**Institutions and cooperation in community-based micro-hydro energy schemes in Kenya**

Mary Karumba and Edwin Muchapondwa

This paper is motivated by management challenges witnessed in community-ownership model of micro hydro schemes in Kenya. Micro hydro resources are situated in remote areas and access to the sites and security of infrastructure can only be guaranteed if local communities are enlisted in the ventures. Communities pool labour, financial and other material resources together to generate and distribute electricity that has limited uses (this is due to limited financing to install higher capacity or simply a limitation in the micro hydro resource). This model is expected to work because of presumed co-operation in the management of the entire system (the infrastructure and power generated). The outcome in the field is mixed with some plants surviving for over 10 years while many others collapse, largely due to inexistence of the presumed co-operation. There is very little empirical literature that can provide lessons on arrangements to increase probability of increased success. In this paper, we borrow ideas from the literature of management of common pool natural resources like canal irrigation systems (which follow a very similar model), to analyse the individual and group level factors that explain the patterns of success and failure we are observing in the field. Specifically, we test the relevance of Ostrom’s design principles in explaining electricity scheme outcomes. Those relevant principles can then form the basis for training and community mobilization modules for use by either state or non-state actors. Individual level characteristics and their impact on the level of co-operation will provide us with a basis for assessing the potential of a certain group to successfully manage a scheme based on average characteristics. This information can also enable mobilizers to anticipate problematic groups and necessary interventions made to avert adverse outcomes. Data from a total of 236 households with membership in both functional and collapsed community based micro hydro-electric schemes in rural Kenya is used. We estimate two regression models explaining the level of cooperation in schemes and the success/failure outcomes in schemes. Two key variables (cooperation and institutional quality) are generated using Principal Component Analysis. The study finds that having more formal education and trust for peers in addition to delivering more electricity to households increases cooperation for users who face higher energy expenditure in their households. Subsequently, increasing cooperation combined with better quality of local institutional arrangements makes successful management of schemes more likely. Additional relevant conditions such as higher installed capacity, bigger groups and clearly defined boundary also seem to increase the chances of success in self-governed micro hydro schemes in this study.

Yes, I am open to publishing in Energy Efficiency. I have browsed and not looked at it in detail. We can discuss relevance. Otherwise the other papers we have are:

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**Consumer Willingness to Pay for Micro Hydroelectricity Service Attributes in Kenya**

Karumba, M. and E. Muchapondwa

This study analyses consumer choice over attributes of an electricity service, supplied through an off-grid micro hydro scheme operated by a rural community in rural Kenya. Micro grid electrification is an important renewable energy solution to the twin problem of access and affordability of electricity service in rural areas. However, scale up of such projects is hampered by a disconnect between the expectations of the consumers from an electricity service and what they actually get from an actualized project. It is also apparent that electricity service has many components that appeal differently to consumers, implying that supply is not a single component but a package of attributes (like prices, quality, ownership, outage structure etc.). Driven by the limited examination of consumer preferences and willingness to pay (affordability) for such attributes, we set out a discrete choice experiment on relevant attributes that we solicited from both consumers and installers of micro hydroelectricity plants in Kenya. The attributes are: quality of electricity (unlimited voltage; 60 watts package; 40 watts package; 20 watts package); ownership (community or private); outage frequency (number of outage per week) and outage duration (hours per each outage day). We arranged these attributes using an efficient experimental design, to ensure that consumers actually traded off those attributes while using survey techniques to make the tasks of choosing simpler to them. An analysis of the resultant 532 choices of 133 individuals choosing over 4 rounds each was carried out using relevant discrete choice models, and the chosen model (conditional logit) revealed that consumers have a highest preference for ‘grid quality’ electricity, which attracted the highest Marginal Willingness to Pay of 8.51 USD per month.  The willingness to pay falls with a reduction in the ‘quality’ of electricity promised to the consumer in this experimental set up. This essentially indicates that consumers do not prefer the ‘small or low quality’ packages delivered by micro hydro schemes that permit only low voltage appliances and a few bulbs to be used in the household. Rather, they would want an electricity service that can be applied to any prospective household use without restricting the voltage.  Another outcome is that community-ownership is preferred to private ownership with a willingness to pay of 4.2 USD per month for communal ownership attribute. Given that most micro hydro resources are found in remote rural areas, it would be wise to consider incorporating local ownership going by our results. The service attribute that appeared to be of least concern to consumers is the combination of outage frequency and outage with a willingness to pay of 0.27 USD to avoid an outage.  Our suggestion is that future studies should perhaps include the timings of outage throughout the day as attributes.

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**The Impact of Micro Hydroelectricity on Household Welfare in Kenya**

Karumba, M. and E. Muchapondwa

This second study was motivated by the lack of analytical work on the impact of small-scale electrification using off-grid rural electrification. The advances in impact evaluation techniques provide us with an opportunity to go beyond quantitative claims of impacts that are widespread in literature. Using field collected data on households that are connected or not connected to micro hydro grid electricity in villages spread across three counties in Kenya, propensity score matching techniques were used to obtain counterfactuals for comparison  purposes between connected (treated) and non-connected (control) on five household outcomes that are expected from such small scale electrification interventions. The outcomes considered in this data are: the amount of kerosene consumption per month, the share of kerosene spending in household monthly budget; cell phone battery recharging expenditure per month, duration of radio use and the number of hours that kids devote to studying in the evening. The results show that on average, households connected to micro hydroelectricity spend 1.42 litres less of kerosene per month compared to those who are not connected. Further, connected households spend 0.2 USD less per month on recharging their mobile phone batteries (this is equivalent to two recharges for a single cell-phone). Lastly, it was interesting to find that kids in connected households spend approximately 0.8 hours less on study in the evening compared to those in non-connected households. The latter is attributed to TV watching or other pre-occupations that are attributed to availability of electricity like playing games on mobile phones. There was no significant difference in the other three outcomes in this particular data. The conclusion here is that if improvements in the quality of service delivery (as shown in the results of the first paper) can be fast-tracked through financing and management of off grid community energy enterprises (we venture into this in the third paper) then there is a potential for achieving electrification goals (particularly elimination of kerosene lighting and access to cheaper electricity) envisaged in the energy theme of Sustainable Development Goals.

Regards

Edwin