses, and elaborate upon the user-centric lens in greater detail. For energy policy and practice, we combine the four lenses to develop a business model framework that policy makers, practitioners and investors could use to assess RE projects or to design future rural electrification strategies.

Keywords: Rural electrification, business model, user-centric

Introduction
Rural electrification (RE) – the creation of electricity services in rural areas - has grown rapidly over the past two decades, both as a practice and as a field of academic research. Creating a better understanding of why RE projects are successful is important because electrification improves social, environmental and economic parameters of rural livelihood (World Bank, 2008c). For example, rural electrification is instrumental in achieving the Millennium Development Goals (Modi et al., 2005; Mustonen, 2010). Experience shows that on the social level, RE positively impacts: (a) the quality of lighting (World Bank, 2008c), (b) health by diminishing indoor exposure to particulate matter (Howells et al., 2005) and by extending clinic hours and strengthening the cold chain (ADB, 2010; World Bank, 2008c), (c) education outcomes, thanks to extended hours for study (ADB, 2010), (d) connectivity to the outside world via increased access to television, radio and mobile phones (Deichmann et al., 2011; Yadoo et al., 2011) and even (e) social status (Chaieb and Ounalli, 2001). In terms of its effects on the environment, RE's effect on deforestation – via wood as fuel for cooking - is contested (Balachandra, 2011; Lachman, 2011). However, the surge of renewable energy technologies (RETs) as valuable alternatives for conventional fossil fuel solutions reduces carbon emissions (Kaufman et al., 1999), making an overall positive impact on the environment more likely.

Despite RE's beneficial social and environmental impact, the economic case remains somewhat uncertain. Deichman and colleagues state that the connection between rural electrification and local revenue growth remains "largely anecdotal" (2011), which suggests that specific programs to promote productive uses should be incorporated in RE project design to stimulate economic growth (World Bank, 2008c). RE's effect on poverty alleviation is doubtful as only "7 percent of dedicated RE projects and energy sector projects have an explicit poverty-reduction objective" (World Bank, 2008c). Over 1.5 billion people lack access to electricity (IEA, 2010; World Bank, 2008a), the vast majority of them are living in Sub-Saharan Africa, India and other developing countries whose population growth rates exceed electrification rates (Barnes and Foley, 2001; IEA, 2010). Consequently, future RE policies, technologies, and strategies could potentially affect a significant base of the pyramid market.

The academic literature on rural electrification is largely populated with country-based approaches which focus on the implementation, problems and outcomes of a project (e.g. Gaunt, 2005; Ghosh et al., 2004; Langevine, 1996) or address the local potential for electrification (e.g. Gulberg et al., 2005; Rabah, 2005; Stutenbäumer et al., 1999). Various studies exclusively discuss aspects of certain technologies (e.g. Krauter and Ochs, 2004; Lubis and Udin, 1991; Munro and Blaesser, 1994) while others focus chiefly on policy and institutional issues (Bond et al., 2007; Ketlogetswe et al., 2006). Comparative studies that analyse different technologies (ARE, 2010), investigate the impact of policy reforms across different countries (Moonga Haanyika, 2006) or try to unpack the drivers of success in the context of particular case studies (Miller and Hope, 2000; Zerriffi, 2007), prove very insightful, but remain rather rare. Although in-depth technological and country-specific research have great value, multifocal research across technological, institutional and financial boundaries is more likely to overcome the general failure to capitalize on past success and generate “a replicable model for rural electrification” (Zerriffi, 2007).

This article attempts to build such an integrated ‘replicable model’ by linking four focal lenses - technology, institutional, viability and user-centric - that are generally used separately to discuss RE projects. Interlinking these four lenses provides a powerful way of thinking about the building blocks of project or organizational success, as demonstrated by the literature on business models (Afuah, 2001; Amit and Zott, 2001; George and Bock, 2011). Our goal is not to provide a single recipe for RE. Instead, we highlight the building blocks of an integrated framework for design and/or assessment of RE projects. By using the business model logic to analyse RE projects, we build on a young tradition that applies business model thinking to address social and environmental issues (George et al., 2012; Jenkins, 2009; Schillebeeckx, 2011; Seelos and Mair, 2005).

In the following sections, we describe the methodology used to assess the literature and report our findings. We deduce and discuss four focal lenses: technology, institutional, viability and user-centric. The user-centric lens is developed in greater detail than the other three because we believe a better understanding of the underlying ‘user’ needs is fundamental to increasing the economic success rate of RE projects. Yet, such an approach has, until recently, been largely absent from the literature on RE. Finally, we develop a generic business model checklist that could act as a framework for practitioners to develop a toolkit that can help turn this sustainability challenge into a business opportunity.

Methodology

We build on prior work by Zerriffi (2007) and Biswas et al. (2001) to classify the RE literature into four different lenses. Zerriffi (2007) states the important elements of RE business models are “organizational form, technology choice, target customers and financial structure” while Biswas et al. (2001) question whether the RE technology is “technically feasible, affordable, socially acceptable, institutionally sustainable and replicable”. From these works and other studies, we develop an *a priori* categorization of technology, institutional, viability and user-centric lenses. We then use content analysis to examine the relevance and trends underlying the use of each lens to study RE. This methodology involves counting and/or classifying text into subgroups used to analyse which subject area is dominant within a field of interest. Such analyses have proven insightful in fields such as psychology (Nilsson et al., 2007), medicine (Cromer and Stager, 2000) and also business (George and Bock, 2011). Following Stemler (2001), three distinct choices must be made: discourse content identification, unit(s) of analysis selection, and the nature of the categorization (emergent or a priori).

On 16 November 2011, we selected a sample of papers using a “title and abstract and keywords” search for “rural electrification” in the Science Direct database. After a few indicative searches, we excluded the journals ‘Fuel and Energy Abstracts’, ‘Refocus’ and ‘Photovoltaic Bulletin’ because they are not academic in nature, although they are categorized as such. We selected scholarly articles to ensure the use of authentic, credible and meaningful sources, representative of work carried out in the field, thereby following good practise guidelines (Gilbert, 2001). Of the 237 hits, 3 articles were excluded because they did not cover rural electrification and the 2 articles from 2012 were excluded. The resulting sample of 232 articles comes from 25 different journals listed in Appendix A and forms the identified discourse content. We then used two complementary units of analysis: 1) individual abstract to which we apply our *a priori* categorization; and 2) the individual word-unit which facilitates the discovery of key concepts and emerging categories (Pilbeam et al., 2008) and allows for the identification of first and second order concepts that in turn leads to a “construction of larger narratives and more generalizable theory” (Rousseau et al., 2008).

Using the abstract, we built on our *a priori* categorization to initially classify 50 randomly selected papers, coding for the various lenses used in each study. We allowed for multiple interpretations and co-

constructed the meaning of the four focal lenses in an iterative process between the authors. Each article was classified with exactly one dominant, and between zero and three secondary lenses. The lead author 'coded' the remaining 182 papers individually while the others assessed additional random samples of 25 papers as a control. The correlation between the authors' coding was high as the same dominant lens was found in all but one of the cases and only in five cases was there discussion about whether or not to include a second or third lens, which suggested the categorization was robust. We solved differences by inclusion, to avoid overestimation of the dominance of a single perspective.

On the individual word-level, we extracted important, meaningful words in the context of RE using count frequency data. We grouped specific words (e.g. solar, wind, hydro, jatropha) into more general first-order concepts with a unified meaning (renewables) to increase the clarity of results and to facilitate interpretation. We used Boolean operators to search for groups of words, quotation marks (" ") to search for specific strings, the star symbol (*) to allow for multiple endings of words and the question mark (?) to allow for a single unknown letter. After the first order categorization, we searched for relationships between the first order words. This stepwise process then allowed categorization into second order concepts that fitted into the overarching dimensions provided by the four a priori lenses (as shown in table 2). These second order concepts then formed the basis of our further description of the various lenses. Some technical details are provided in Appendix B, together with a list of the exact words we used to determine the first order words (numbers 1 to 9 in figure 3).

Findings

Figure 1 depicts a growing interest in "rural electrification" overall. From the phrase's first appearance in 1990 and through to 1992, there were just 1, 2 and 4 papers published each year on the topic. By 2009, the number of publications had grown significantly, and this trend continued through until 2011 with 25 (2009), 27 (2010) and 49 (2011) articles appearing in our sample. In total, the period 1990-2000 produced 47 papers (20%), while 185 articles (80%) were written between 2001 and 2011.

Figure 1: Number of publications per dominant lens between 1990 and 2011

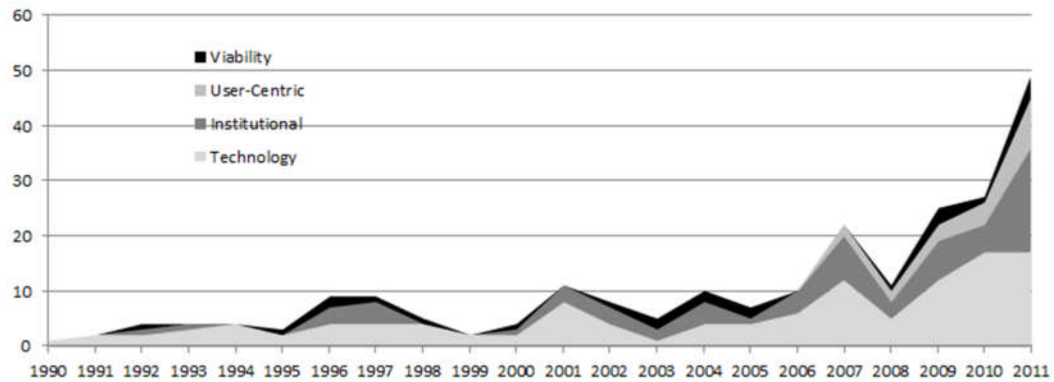


Figure 2 provides an overview of the relative incidence of different lenses per year. It demonstrates large variation, although the dominance of technology exhibits a diminishing trend while the institutional lens seems to fluctuate at around 30% dominance since 2001. The figure reveals that the user-centric lens gained dominance only in 2007. Given the limited number of data points, we refrain from any statistical tests about the significance of these changes over time.

Figure 2: Relative incidence of the four focal lenses

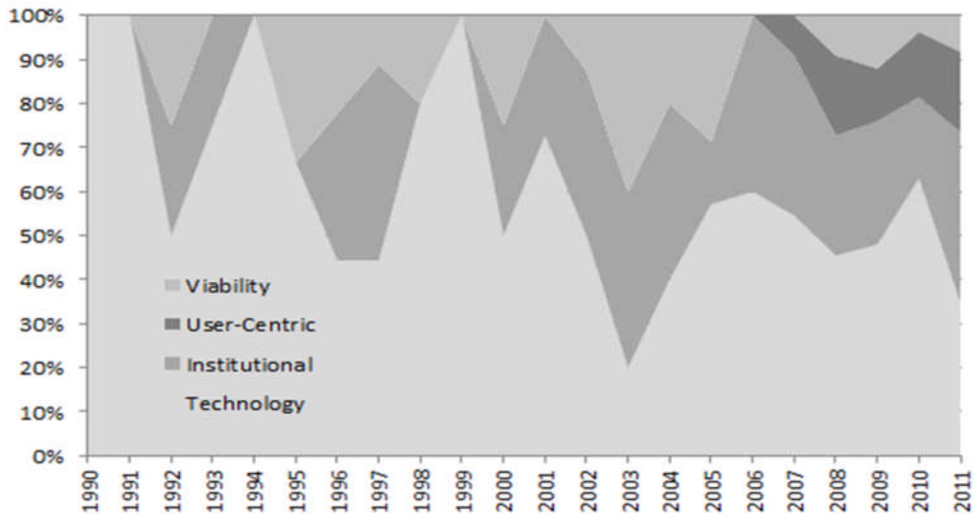


Table 1 summarizes the classification of the 232 papers. It distinguishes between dominant and secondary lenses and divides the sample into two 11 year periods. Every study was classified as having one dominant lens. One or more secondary lenses were attributed to nearly 40% of the papers (90 papers used in total 125 secondary lenses). The numbers between brackets reflect percentages of relative incidence[1].

Table 1: Prevalence of Four Lenses

Dominant	Technology	Institution	User-centric	Financial
Total	120 (52%)	69 (29.5%)	20 (8.5%)	23 (10.0%)
1990 - 2000	30 (64.0%)	10 (21.5%)	0 (0.0%)	7 (15.0%)
2001 - 2011	90 (48.5%)	59 (32.0%)	20 (11.0%)	16 (8.5%)
Secondary	Technology	Institution	User-centric	Financial
Total	37	24	31	31
1990 - 2000	7	7	4	3
2001 - 2011	30	17	27	28

Between 1990 and 2000, almost 64% of papers used a dominant technology lens whereas 21.5% of articles used a dominant institutional lens. Post 2001, 48.5% of articles used the technology lens, whereas 32.0% of articles chose an institutional lens. While we expected that the user-centric lens had received relatively little attention (8.5% in total), we did not anticipate the paucity of studies that use the viability lens (10.0% in total). This can potentially be explained by the lack of data availability as many projects are still operational, and hence no conclusive financial results are known. Alternative explanations for why so few studies have an explicit financial focus could be: (1) data security when particular financial flows are of competitive importance, (2) lack of transferability because replicating financial schemes is often difficult given regulatory, cultural or climate-related regional disparities, or (3) our allotting system did not score studies as such because the studies only briefly allude to the project's financial scheme.

The secondary lens data show that since 2001 the user-centric and viability lenses (27 and 28) are almost as prevalent as the technology lens (30), indicative of their growing relevance in the literature. Moreover, the numbers are also indicative of an increasing integration of various lenses. Before 2001, secondary lenses were used 44% of the time, while after 2001 this number rose to 55%[2].

In order to increase confidence in our early categorization, we compiled the 232 abstracts into a single file and used word frequency counts to analyse key themes. Figure 3 depicts the first order word frequency categorization, matched with the four lenses. When controlling for the number of distinct first order words (and thus different meanings), the figure exhibits a strong prevalence of the technology and institutional lenses, which are centred on a small number of words. The figure also highlights the complexity of the user-centric lens, which requires a broad selection of words to fully capture its meaning. We standardized the word counts and, consistent with previous observations, found that the word incidence for technology and institutional first order words was almost twice as high as for viability and user-centric words.

Figure 3: First order words

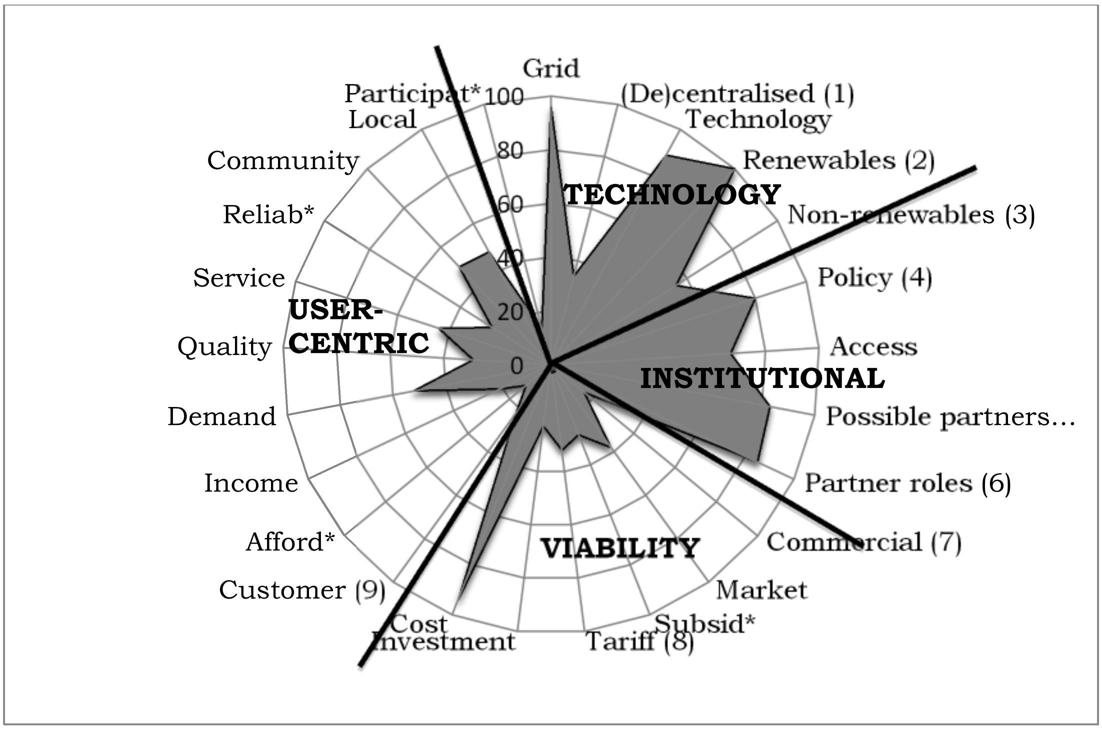


Table 2 brings together the a priori categorization on the abstract-level, with the emergent second order concepts that are themselves based on the word frequency data on the word-level. The next section uses these second order concepts as pillars for the description of the four lenses. While we describe the technology, institutional, and viability lenses relatively briefly, we elaborate more on the user-centric lens. We do so to provide a counterweight to the current dominance of the other lenses and because we firmly believe that a structured discussion of the user-centric lens can both contribute to practice and policy as to future research.

Table 2: Overview of lenses and 1st & 2nd order concepts

1st order words	2nd order concept	Lens	Exemplary papers
Centralised / Decentralized + Grid / Off-Grid	Distribution	TECHNOLOGY: The paper focuses on the design or use of a specific RE technology or a specific way of distributing electricity or compares different technologies and their economic viability.	Darkazalli and Nowlan (1996); Lemaire-Potteau et al. (2006); Siemons (2001)
Renewable / Non-Renewable + Technology	Technology Choice		
Policy + Access	Governance	INSTITUTTIONAL: The paper deals focuses on policy and governance issues (e.g. access,	Gurung et al. (2011); Moonga Haanyika (2006); Nygaard (2010)

Partners (types) + Partners (roles)	Partners / Consortium	evaluation) of the RE project or on the various partners within the RE project.	
Commercial + Market + Subsidies	Approach	VIABILITY: The paper focuses on the financial mechanisms used to enable (or disable) financial viability of the project.	Jacobson (2007); Pereira et al. (2011); Waddle and Perlack (1992)
Cost + Investment + Tariffs	Revenue Structure		
Affordability + Income + Customer	Affordability	USER-CENTRIC: The paper puts the potential or future user of the RET at the heart of the debate and investigates their needs, the role of their communities and their resource limitations.	Miller and Hope (2000); Moner-Girona (2009); Yadoo and Cruickshank (2010)
Quality + Service + Demand / Sufficiency	Reliability		
Community Involvement + Cultural Sensitivity + Competence Building	Local Embedded-ness		

The Four Lenses in Rural Electrification Studies

Technology Lens

The technology lens focuses on the distribution system of electricity and the selection and regional and environmental suitability of specific technologies.

There is currently no clear consensus on the system properties most conducive to electricity distribution. While the 20th century saw the centralized system gradually coming to dominate the global electricity market, this outcome was neither inevitable nor universal (Granovetter and McGuire, 1998). Now, at the dawn of the 21st century, arguments for more decentralized systems, such as mini-grid and off-grid solutions in developing countries, are rapidly gaining currency (Nouni et al., 2008; World Bank, 2005, 2008b). What is increasingly agreed upon is that both centralized and decentralized solutions can be superior depending on the context. For example, Zerriffi (2007) argues that the scope for distributed power generation is partly “a function of fundamental technical factors related to topography, population density, and the like that make centralized systems ill-suited to serving some rural populations”. The answer to the question “to grid or not to grid?” seems to be a disputable area that shrinks or expands based on changes in, amongst others, technology, subsidies and institutional capacities.

Studies reveal that technology choice is a function of the local cost of energy and of the environmental impact it entails. Understanding the *cost drivers* goes beyond a comparison of available electricity generation technologies (REN21, 2011; World Bank, 2008b) and three-phase or single-phase transmission lines (Bekker et al., 2008). Instead, robust estimates of energy cost require an understanding of a broader range of cost drivers, such as the price volatility of diesel for diesel gensets (Casillas and Kammen, 2011), natural resource endowments and available infrastructure. The stronger the availability of natural resources that serve as an energy source - be it water flow, solar irradiation or wind - the cheaper energy production could be. Road infrastructure affects the costs of fuel transport, which is generally higher for micro-grids than for off-grid solutions (Wamukonya, 2007) and impacts on the costs of servicing and maintaining a given technology. These costs are especially high when the local transportation system is underdeveloped (Müller, n.d.). Proximity of electricity distribution infrastructure is also an essential cost parameter. For example, micro hydro systems, wind-solar hybrid systems and stand-alone PV systems can become feasible substitutes with coal-fired grid based power plants on a distance of respectively 5, 12 and 18 kilometres between the village and the grid (Krishnaswamy, 2010).

As the impact of extreme weather and climate change related events is likely to be more severe in developing countries than in the West (UNFCC, 2007), *environmental concerns* are increasingly driving technology choice. Balachandra (2011) states the key objective for India’s energy policy should be providing electricity access to the poor without compromising India’s ambitions with regards to climate change. In fact, UNDP’s Human Development Report, notes that providing basic modern energy services for the entire world would only raise carbon dioxide emissions by 0.8%, taking into account already announced policy commitments (UNDP, 2011). Distributed technologies, decreasing RET costs and increasing fossil fuel and distribution prices, in combination with a better understanding of technology-related cost drivers and rising environmental concerns, prove to be fundamental determinants of the technology lens.

Institutional Lens

The focus of the institutional lens for RE projects is on governance issues, such as policy design and access, and on the formation of a partnership or consortium able to deliver the desired services.

Governance can be understood as the process of designing and enforcing the rules of the game in order to create a supportive RE environment. CORE (2003) acknowledges the vital importance of a supportive environment, stating that no electrification project has ever succeeded without significant government backing and strong political will. For instance, one of the key success factors in the Vietnamese success story was local and central government's unwavering commitment to rural electrification (World Bank and ASAEP, 2011). The importance of government involvement is not restricted to the developing world, as exemplified by Granovetter and McGuire (1998). The rules of the game are encapsulated in the energy policy of the government. First and foremost, the government decides on a sequential order for *access* to regional electrification. Deichmann et al. (2011) argue in favour of an economical algorithm that focuses on lowest marginal cost per connection, which following World Bank (2008b) depends on household service level, total number of households at location, load density, load growth, load curve, productive loads, renewable resource availability, fuel costs, necessary supply reliability and long-term electrification planning (World Bank, 2008b). The Peruvian government on the contrary gives priority to those regions with the lowest incidence of electricity connectivity and highest poverty index (DGER, 2010) while Costa Rica and Thailand used other differentiators such as level of commercial development and infrastructure investments to prioritize regional access (Barnes and Foley, 2001).

Independent of the parameters used to decide who gets access first, Stapleton (2009) suggests that a *transparent energy policy* must be clear about what regions will be electrified in the next 5 to 10 years. This transparency in combination with an enforceable and independent regulatory framework can spark entrepreneurial activities of independent power producers, who require official authorization to build and operate power plants, to sell energy to utilities and to gain access to transmission and distribution (T&D) systems at acceptable prices (World Bank, 2008b). Alternatively, the government can opt for a "lowest-subsidy-auction" and cooperate with the lowest bidder that meets government's expected results, as was the case in Bolivia (Reiche et al., 2007) and Argentina (Covarrubias and Reiche, 2000).

Besides crafting an energy policy and designing the systems to facilitate market functioning, governments generally require the cooperation of various partners to develop concrete RE projects. In line with recent business literature, this shows that providing services to the poor is not a matter of national governments alone anymore (George et al., 2012; Prahalad and Hammond, 2002; Thompson and MacMillan, 2010). A multipartite approach capitalises on the strengths of each partner and mitigates their respective weaknesses thereby improving the governments' capacity to deal with RE's complexity. We see four different roles - implementation, capacity building, knowledge and finance - in any rural electrification consortium. All these roles also interact and intersect with good governance.

Implementation deals with the physical realization of the project on the ground. Traditionally utility companies, governmental departments and private sector businesses take on the role of implementers. *Knowledge* partners not only bring in knowledge about local customs (often Non-Government Organisations, Community Based Organisations or local entrepreneurs) and technical solutions (utilities, multinational institutions), but also contribute actively to national and local institutional capacity building (World Bank, 2004, 2008c). *Capacity building* by involved utilities, for instance, includes branching into specific RE agencies to develop the skills needed to successfully implement RE strategies (Foley, 1992). *Finance* envelops those organizations that invest in financial means via loans, subsidies, affordable credits and tax reductions or via international systems like the Clean Development Mechanism. A variety of lenders, ranging from global organizations like World Bank to locally operating micro-finance institutions and informal savings groups, provide grants or loans and co-construct a supportive environment for RE investments. An in-depth analysis of the various roles organizations enact is beyond the scope of this paper, but it is generally acknowledged that most partners incorporate various and partially overlapping roles. This is especially common in the case of large global institutions like World Bank who can enact all roles and influence governance at the same time.

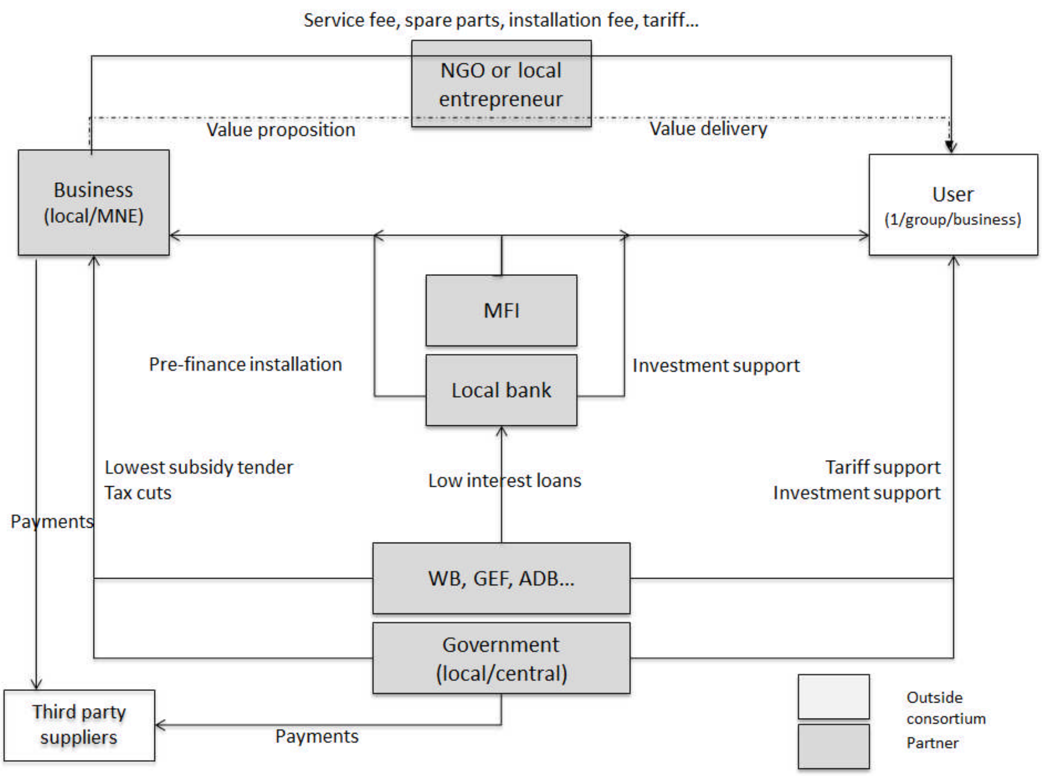
In summary, the institutional lens looks at RE by analysing governance issues such as policy design, access creation, and forging cooperation with partners who possess complementary capabilities and resources.

Viability Lens

The viability lens addresses the revenue structure of the consortium's business model. We define the revenue structure as the organization of financial flows between the partners, the customers and potential third parties[3]. If these financial flows cover the acquisition of technology, delivery of electricity, maintenance of the system and all personnel costs then the project is viable. Although the boundaries between third parties and partners are vague, we limit 'the consortium' to those partners that bear an operational risk and are actively engaged in the realization of the project. In other words, a consortium comprises of organizations whose complementary assets provide the resources required to deliver the intended service.

Figure 4 offers a conceptual model of financial flows among members of the consortium (grey) and potential third parties and customers (white). All 'solid' arrows represent financial flows whereas the 'dash-type' arrow depicts the direction of the 'value proposition', which can be understood as the service or product that the business delivers to the customer.

Figure 4: Revenue structure for Rural Electrification



Our definition of viability does not determine the distribution of rents and investments between the partners. The approach chosen by the initiating partners is situated on a continuum between completely commercial (no subsidies at all) and completely social (100% subsidized). Most projects are incompletely commercial, which means that end users do not pay for some aspect of the total cost. A financer can then choose to (partially) fund capital investment, spare parts, operations and maintenance (O&M) and/or electricity. Research suggests that fully subsidised schemes are suboptimal for long-term viability (e.g. Stapleton, 2009), though it is necessary that the local market tariff/price be affordable and thus partially subsidized for low-income, low-consumption customers (Niez, 2010). According to CORE's research (2003), the idea that rural inhabitants would be unable or unwilling to pay for electricity is a misconception that creates an unviable subsidy-dependence. Additionally, viability has an important *time-dimension* that is especially important in an imperfect world with imperfect markets (Mulder and Tembe, 2008). Governments can provide a wide range of incentives to incorporate the time-dimension (e.g. what happens after the subsidy?) of the project, increase affordability and reduce risk and uncertainty for local people (e.g. REN21, 2010).

User-Centric Lens

The user-centric lens puts the user in the centre of business model design and attempts to understand the needs of customers, end users and involved/affected communities (IDEO, 2009). Barnett (1990) underlines the importance of this approach, stating that "one of the few characteristics that clearly distinguishes between success and unsuccessful innovation is whether the technology meets the needs of the particular users" (p547) and that more must be invested in "understanding the needs of potential users of technology in rural areas" (p551). Consequently, a better understanding of what problem the technology is meant to solve, has high returns (Barnett, 1990). By analysing the literature through a user-centric lens, we deduced three core second order concepts – affordability, reliability and local embeddedness - that are fundamental to understanding user needs. As previously stated, to overcome the relative lack of attention in the relevant literature, we develop the user-centric lens in more detail.

Affordability

Three distinct yet intertwined concepts determine affordability: *capital access*, *periodic payments* and *risk shifting*. First, low income, few savings and a lack of experience in purchasing durable goods (Balint, 2006; Banerjee and Duflo, 2007) exacerbate poor people's credit needs for investments in electricity generating technologies. But, credit markets often do not exist or require collateral and/or a regular income stream poor people often do not possess (Howells et al., 2005; Sengendo, 2001). This lack of access to functioning credit markets explains why lump sum down payments or installation fees for renewable energy technologies (RET) form severe barriers to RET diffusion (Biswas et al., 2004). In Bolivia for instance, a small local grid doubled its number of customers when it started to spread connection cost payment over five years, whereas in Malawi the electricity company demands a full upfront payment of the 30 year cost of line extension, resulting in a RE rate of only 2% (Barnes and Foley, 2001).

Second, the size, timing and duration of periodic payments – the combination of periodic charges including tariffs, O&M, spare parts and interests - are vital drivers of affordability. No overarching studies investigating the maximum percentage of income that can be spent on energy have been found, but the low income-generating potential of RETs (e.g. Wamukonya, 2007) seems to suggest that it cannot be a lot more than people spent on energy sources before their connection (about 25% of daily/monthly budget). It seems probable that longer payback periods are preferred over higher periodic fees so that people need to divert less income from other pressing needs (Mala et al., 2009). Importantly, the moment of payment can be adapted to local needs. For example, in Zimbabwe, payments were on a yearly basis, following the annual cotton sale (Mapako and Afrane-Okese, 2002).

Third, depending on the revenue structure of the business model, periodic payments can be fixed or (partially) variable. The variability of costs adds considerable risk to the investment, which studies on risk aversion (Kahneman and Tversky, 1979, 1981; Miller and Hope, 2000) suggest would be likely to disproportionally lower RE uptake liken to predictable cost scenarios. This problem of risk shifting also occurs when ownership is transferred. because the customer suddenly bears the operation and maintenance (O&M) risks and associated costs. However, there are business models that avoid this problem: in Bangladesh, the operational risk remained with Grameen Shakti, although ownership was immediately transferred to the customer (Alamgir, 1999). We found no single RE paper that explicitly incorporated these replacement costs and associated risks in their analysis of the purchasing decision.

Reliability

The reliability of electricity provision is an important parameter in the customer's decision-to-connect. We understand reliability as a combination of quality, service level and sufficiency (timely delivery of desired quantity). Customers can generally not assess the objective quality of a technology (Gradl and Knobloch, 2011; Rebane and Barham, 2011), but this does not mean that quality is not important to them. In Morocco, Argentina and Indonesia, various quality control systems were implemented to ensure high quality standards and increase customer confidence (Arias, n.d.; FFEM, 2005; World Bank, 2004). When this does not happen, the results can be damaging. For instance, Dagbjartsson et al. (2007) argue that Africa's legacy of diverse standards has resulted in the "unavailability of spares, non-upgradeable aging networks and equipment incompatible with the environment",. Wamukonya (2007) suggests that labelling, standardization, and regulation are an important avenue for dealing with these threats to quality.

Service primarily deals with the financial and operational responsibility of the O&M of the installed systems. Shifting responsibility to the service deliverer or increasing local competences by basic maintenance training and simple manuals could increase the needed support for installed technologies (Wamukonya, 2007). In Lao PDR, the lack of service heavily limited the functionality of installed solar housing systems (SHS) (World Bank, 2008c), while both Temasol in Morocco (Allalli, 2011) and Grameen Shakti in Bangladesh (Alamgir, 1999) designed a profitable service model that maintained the functionality of the installed equipment.

The sufficiency of supply is determined by the provided quantity at the moment when the electricity is needed. In Indian rural areas, the grid offers an erratic supply at best (Krishnaswamy, 2010). This generally has a negative impact on the rate of electrification (Kemmler, 2006) but sometimes drives decentralized solutions (Rajvanshi, 2006). In Gambia, T&D losses and unmetered consumption are estimated at about 40%, which drastically reduces sufficiency (Sanneh and Hu, 2009). Dagbjartsson et al. (2007) note that customers who depend on PV systems are less satisfied than those connected to the grid because of insufficient quantity of supply. The World Bank (2008c) confirms this for Sri Lanka but importantly notes that grid users use on average six times more electricity than SHS users, which might explain their greater satisfaction.

Local embeddedness

Local embeddedness encompasses those aspects of a project that relate to how people in the targeted communities experience the change in their environment. Our interpretative review reveals that community involvement, cultural sensitivity and competence building are constituent factors. Walker and Devine-Wright (2008) argue that community involvement has both a process and outcome dimension. On a process level, CORE (2003) states that "[p]articipation of rural people in the designing, planning, implementation and operations of rural development programs is crucial in order to ensure the sustainability of such programs". Peters et al. (2010) confirm that locally conceived projects could overcome barriers that would otherwise arise, while Hossein Mondal et al. (2010) state that involving local stakeholders will facilitate RET diffusion. Involving the community from the conception stage thus reduces the 'not invented here syndrome' and improves acceptance of new technologies. They conclude that technology push projects seldom involve local communities and that this lack of involvement might be one of the crucial reasons for their demise. On an outcome level, Reiche et al. (2000) state that giving local communities ownership will also increase sustainability. Yadoo et al. (2011) argue in a similar vein that Nepal's RE programme is so successful thanks to its proven ability to generate a sense of community ownership.

Cultural sensitivity refers to the extent to which RE programmes embed local habits and norms into their designs. In their discursive analysis of a technology introduction, Munir and Phillips (2005) conclude that managing the meaning of a new technology, embedding it in everyday life and integrating its use with social dynamics occurring within the relevant society is potentially more important for local adoption than the nature of the technology itself. Müggenburg (2011) writes that in developing countries more attention should be given to (emerging) cultural values, traditions, beliefs, norms and social structures to increase local acceptance of electrification programmes. The importance of culture is exemplified in successful projects that explicitly recognised cultural issues relating to the role of women and local customs and in the failure of those that do not. In Uganda for instance, women were explicitly considered as target customers (World Bank, 2008c), and in Nepal female only discussion and decision groups were formed to ensure participation and voice (Yadoo et al., 2011) which made both projects fairly successful. In South Africa on the other hand, the failure to acknowledge local cooking customs was one of the causes of the poor project outcome (Howells et al., 2010).

Competence building can reduce operational costs and increase learning effects within participating organizations. Krishnaswamy (2010) argues that teaching users how the installed system works, and specifically what its limitations are, is of utmost importance in developing successful RE projects. Providing customers with "reference material that explains handling and maintenance and outlines common issues and solutions" will decrease O&M costs and thus makes business sense (Gradl and Knobloch, 2011). Involving locals in the project operations might further reduce costs. The Vietnamese government and World Bank for instance developed a service-agent model in which local community members maintained the low voltage systems, carried out simple repairs and handled collections on behalf of the power companies. The benefits of this approach were non-payment minimization, reduction in O&M costs, accountability of local communities and reduced system losses (World Bank and ASAEP, 2011). On a business level, it is moreover important that companies engaged with RE, reap themselves the opportunities of competence building. By working abroad and developing new markets, companies invest in the competences of their own people and learn lessons can eventually be integrated back in their core business.

Conclusion: Towards an integrated business model framework

Thus far, we have drawn insights from the various lenses used to discuss RE projects. Our content analysis of 232 papers showed a clear dominance of technology and institutional lenses while highlighting a much smaller incidence of viability and user-centric lenses. This finding shows that less attention has been paid to understanding user needs and revenue models than to understanding technology and institutional contexts. While our exploration of the viability lens has been brief, we have highlighted the importance of the subsidy-commercial continuum and explicitly incorporated the time dimension. We recommend including a post-project plan for after the subsidization period to increase the likelihood of self-sufficiency and long-term viability. Our conceptualization of the user-centric lens underlines the importance of affordability, reliability and local embeddedness for project uptake and diffusion of RETs.

Our final step is to collate these four lenses to create an integrated business model toolkit for RE projects. We have used business model thinking in a new context that does not focus on a single business but on cooperative projects between various partners, without an obvious profit-orientation and with a socially responsible endgame. While this context is novel, we follow Zott et al. (2011) in our emphasis on a holistic approach, our focus on systemic perspectives and our exploration of the value-creating, beyond mere value-capturing, potential of the business models involved. The important lesson is that in RE projects, the whole is more than the sum of the parts. By integrating the four lenses into a coherent framework, represented by the toolkit in table 4, we stress the importance of understanding the links between the choices that need be made both in design and assessment of RE projects. As suggested by George and Bock (2012), often it is the coherence of the business model narrative that determines the difference between success and failure. Without integration of the various lenses, the construction of a coherent RE narrative seems almost impossible.

We believe that a better understanding of users and more community-involvement is likely to increase long-term sustainability of RE projects, thereby increasing the effect of limited governmental resources. Our proposed business model toolkit not only provides a powerful summary to the paper but also provides policy makers, practitioners and investors with a checklist of pre-requisites for a sustainable and viable rural electrification project.

Table 3: Integrated Business Model Toolkit

	User	Who is the user? (Rural, urban, household, entrepreneur, existing business?) What is the monthly income of the user? What savings does the user have in cash or goods?
User-centric	Affordability	How much is the user spending on energy on a daily/weekly/monthly basis? Does the user have access to credit and at what interest rate? Is the loan repayment schedule flexible i.e. Payment in installments based on seasonal variations? What % of income would the user be able to pay for energy provision? What costs are fixed in the periodic payment and which ones are variable?
	Reliability	Can the installed system be repaired within a reasonable timeframe? Are spare parts available and accessible to users? Who is responsible for maintaining the system? Does the maintaining agency have a credible track record? What quality control systems are implemented to ensure the proper functioning of the technology? Is energy access easy and consistent throughout the day and night? Is the quantity of energy provided sufficient to meet the needs of the user? How many outages are expected on a monthly basis?
	Local Embeddedness	Has there been a need assessment carried out for the target community? Is the target community involved in the design, planning and implementation of the project? Will the community gain ownership of the installed system? Are local cultural values, habits and norms considered? Are local competences being built during the project? Are the users willing and able to pay the tariffs? Has there been an element of training built in the project? Is there a manual in local language that explains the functionality and maintenance of the system? Does the user understand how the installed system works and what its limitations are?
Technology	Distribution	Does the project require central grid extension or not? What rationale is used for the choice between grid or off-grid solutions? How far away is the target community from the nearest central grid connection?
	Technology Choice	What technology will be used to generate electricity? What kind of transmission lines will be used to transport the energy? Is the infrastructure available to support continuous supply of necessary inputs? Are natural resource endowments being exploited as energy sources? What is the environmental impact of the chosen technology? Are forecasts of prices and availability for necessary inputs (spare parts, fossil fuels) realistic?
Institutional	Governance	Is there political will in the country/region for energy provision? Does the energy policy of the country support rural electrification? Is there a clear road map for future extension for RE in the nations energy policy? What parameters drive the prioritization of access creation? Is there a functioning regulatory framework for entrepreneurial energy providers? Do independent power producers have access to T&D lines at acceptable prices? Does the government execute tight control over the implementation?

	Partners	Are the necessary capacities with regards to knowledge, implementation and finance represented? Is national and local capacity building an objective of the partnership? How experienced are the various partners in the provision of low-cost rural energy services? Have the roles and responsibilities of all partners been defined clearly and agreed before the project commences?
Viability	Approach	Does the project have an explicit poverty alleviation and social impact goal? Does the project set tariffs that are pro-poor and pro-business? Does the project support economic growth by livelihood creation? Does the project create an enabling environment for local commercial businesses to invest? If there are subsidies and tax breaks built into the costing have they been agreed by all partners? What kind of financial (incentive) structures have an impact on total cost?
	Revenue Structure	What is the total expected project cost? What percentage of the total project cost is subsidized externally and internally? What percentage of the project cost is borne by users? Is the expected periodic payment below the revenue boundary of the target community? Is there a short-term and long-term plan to sustain the O&M costs? How is the revenue collected? Is there a microcredit or low interest lending system set up for users? Are the possible financing risks considered and mitigated?

Although our toolkit focuses specifically on RE, it could be interesting to see whether it could be applied to other forms of infrastructure, such as water, transportation, or even healthcare. The technology lens would clearly have to be adapted, but the other three might prove to be more generic than initially intended. In a similar vein, our approach of using business model thinking to explore project-based cooperations opens up new research avenues. While business model thinking has to this point been largely confined to the world of firms, a consortium-approach to business models provides new challenges for future research. The cooperation of corporate, non-governmental and governmental actors in a single project makes the development of a coherent business model and according narrative very challenging. Nonetheless, these cooperative endeavours are fundamental to the success of RE projects and many other projects in the fields of sustainable development. It is only through consortia that the necessary resources and capabilities can be effectively brought to bear on the social ills that are being faced at the bottom of the pyramid. With a market expected to grow to 3.5 billion in the foreseeable future, the potential for creating radically innovative business models built on cooperation is great. We hope our paper can make a contribution to tackling this important challenge.

Acknowledgements
We gratefully acknowledge the support of the Engineering and Physical Sciences Research Council project “Replication of Rural Decentralised off-grid Electricity Generation through Technology and Business Innovation” (EPSRC grant EP/G06394X/1). The comments of two reviewers and Sam Macaulay have helped improve this paper. We thank the Rajiv Gandhi Centre at Imperial College Business School for supporting research on business models in resource constrained environments. Gerry George gratefully acknowledges the support of the Professorial Fellowship of the UK’s Economic and Social Research Council (RES-051-27-0321).

References

ADB, 2010. Asian Development Bank’s Assistance for Rural Electrification in Bhutan – Does Electrification improve the Quality of Rural Life? ADB Evaluation Study, Asian Development Bank.
Afuah, A., 2001. Business Models: A strategic management approach McGraw-Hill/Irwin Publishing, New York.

Alamgir, D.E.H., 1999. Application of PV Technology for Rural Electrification and Income Generation: Experience of Grameen Shakti International Workshop on Dissemination of Solar Photovoltaic Energy in Bangladesh, Bangladesh.
Allalli, N., 2011. TEMASOL: Providing energy access to remote rural households in Morocco
Amit, R., Zott, C., 2001. Value creation in e-business. Strategic Management Journal 22, 28.
ARE, 2010. Rural Electrification with Renewable Energy, Technologies, Quality standards and Business Models Alliance for Rural Electrification, p. 56.
Arias, C.A., n.d. Argentina, EJSEDSA – Programa de Abastecimiento Electrico a la Poblacion Rural de Argentina.
Balachandra, P., 2011. Modern energy access to all in rural India: An integrated implementation strategy. Energy Policy 39, 12.
Balint, P.J., 2006. Bring solar home systems to rural El Salvador: lessons for small NGOs Energy Policy 34, 9.
Banerjee, A.V., Duflo, E., 2007. The economic lives of the poor Journal of Economic Perspectives 21, 27.
Barnes, D., Foley, G., 2001. Rural Electrification in the developing world: a summary of lessons from successful programs, Joint UNDO/World Bank Energy Sector Management Assistance Programme.
Barnett, A., 1990. The diffusion of energy technology in the rural areas of developing countries: a synthesis of recent experience. World Development 18, 15.
Bekker, B., Eberhard, A., Gaunt, T., Marquard, A., 2008. South Africa's rapid electrification programme: Policy, institutional, planning, financing and technical innovations Energy Policy 36, 13.
Biswas, W.K., Bryce, P., Diesendorf, M., 2001. Model for empowering rural poor through renewable energy technologies in Bangladesh. Environmental Science & Technology 4, 12.
Biswas, W.K., Diesendorf, M., Bryce, P., 2004. Can photovoltaic technologies help attain sustainable rural development in Bangladesh? Energy Policy 32, 9.
Bond, M., Fuller, R.J., Aye, L., 2007. A policy proposal for the introduction of solar home systems in East Timor. Energy Policy 35, 11.
Casillas, C.E., Kammen, D.M., 2011. The delivery of low-cost, low-carbon rural energy services Energy Policy 39, 9.
Chaieb, S., Ounalli, A., 2001. Rural Electrification Benefits Women's Health, Income and Status in Tunesia Energia News 4, 3.
CORE, 2003. Issues and options for rural electrification in SAPP member countries and rural electrification planning in Lesotho Energy and Environment Training Program Global Bureau - USAID, Washington.
Covarrubias, A.J., Reiche, K., 2000. Energy Services and the World's Poor, Energy and Development Report 2000: A case study on exclusive concessions for rural off-grid service in Argentina, in: Programme, E.S.M.A. (Ed.). World Bank, Washington.
Cromer, B., Stager, M., 2000. Research Articles Published in the Journal of Adolescent Health: A Two-Decade Comparison. Journal of Adolescent Health 27, 7.
Dagbjartsson, G., Gaunt, C.T., Zomers, A.N., 2007. Rural Electrification: a scoping report
Darkazalli, G., Nowlan, M., 1996. Photovoltaic manufacturing in developing countries. Renewable Energy 8, 415-419.
Deichmann, U., Meisner, C., Murray, S., Wheeler, D., 2011. The economics of renewable energy expansion in rural Sub-Saharan Africa. Energy Policy 39, 13.
DGER, 2010. Plan Nacional de Electrificacion Rural (PNER) – Periodo 2011 - 2020, in: Minem (Ed.). Direccion General de Electrificacion Rural, , Lima.
FFEM, 2005. Decentralised rural electrification in Morocco – Combating the greenhouse effect and climate change. Fonds Francais pour l' Environnement Mondiale,.
Foley, G., 1992. Rural electrification in the developing world Energy Policy 20, 8.
Gaunt, C.T., 2005. Meeting electrification's social objectives in South Africa, and implications for developing countries. Energy Policy 33, 9.
George, G., Bock, A.J., 2011. The business model in practice and its implications for entrepreneurship research. Entrepreneurship Theory and Practice 35, 29.
George, G., Bock, A.J., 2012. Models of opportunity, how entrepreneurs design firms to achieve the unexpected. Cambridge University Press, Cambridge.
George, G., McGahan, A.M., Prabhu, J.C., 2012. Innovation for inclusive growth: Towards a theoretical framework and research agenda. Journal of Management Studies 49, 23.
Ghosh, S., Das, T.K., Jash, T., 2004. Sustainability of decentralized woodfuel-based power plant: an experience in India. Energy 29, 12.
Gilbert, N., 2001. Researching Social life, 2nd ed. Sage Publishers, London.
Gradl, C., Knobloch, C., 2011. Energize the BoP: Energy business model generator for low income markets – a practitioner's guide. Endeva.

Granovetter, M., McGuire, P., 1998. The making of an industry: electricity in the United States, in: Callon, M. (Ed.), The Laws of the Markets Blackwell Publishers / The Sociological Review Oxford.
Gulberg, M., Ilskog, E., Katyega, M., Kjellström, B., 2005. Village electrification technologies – an evaluation of photovoltaic cells and compact fluorescent lamps and their applicability in rural villages based on a Tanzanian case study. Energy Policy 33, 10.
Gurung, A., Kumar Ghimeray, A., Hassan, S.H.A., 2011. The prospects of renewable energy technologies for rural electrification: A review from Nepal. Energy Policy.
Hossein Mondal, M.A., Kamp, L.M., Pachovam, N.I., 2010. Drivers, barriers and strategies for implementation of renewable energy technologies in rural areas in Bangladesh – an innovation system analysis Energy Policy 38, 9.
Howells, M.I., Alfstad, T., Victor, D.G., Goldstein, G., Remme, U., 2005. A model of household energy services in a low-income rural African village. Energy Policy 33, 18.
Howells, M.I., Jonsson, S., Käck, E., Lloyd, P., Bennett, K., Leiman, T., Conradie, B., 2010. Calabashes for kilowatt-hours: Rural energy and market failure. Energy Policy 38, 2729-2738.
IDEO, 2009. Human Centered Design – Toolkit, in: IDEO (Ed.), HCD connect.
IEA, 2010. Technology Roadmap, Solar Photovoltaic Energy in: International Energy Agency (Ed.), Technology Roadmaps. IEA.
Jacobson, A., 2007. Connective power: solar electrification and social change in Kenya. World Development 35, 144-162.
Jenkins, H., 2009. A business opportunity model of corporate social responsibility for small- and medium-sized enterprises. Business Ethics: A European Review 18, 16.
Kahneman, D., Tversky, A., 1979. Prospect theory: an analysis of decision under risk. Econometrica 47, 30.
Kahneman, D., Tversky, A., 1981. The framing of decision and the psychology of choice. Science 211, 6.
Kaufman, S., Duke, R., Hansen, R., Rogers, J., Schwartz, R., Trexler, M., 1999. Rural Electrification with Solar Energy as a Climate Protection Strategy, in: Project, R.E.P. (Ed.).
Kemmler, A., 2006. Regional disparities in electrification of India – do geographic factors matter? . Centre for Energy Policy and Economics, Zurich.
Ketlogetswe, C., Mothudi, T.H., Mothibi, J., 2006. Effectiveness of Botswana's policy on rural electrification. Energy Policy 35, 8.
Krauter, S., Ochs, F., 2004. Integrated solar home system. Renewable Energy 29, 12.
Krishnaswamy, S., 2010. Shifting of goal posts – rural electrification in India: a progress report in: Aid, C. (Ed.), United Kingdom.
Lachman, D.A., 2011. Leapfrog to the future: Energy Scenarios and Strategies for Suriname to 2050 Energy Policy 39, 10.
Langevine, L.P., 1996. A diagnostic study of photovoltaic systems at rural health centres in Guyana Renewable Energy 10, 4.
Lemaire-Potteau, E., Vallvé, X., Pavlov, D., Papazov, G., Borg, N.V., Sarrau, J.F., 2006. ABLE project: Development of an advanced lead-acid storage system for autonomous PV installations. Journal of power sources 162, 884-892.
Lubis, A., Udin, Z., 1991. Three and a half years field test of fluorescent lamp as a load for PV rural electrification system. Renewable Energy 2, 3.
Mala, K., Schläpfer, A., Pryor, T., 2009. Better or worse? The role of solar photovoltaic (PV) systems in sustainable development: Case studies of remote atoll communities in Kiribati. Renewable Energy 34, 4.
Mapako, M.C., Afrane-Okese, Y., 2002. Experiences and Lessons in the Implementation of Solar Home Systems from Zimbabwe, Domestic Use of Energy Conference, Cape Technicon, Cape Town.
Miller, D., Hope, C., 2000. Learning to lend for off-grid solar power: policy lessons from World Bank Loans to India, Indonesia, and Sri Lanka. Energy Policy 29, 19.
Modi, V., McDade, S., Lallement, D., Saghir, J., 2005. Energy Services for the Millenium Development Goals The International Bank for Reconstruction and Development, The World Bank, United Nations Development Programme, Washington.
Moner-Girona, M., 2009. A new tailored scheme for the support of renewable energies in developing countries. Energy Policy 37, 2037-2041.
Moonga Haanyika, C., 2006. Rural electrification policy and institutional linkages. Energy Policy 34, 17.
Müggenburg, H., 2011. Rural Electrification: Acceptance of Pico Photovoltaic Systems in Ethiopia Psychology. Technical University of Darmstadt.
Mulder, P., Tembe, J., 2008. Rural electrification in an imperfect world: a case study from Mozambique. Energy Policy 36, 10.
Müller, H., n.d. Home Power! Awareness, Financing, Training, Namibia

Munir, K.A., Phillips, N., 2005. The Birth of the 'Kodak Moment': Institutional Entrepreneurship and the Adoption of New Technologies Organization Studies 26, 23.
Munro, D.K., Blaesser, G., 1994. The performance of PV systems and components in the thermie programme. Renewable Energy 5, 9.
Mustonen, S.M., 2010. Rural energy survey and scenario analysis of village energy consumption: a case study in Lao People's Democratic Republic Energy Policy 38, 9.
Niez, A., 2010. Comparative study on rural electrification policies in emerging economies – keys to successful policies, IEA Information Paper. International Energy Agency.
Nilsson, J., Flores, L., Berkel, L.V., Schale, C., Linnemeyer, R., Summer, I., 2007. International career articles: A content analysis of four journals across 34 years. Journal of Vocational Behavior 70, 12.
Nouni, M.R., Mullick, S.C., Kandpal, T.C., 2008. Providing electricity access to remote areas in India: an approach towards identifying potential areas for decentralized electricity supply Renewable and Sustainable Energy Reviews 12, 34.
Nygaard, I., 2010. Institutional options for rural energy access: Exploring the concept of the multifunctional platform in West Africa. Energy Policy 38, 1192-1201.
Pereira, M.G., Sena, J.A., Freitas, M.A.V., Silva, N.F., 2011. Evaluation of the impact of access to electricity: A comparative analysis of South Africa, China, India and Brazil. Renewable and Sustainable Energy Reviews 15, 1427-1441.
Peters, M., Fudge, S., Sinclair, P., 2010. Mobilising community action towards a low-carbon future: Opportunities and challenges for local government in the UK. Energy Policy 38, 7596-7603.
Pilbeam, C., Denyer, D., Wallace, M., 2008. Systematic reviews: RDI systematic literature reviewing workshop, AIM COnference. AIM, London.
Prahalad, C.K., Hammond, A., 2002. Serving the World's Poor, Profitably Harvard Business Review 80, 10.
Rabah, K.V.O., 2005. Integrated solar energy systems for rural electrification in Kenya. Renewable Energy 30, 20.
Rajvanshi, A.K., 2006. Strategy for Rural Electrification Project Monitor editorial.
Rebane, K.L., Barham, B.L., 2011. Knowledge adoption of solar home systems in rural Nicaragua. Energy Policy 39, 12.
Reiche, K., Covarrubias, A.J., Martinot, E., 2000. Expanding Electricity Access to Remote Areas: Off-Grid Rural Electrification in Developing Countries. World Power, 9.
Reiche, K., Rysankova, D., Goldmark, S., 2007. Output-based Aid in Bolivia: Balanced tender design for sustainable energy access in difficult markets, OBApproaches, pp. 1-4.
REN21, 2010. Renewables 2010 Global Status Report Renewable Energy Policy Network for the 21st century,, Paris.
REN21, 2011. Renewables 2011 Global Status Report Renewable Energy Policy Network for the 21st century,, Paris.
Rousseau, D.M., Manning, J., Denyer, D., 2008. Evidence in Management and Organizational Science: Assembling the field's full weight of scientific knowledge through syntheses in: Management, A.o. (Ed.), Annals of the Academy of Management Academy of Management.
Sanneh, E.S., Hu, A.H., 2009.): Lighting rural and Peri-Urban Homes of the Gambia Using Solar Photovoltaics (PV) The Open Renewable Energy Journal 2, 12.
Schillebeeckx, S., 2011. MVO 2.0 een duurzaam business model voor innovatieve ondernemers Wolters Kluwer, Brussels.
Seelos, C., Mair, J., 2005. Social Entrepreneurship: Creating new business models to serve the poor. Business Horizons 48, 6.
Sengendo, M.C., 2001. Photovoltaic project for rural electrification – Uganda Energia News 4.
Siemons, R.V., 2001. Identifying a role for biomass gasification in rural electrification in developing countries: the economic perspective. Biomass and bioenergy 20, 271-285.
Stapleton, G.J., 2009. Successful implementation of renewable energy technologies in developing countries. Desalination 248, 8.
Stemler, S., 2001. An overview of content analysis, Practical Assessment, Research, and Evaluation.
Stutenbäumer, U., Negash, T., Abdi, A., 1999. Performance of small-scale photovoltaic systems and their potential for rural electrification in Ethiopia. Renewable Energy 18, 14.
Thompson, J.D., MacMillan, I.C., 2010. Business Models: Creating New markets and Societal Wealth Long Range Planning 43, 17.
UNDP, 2011. Human Development Report 2011 – Sustainability and Equity: A Better Future for All United Nations Development Program,.
UNFCC, 2007. Climate Change: Impacts, vulnerabilities and adaptation in developing countries. United Nations Framework Convention on Climate Change.

Waddle, D., Perlack, R., 1992. Financing and disseminating small energy systems in rural areas. Energy 17, 1255-1262.
Walker, G., Devine-Wright, P., 2008. Community renewable energy: What should it mean? . Energy Policy 36, 4.
Wamukonya, N., 2007. Solar home system electrification as a viable technology option for Africa's development. Energy Policy 35, 9.
World Bank, 2004. Implementation Completion Report (TF-28488) on a GEF Grant in the amount of SDR 16,8 million to the republic of Indonesia for the Solar Home Systems Project. World Bank.
World Bank, 2005. Technical and Economic Assessment: Off-Grid, Mini-Grid and Grid Electrification Technologies. World Bank.
World Bank, 2008a. Designing sustainable off-grid rural electrification projects: principles and practices – operational guidance for World Bank group staff World Bank,.
World Bank, 2008b. Issues Note of the REToolkit – REToolkit: A resource for renewable energy development. World Bank,.
World Bank, 2008c. The Welfare Impact of Rural Electrification: A Reassessment of the Costs and Benefits, an IEG Impact Evaluation. World Bank.
World Bank and ASAEP, 2011. Vietnam, state and people, central and local, working together – the rural electrification experience World Bank and Asia Sustainable and Alternative Energy Program, Washington, p. 100.
Yadoo, A., Cruickshank, H., 2010. The value of cooperatives in rural electrification Energy Policy 38, 7.
Yadoo, A., Gormally, A., Cruickshank, H., 2011. Low-carbon off-grid electrification for rural areas in the United Kingdom: Lessons from the developing world. Energy Policy 39, 8.
Zerriffi, H., 2007. Making Small Work: Business Models for Electrifying the World Stanford University, Stanford.
Zott, C., Amit, R., Massa, L., 2011. The business model: Recent developments and future research Journal of Management 37, 2011.

Appendix A

Journals and article count of an initial sample of 267 articles

Journal Title	Original Count	Final Count
Renewable Energy	62	62
Energy Policy	60	60
Energy for Sustainable Development	29	29
Renewable and Sustainable Energy Reviews	24	24
Fuel and Energy Abstracts	14	0
Refocus	11	0
Energy	10	10
Solar Energy	9	9
Applied Energy	6	6
Photovoltaics Bulletin	5	0
Journal of Cleaner Production	4	3
Solar Energy Materials and Solar Cells	4	4
Biomass and Bioenergy	3	3
Energy Conversion and Management	3	3
International Journal of Hydrogen Energy	3	3
World Development	3	3
Desalination	2	2
Energy Procedia	2	2
International Journal of Electrical Power & Energy	2	2
Current Opinion in Environmental Sustainability	1	1
Journal of rural studies	1	1
Computers and industrial engineering	1	1
The electricity journal	1	0
Energy Economics	1	1
Futures	1	1
International Transactions in operational research	1	1
Journal of Power Sources	1	1
Sociologie du travail	1	0
Technology in society	1	1
Utilities policy	1	1
TOTAL PAPERS	267	234
TOTAL JOURNALS	30	25

Appendix B

Science Direct permits the use of specific operators such as * which allows for an open ending of a word (e.g. subsid* can refer to subsidy, subsidize or even subsidiary (we checked for the latter and found 0 articles using this word) or '?' which allows for an open letter (e.g. decentrali?ed allows both the English and American spelling with respectively s or z). Also we used quotation marks when looking for exact word combinations (e.g. "private sector"). Moreover, Science Direct searches incorporate the plural of words when the singular form is given (E.g. policy will also return policies as a hit).
We checked whether the search for 'grid' included all variants such as mini-grid, off-grid and micro-grid and found that all articles that only mentioned those variants were included in the original search for 'grid' as well.

We further constructed our search queries using the OR operator which returns a hit whenever one of the selected words is found. We chose this way of working to allow for meaningful combinations of words in the first order words. All our word combinations are explained in the table below. The numbers in the table refer to the numbers in figure 3.

entrali?ed or decentrali?ed
olar or wind or hydro or biomass or biogas or jathropa or wood or photovoltaic.
ctual value is 144, this has been set to 100 to increase the clarity of the figure!!
ossil or petroleum or diesel or kerosene
olicy or Regulat*
overnment or NGO or entrepreneur or bank or World Bank or utility or "private
ector"
apacity or implement* or finance or knowledge
ommerc* or Profit
ariff or Price
ustomer or client or consumer

To construct the second order words, we redid the searches for every second order concept in order to avoid double counting single papers. The table below gives the numerical value for the second order concepts with and without double counting. The second column refers to the value derived from merely summing the incidence of first order words, whereas the combined sum disallows double counting. For example, the combined sum of distribution was found by looking for (Grid or centrali?ed or decentrali?ed) in one single search, whereas the normal sum merely sums the search for (Grid) with the sum of (centrali?ed or decentrali?ed). The difference between the two sums gives the number of articles that used both a 'grid-term' and a 'centrali?ed-term'. The combined sum thus does not count these articles twice.

	ombined sum of eywords	ey word incidence
stribution	07	30
t & Selection	70	36
overnance	10	47
liance	35	68
pproach	7	2
evenue structure	20	49
fordability	9	07
eliability	1	9
ocal Embeddedness	9	12

[1] We only provided percentages for the dominant lens (rounded to 0.5%) because every article relates to exactly one dominant lens. Given that many articles do not use a secondary lens or some have multiple lenses, percentages for the secondary lenses would have been meaningless.
[2] Based on table 1: (7 + 7 + 4 + 3) / 47 papers published before 2001 = 44%, (30 + 17 + 27 + 28) / 185 = 55%
[3] These potential third parties are not part of the consortium but might be instrumental in the delivery of the service. Examples are suppliers of essential technology, light bulbs or spare batteries if they are not part of the consortium or external assessors of quality of equipment.