Expanding Access to Clean Energy in Developing Countries: The Role of Off-grid Mini Hydro Power Projects in Kenya

George Ruchathi Mwaniki*, Michael Omondi Okok*‡, Ezekiel Oromat***

*Research & Planning, National Environment Trust Fund (NETFUND), P.O. Box 19324-00202, Nairobi

** Research & Planning, National Environment Trust Fund (NETFUND), P.O. Box 19324-00202, Nairobi

*** Research & Planning, National Environment Trust Fund (NETFUND), P.O. Box 19324-00202, Nairobi

(grmwaniki@gmail.com, mikeokok2010@gmail.com, ezekieloramat2@gmail.com)

++Corresponding Author; Michael Omondi Okok, P.O. Box 19324-00202, Nairobi, Tel: +254 2369563, mikeokok2010@gmail.com

Received: 09.05.2019 Accepted: 26.06.2019

Abstract- Access to electricity is considered as one of the key drivers for economic growth and human development. However, in most developing countries access to energy has been a major challenge. This challenge has been compounded by the environmental challenges associated with conventional energy generation and distribution. As such there is a need for policy makers and the community of practice to explore other energy generation and distribution systems that minimizes environmental impacts and sets out a sustainable development pathway. These considerations must explore the role of small renewable energy systems in ending energy poverty, especially for communities living in isolated areas, where a considerable investment would be required to connect them to the national grids.

This paper argues that mini-hydropower projects can play a critical role in ending energy poverty for rural communities in off-grid areas. The results presented here are based on three case in Kenya. The study integrated qualitative and quantitative methodologies to generate and analyze the data collected from Magiro Power, Diguna Mission Centre and Boston school. These studies demonstrate that mini-hydropower projects can deliver important outcomes to institutions and rural communities.

Despite their potential in reducing energy poverty, mini-hydropower projects are faced by several challenges ranging from technical, financial, policy and regulatory factors. To address these challenges and unlock their potential, we recommend an inclusive approach that brings together policy makers, academia, local communities and private sector players to work together to create an enabling environment for the accelerated development of off-grid power projects.

Keywords- Off-grid, mini-hydro, small-hydro, Magiro.

1 Introduction

The United Nations Sustainable Development Goal number seven (SDG7) aims at ensuring access to affordable, reliable, sustainable and modern energy for all. While energy is central to economic development and poverty reduction, clean and sustainable energy is central to ensuring a sustainable development pathway [1], [2]. In most developing countries, access to clean and modern energy still remains a challenge especially for rural communities. A study by the World Bank on energy access in sub-Saharan Africa indicated that more than 45% of the population is still not connected to electricity [3]. Therefore, to achieve the goals set out in SDG7, there is a need to focus on priority policy actions that would spur the development of initiatives aimed at increasing electricity generation and distribution, especially for rural and isolated communities.

Traditionally electricity supply in most countries is achieved through national grids, where power is generated from centralized locations then distributed across the country through a network of power lines. These systems are often owned and managed by national governmental entities such as the state-owned national utility, rural electrification agency and ministries of energy, acting alone or together [4]. In this system, increased electricity access is achieved only through an extension of the national grid. Historically, this system has proved adequate in providing power for major urban areas. However, it’s application in rural communities where populations are sparsely distributed can be challenge, especially due to the considerable investment requirements for the grid extension and the low profitability associated with rural household connections [5], [6]. Overcoming these challenges will require innovative approaches including adoption of off-grid systems which must go hand in hand with exploitation of locally available electricity sources such as solar, and mini hydro [7], [8] .

Off-grids or mini-grid electricity systems are decentralized small scale distribution networks that provide power to one or more communities and generate electricity from small generators using fossil fuels, renewable fuels or combination of the two [4]. The systems may be connected to a main grid to feed in excess electricity or may be standalone system, independent of the national grid [9]. Renewable energy based off-grid systems exploit local natural resources like wind, water and solar radiation to generate electricity to supply power to local communities [10]. Off-grids such as mini-hydros are important complements and forerunner to the national grid by availing electricity to rural communities long before they are reached by the national grid [5]. In addition, off-grid power system can enhance energy systems environmental sustainability as outlined by Reiche [11].

Most remote and off-grid rural areas in developing countries are endowed with several renewable energy resources which can be exploited to generate off-grid electricity for local communities [5]. Despite these potential opportunities, these resources remain unexploited due to some challenges. One such challenge is the minimal interest from the private sector, citing their high risks, low returns on investments and the lack of clear and effective policies to govern the sector [12]. Additionally, environmental factors including erosion, droughts and floods have also been cited as potential hindrance to this investments, especially for mini-hydropower generation, for instance Taele [13], in a review of small hydropower development in Lesotho, identified heavy siltation of reservoirs caused by extensive erosion upstream as a key challenge facing small hydropower projects.

The development of mini-grids has a great potential in reducing the energy access gap, especially for rural and isolated communities in developing. To fully realize this potential, there is a need to better understand how these systems can have wider reaching impacts beyond energy access. This information, would serves as a catalyst for policy makers to create an enabling environment that will spur and facilitate investments in these systems. Most studies have mainly discussed the theoretical benefits of off-grids and the focus has mainly been on energy access and not necessarily the outcomes beyond energy access. This study demonstrates practical experiences with off-grid mini-hydro power projects with respect to their role on economic and social development as well as environmental protection. This paper aims at adding to the body of knowledge on the benefits of mini-hydros beyond access to electricity for rural communities and institutions. In addition, the paper aims at bring into perspectives the challenges these projects face.

2 Method

The study reported here integrated both qualitative and quantitative methods to generate the results. It involved an in-depth analysis of three case studies of mini-hydro power projects in Kenya; Magiro Power in Muranga County, Boston School mini-hydropower in Kericho County and Diguna Christian Mission center mini-hydropower in Nandi County. Qualitative data was collected through structured interviews with key informants particularly the managers and owners of the projects. Two representatives from each mini-hydropower project were interviewed as key resource persons to compliment quantitative data. Quantitative data was collected through household survey of the community connected to the Magiro mini-hydropower project using structured questionnaires. Of the 200 households in Njumbi location, in Muranga County connected to the mini-hydropower grid, questionnaires were administered to 50 households randomly selected across the villages. Quantitative data was analyzed by aid of Statistical Package for Social Sciences (SPSS) while qualitative data was analyzed based on professional experience and pattern building as highlighted in Figure 1. .

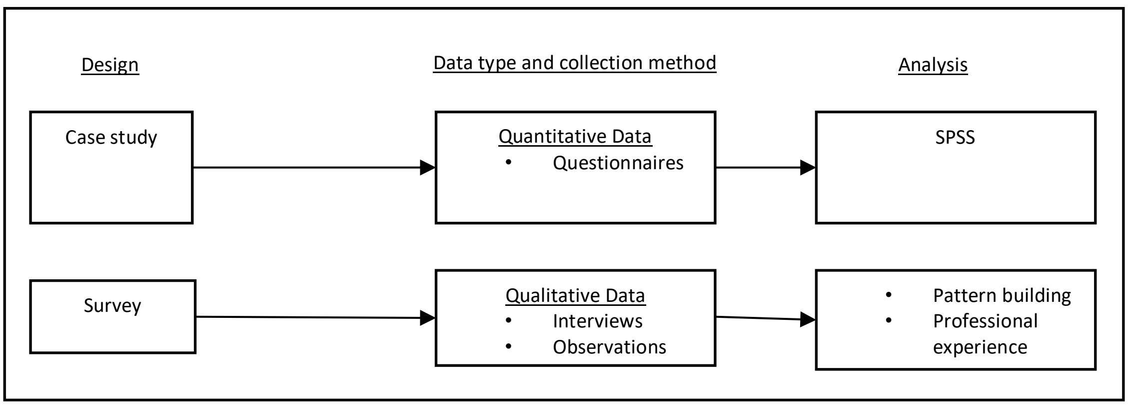

Figure 1: Methodology adopted for the study

3 Results and Discussions

3.1 Background of the Mini-grids

Diguna mini-hydro located in Chepkemelel village in Tinderet sub-county, Nandi County and was established in 1997. It operates on a water head of 75 meters generating up to 500 kWh. It was developed by Diguna Mission center, a non-governmental organization that needed electricity for its facilities that included; a children's home and a polytechnic. At the time, when these facilities were established, the area was not linked to the national grind, as such the cost of electricity connection would have been prohibitive. Therefore, the availability of a water fall in the vicinity was an opportunity for power generation at a more affordable and sustainable way.

Magiro Power project is a private initiative located in Njumbi location, Mathioya Sub-county in Muranga County. It was established long river Mihuti in 2013 by a local innovator who was at the time attending high school. Before the development and connection to the mini-hydropower, the community depended on a mix of energy sources for domestic use.

3.2. Access to Energy

There is no national grid electricity network in Njumbi location, Mathioya sub-county in Muranga County, where Magiro mini-hydro is located. Before the development and connection to the mini-hydropower, the community depended on a mix of energy sources for domestic use. Figure 2 shows the energy mix of the surveyed households before connecting to Magiro mini-hydropower project. The high use of wood fuel (60%) and charcoal (53%) implies a serious challenge to forest conservation in the area as households depended on the forest within their locality for their energy needs.

The results show that kerosene was the most popular energy source (90%) for households (90%) especially for lighting. Kerosene is commonly used for lighting in rural areas because it is accessible and the most affordable lighting fuel. Uptake of other clean energy sources and technologies such as biogas and solar was also found to be low among the surveyed households. Adoption of such technologies is always influenced by factors such as awareness level, cost, household income and technology among others [14].

After establishment of the mini-hydropower project, the number of households that use kerosene for lighting has significantly reduced. The electricity is however not sufficient to support cooking although some households use it for boiling water.

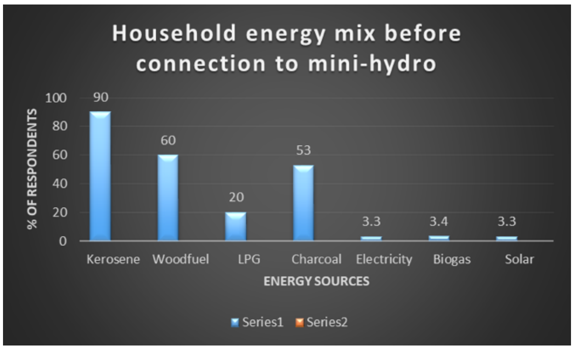

Figure 2: Household energy mix before connecting to Magiro mini-hydropower project

3.3. Economic Outcomes

The three mini hydropower projects have had significant economic contributions to the institutions and communities in which they are established. Diguna Christian mission center undertakes several activities that require energy supply including polytechnic, children home, carpentry, welding workshop and residential area for employees and volunteers that jointly consumes 150 kWh for 12 hours daily. According to International Renewable Energy Agency [15], the average cost of producing 1kWh of electricity calculated after integrating cost of installation, operation and maintenance of mini-hydropower projects in Africa is two Kenya shillings (Ksh. 2) or US$ 0.02. Using this figure as a reference, it implies that Diguna mission spends US$ 3/hour to produce 150kWh of electricity, US$ 36 for 12 hours/day, and US$1,080/month. The cost of the electricity from the main national grid is US$ 0.12/kWh without the connection fee according to the Energy Regulatory Commission (ERC). Through the mini-hydropower project the organization is able to save US$ 5,400 on electricity bill per month.

Similarly, Boston School was spending about Ksh. 303 or US$ 3.03 per night on diesel to run a generator for lighting which translated to US$ 90.90 per month. With the mini-hydropower project, the school only spent US$ 0.8 for the required 10 kWh of electricity for four hours per day and saved US$ 66.90 per month.

Economic outcomes are also realized by households when connected to off-grid mini-hydropower projects particularly through reduction in domestic energy spending as shown in Table 1. About 93% of respondents in the survey acknowledged a reduction in domestic energy spending on phone charging, kerosene, and dry cell batteries, and in some instances wood fuel. Before connecting to the mini-hydropower grid, the average household energy spending was Ksh. 110/day or US$1.10 which was then reduced to US$ 0.07 which is a saving of US$ 1.03/day if the monthly payment of Ksh. 200 or US$ 2 they make for mini-hydropower electricity is prorated across 30 days of the month. The results shows that over 70% of the households have monthly income of not more than Ksh. 10,000 or US$100. Assuming this as the maximum household income and is distributed across the 30 days of the month, it gives an average of US$ 3.33 available for a household per day. The results also show that an average household size is 4 members hence each member has an average of US$ 0.83 to spend per day which technically places them below the poverty line. Saving US$ 1.03 on energy per day as a household adds extra US$ 0.26 available for each household member to spend. It can be argued that this extra amount increases the individual's purchasing power and moves them towards crossing the poverty line. Mini-hydropower projects therefore provides an opportunity for poverty reduction among poor communities as savings on energy provide households with extra resources to meet other needs.

Figure 3 illustrates the various energy uses supported by Magiro mini-hydropower electricity. Lighting is the main use of electricity because it is more affordable, clean and offers quality lighting. The electricity has also enhanced communication among households as it supports phone charging, television sets and radio receivers. The community can also iron their clothes conveniently. All these improves the quality of life of a community.

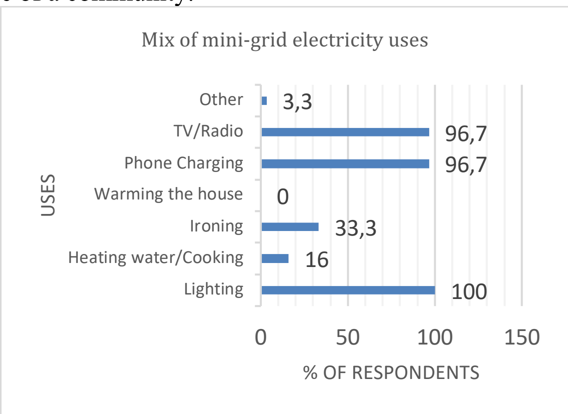

Figure 3: Various household uses of mini-hydropower electricity

Table 1: Summary of economic savings of mini-hydropower

Mini-hydro users	Energy expenses before connection per month (US$)	Energy Expenses after connection per month (US$)	Savings on energy expenses per month (US$)
Digguna Mission	6,480	1080	5,400
Boston School	90.90	24.00	66.90
Magiro beneficiaries (single household)	33.00	2.00	31.00

3.4. Health Outcomes

Access to electricity through the Magiro mini-hydropower project has resulted in positive health outcomes as shown in Figure 4 below. Before connecting to the mini-hydropower, the most common household health problems were sneezing (96%) and eye irritation (81.8%). Although all health challenges were noted to have reduced among some of the households, sneezing and eye irritation were reduced in a significant number of households. Burning kerosene emits black carbon which contributes to indoor air pollution and consequently resulting into various respiratory ailments [16]. Reduction in health challenges after connecting to electricity is a result of reduced use of kerosene for lighting hence improved indoor air quality.

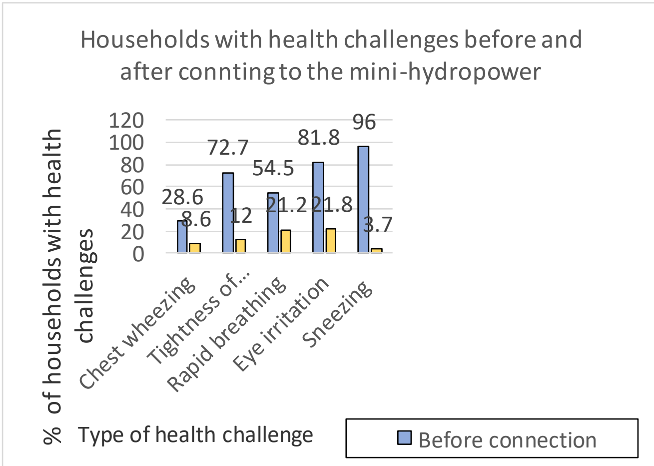

Figure 4: Comparing health challenges before and after connecting to mini-hydropower electricity

3.5. Environmental Outcomes

Environmental outcomes have also been realized from mini-hydro power as demonstrated by Diguna and Magiro power projects as presented in Table 2. .

Table 2: Summary of environmental outcomes of mini-hydropower projects

Diguna Hydropower	
Estimated forest that would be used annually for fuelwood without mini-hydropower	56 Acres
Forest used annually for fuelwood after mini-hydropower	0 acres
Annual Forest conservation outcome of mini-hydropower	56 acres
Magiro Hydropower	
CO2eq emitted by households before mini-hydropower	859,356
CO2eq emitted by households after mini-hydropower	0
Annual Emission reduction outcome of hydropower	859,356

First, the initiatives contribute significantly to forest conservation by providing alternative source of energy to wood fuel. About 168 tons of dry wood fuel would have been required to provide cooking energy for the 400 people in Diguna mission center. According to Langholtz [17], three tones of dry wood is harvested from one acre of a standard forest. And estimated 56 acres of forest would be required per year to provide 160 tons of fuelwood, which has been saved by use of electricity at Diguna mission.

Although Magiro power project has the potential to reduce significantly the use of fuelwood by households, this has been hindered by low production of electricity that cannot support cooking (although some households use it for heating water) hence there is minimal reduction in use of fuelwood. Before connection, households used an average of 2 bundles (1 bundle is equal to 25kgs according to Food and Agriculture Organization) which has only reduced to 1.7 bundles.

Magiro power project has also reduced the amount of black carbon emitted into the atmosphere by eliminating use of kerosene. Reduction of black carbon also contributes to minimization of global warming. Black carbon particles reduce the planet albedo which results in increased warming, making them a major climate forcer, second only to CO_2 [18]. At least 270,000 tons of black carbon per year is estimated to be emitted from kerosene lamps worldwide, having a climate warming equivalent close to 240 million tons of CO_2 [19]. Alternatives to kerosene lighting such as mini-hydropower electricity are therefore attractive areas for achieving quick and cost-effective climate benefits. Before the connection to Magiro mini-hydropower, each household connected to Magiro power project used an average of 400ML (0.4L) of kerosene daily. This has since reduced to 100ML (0.1L), a reduction of 0.3L. Eliminating 1L of kerosene reduces 0.0436 tons of black carbon [19]. The 200 households connected to electricity by Magiro where an average household has saved up to 0.3L daily translates to a total of up to 21,900L annually and saves potential emission of 954.84 tons of black carbon. Using the 100 year Global Warming Potential (GWP) factor of 900 as estimated by Bond [18], this would mean a saving of 859,356 CO_2 equivalent from the atmosphere.

There is also deliberate efforts made by management of mini-hydropower projects and communities to protect the catchment area with understanding that degradation of the catchment will reduce the water discharge and flow. The management of Diguna and Magiro continuously plant trees along riverine and discourage communities from cutting trees in these areas. In the case of Magiro, the community is aware that reduced water discharge would affect electricity production hence they deliberately conserve trees along the river.

3.6. Challenges Facing Mini-hydro Power Projects

While mini-hydropower projects play significant role in enhancing energy access to institutions and households in off-grid areas, this study shows that economic, technological, environmental and policy barriers continue to undermine their development and sustainability.

3.6.1 Economic

Economic challenges facing mini-hydro projects include initial cost of development, as well as operation and maintenance. Establishment of effective mini-hydro projects are capital intensive which in most cases cannot be raised by community based organization and private individuals in the rural areas who are the major investors in such projects. Consequently, low quality equipment and machinery are used in installation of mini-hydropower plants, leading to underperformance [20]. Boston School provides a good case where the interview revealed that the destruction of the power plant was partly due to use of poor quality materials for construction of the reservoir and the water conveyance to the power house. On the same note, the river where Magiro is installed has a potential to generate more electricity but the developer could not afford a larger turbine that can exploit this potential. Secondly, business models used to operate hydro-power projects that supply communities with electricity have not been effective in generating returns for the investors. These models do not guarantee financial returns that can ensure self-sustenance of the projects and therefore continuous investment in the projects is required and in the long run become unsustainable for community based mini-hydros.

3.6.2 Technological

Technological challenges identified by the study include inadequate skills and technical know-how on development and operation of mini-hydropower projects and on suitable technologies. All the developers or managers of mini-hydropower projects covered by the study do not have technical training on these systems. They engage the services of specialized contractors who do the installations and hand over the projects. Such projects might fails to function as expected if the developer has no funds to employ skilled personnel for operations and maintenance. It was also noted that upgrading old technologies in mini-hydo power plants is sometimes impossible or very expensive.

3.6.3 Environmental

Changes in environmental factors that impact river discharge and velocity also pose considerable challenges to the operation of mini-hydropower projects. Dry seasons and droughts reduces river flows thus affecting the amount of electricity generated [21]. On the other hand, heavy rains increase river discharge, causes overflows in the water reservoir and this can break the embankments like in the case of Boston School. By the fact that floods and droughts impact mini-hydropower project, climate change will definitely have strong implications for such projects. Other environmental factors includes degradation of catchments which increases erosion and causes siltation of reservoirs as well as destruction of the turbines which the study shows affected Boston School and Magiro hydropower projects.

3.6.4 Policy and Legislation

Energy policy and legal frameworks for any country is critical in defining development of renewable energy systems [22]. Effective policies require a coordinated framework at local, national and regional levels [23] . Policy and legislative environment in Kenya has been identified by the study as a major barrier to the development of mini-hydropower projects especially by private sector and non-governmental organizations. There is no clear policy and legislative framework and guidelines on off-grid electricity systems especially those operated by private sector and non-governmental organizations. Existing policies and legislations that guide electricity generation in the country are disintegrated and do not promote development of mini-hydropower systems. One of the most important aspect of mini-hydropower projects that is limited by policies and legislations relate to spatial planning [24]. For instance, respondents interviewed raised concern that several licenses and permits required to run such projects are not only costly but are also difficult to acquire due the bureaucracy involved. These include environmental impact assessment, license from energy regulatory commission and annual payments to the Water Resources Authority which make it difficult to operate such projects as low cost electricity for communities.

4. Conclusion

Mini-hydropower systems have a great potential in enhancing access to clean and affordable energy for institutions and rural communities in off-grid areas. They can provide alternative energy for domestic and institutional use and deliver positive economic, health and environmental outcomes. By accessing affordable electricity, institutions and poor households can realize significant savings on energy costs and such savings can meet other needs. The findings also demonstrate that delivering electricity through mini-hydropower projects to remote areas can increase the purchasing power of households and move then out of poverty. Access to electricity also replaces ‘dirty’ forms of energy such as kerosene that cause indoor air pollution and this reduces associated ailments among households. In addition, access to electricity contributes to environmental conservation by reducing deforestation and carbon emission.

While it is costly to distribute electricity in rural and remote areas through the main national electricity grid, these areas are commonly endowed with water resources that can be exploited to generate and provide electricity with substantially minimal investments relative to the main grid. Various actors including government, private sector and non-governmental organization should therefore accelerate investment in the development of mini-grids, to bridge the energy gap.

To support the development and investments in mini-grids by the private sector, there is a need for policy integration for both off-grid and national grid systems, and development of a conducive legislative framework to promote these investments. Such policies should also focus on development of appropriate business models that promote financial sustainability for these investments.

Acknowledgements

We acknowledge the National Environment Trust Fund (NETFUND) who availed the resources to facilitate data collection for this study. We also appreciate various actors from Magiro, Diguna and Boston mini-hydropower projects who volunteered their time to provide valuable information that has informed this paper.

References

[1] M. Kanagawa and T. Nakata, ‘Analysis of the energy access improvement and its socio-economic impacts in rural areas of developing countries’, *Ecological Economics*, vol. 62, no. 2, pp. 319–329, Apr. 2007.

[2] S. Gyamfi, N. S. A. Derkyi, E. Y. Asuamah, and I. J. A. Aduako, ‘Chapter 6 - Renewable Energy and Sustainable Development’, in *Sustainable Hydropower in West Africa*, A. Kabo-Bah and C. J. Diji, Eds. Academic Press, 2018, pp. 75–94.

[3] World Bank Group, ‘State of Electricity Access Report (SEAR) 2017’, 2017.

[4] B. Tenenbaum, C. Greacen, T. Siyambalapitiya, and J. Knuckles, ‘From the Bottom Up: How Small Power Producers and Mini-Grids Can Deliver Electrification and Renewable Energy in Africa’. World Bank Publications, 2014.

[5] H. Ahlborg and L. Hammar, ‘Drivers and barriers to rural electrification in Tanzania and Mozambique – Grid-extension, off-grid, and renewable energy technologies’, *Renewable Energy*, vol. 61, pp. 117–124, Jan. 2014.

[6] Raluca Golumbeanu Douglas Barnes, *Connection Charges and Electricity Access in Sub-Saharan Africa*. The World Bank, 2013.

[7] E. Hossain, R. Bayindir, E. Kabalci, and S. Demirbas, “Microgrid facility around Asia and far east,” *2014 International Conference on Renewable Energy Research and Application (ICRERA)*, (pp. 873-879), Milwaukee-USA, 2014.

[8] P. Alstone, D. Gershenson, and D. M. Kammen, 'Decentralized energy systems for clean electricity access', *Nature Climate Change*, vol. 5, no. 4, p. 305, 2015.
[9] D. Paramashivan Kaundinya, P. Balachandra, and N. H. Ravindranath, 'Grid-connected versus stand-alone energy systems for decentralized power—A review of literature', *Renewable and Sustainable Energy Reviews*, vol. 13, pp. 2041–2050, Oct. 2009.
[10] B. Bhandari, K.-T. Lee, C. S. Lee, C.-K. Song, R. K. Maskey, and S.-H. Ahn, 'A novel off-grid hybrid power system comprised of solar photovoltaic, wind, and hydro energy sources', *Applied Energy*, vol. 133, pp. 236–242, Nov. 2014.
[11] K. Reiche, A. Covarrubias, and E. Martinot, 'Expanding electricity access to remote areas: Off-grid rural electrification in developing countries', *Fuel*, vol. 1, pp. 1–4, Jan. 2000.
[12] N. Williams, P. Jaramillo, J. Taneja, and T. S. Ustun, 'Enabling private sector investment in microgrid-based rural electrification in developing countries: A review', *Renewable and Sustainable Energy Reviews*, vol. 52, pp. 1268–1281, Dec. 2015.
[13] B. Taele, L. Mokhutšoaneb, and I. Hapazari, 'An overview of small hydropower development in Lesotho: Challenges and prospects', *Renewable Energy*, vol. 44, pp. 448–452, Aug. 2012.
[14] S. Batel and P. Devine-Wright, 'Towards a better understanding of people's responses to renewable energy technologies: Insights from Social Representations Theory', *Public Understanding of Science*, vol. 24, no. 3, pp. 311–325, 2015.
[15] International Renewable Energy Agency. (2012). Renewable energy technologies: Cost analysis series - Minihydropower
[16] M. Barron and M. Torero, 'Household electrification and indoor air pollution', *Journal of Environmental Economics and Management*, vol. 86, pp. 81–92, 2017.
[17] M. Langholtz, R. Plate, and M. C. Monroe, *Sources and supply*. Univ. of Florida Coop. Ext. Serv. Wood to Energy Fact Sheet, University of University of Florida, 2007.
[18] Bond TC, Doherty SJ, Fahey DW, Forster PM, Berntsen T, DeAngelo BJ, Flanner MG, Ghan S, Kärcher B, Koch D, Kinne S., 'Bounding the role of black carbon in the climate system: A scientific assessment', *Journal of Geophysical Research: Atmospheres*, vol. 118, no. 11, pp. 5380–5552, 2013.
[19] N. L. Lam, Chen Y, Weyant C, Venkataraman C, Sadavarte P, Johnson MA, Smith KR, Brem BT, Arineitwe J, Ellis JE, Bond TC., 'Household light makes global heat: high black carbon emissions from kerosene wick lamps', *Environmental science & technology*, vol. 46, no. 24, pp. 13531–13538, 2012.
[20] S. Bojic, D. Bozic, and M. Pavlica, "Refurbishment of small hydro power plant," *2012 International Conference on Renewable Energy Research and Applications (ICRERA)*, (pp. 1-5), Nagasaki, Japan, 2012.
[21] Islam MS, Gupta SD, Raju NI, Masum MS, Karim SA. Potentiality of small-scale hydro power plant using the kinetic energy of flowing water of Gumoti & Surma river of Bangladesh: an energy odyssey. International Journal of Renewable Energy Research (IJRER), vol. 3, no. 1, pp. 172-179, Mar. 2013.
[22] A. Z. Aktas, "A Review and comparison of renewable energy strategies or policies of some countries," *2015 International Conference on Renewable Energy Research and Applications (ICRERA)*, pp. 636-643, Palermo, Italy, 2015.
[23] O. T. Winarno, Y. Alwendra, and S. Mujiyanto, "Policies and strategies for renewable energy development in Indonesia," *2016 IEEE International Conference on Renewable Energy Research and Applications (ICRERA)*, (pp. 270-272), Birmingham, UK, 2016.
[24] H. Basic, "Methodology for definition of requirements for small hydropower plants development," *2012 International Conference on Renewable Energy Research and Applications (ICRERA)*, (pp. 1-4), Nagasaki, Japan, 2012.