MUST Journal of Research and Development (MJRD) Volume 6 Issue 4, December 2025
e ISSN 2683-6467 & p ISSN 2683-6475

Assessment of Electricity Demand for Utilisation of Renewable Energy Hybrid Systems: A Case Study of Kitai Prisons Complex in Tanzania

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DOI: https://doi.org/10.62277/mjrd2025v6i40013

ARTICLE INFORMATION

Article History

Received: 03rd September 2025
Revised: 13th November 2025
Accepted: 20th November 2025
Published: 31st December 2025

Keywords

Renewable energy
Micro-hydro
Solar PV
Energy demand
HOMER Pro
Hybrid system optimisation

ABSTRACT

The utilisation of renewable energy hybrid systems offers a sustainable solution to the electricity challenges faced by developing regions. This study assesses the electricity demand of the Kitai Prisons Complex in Tanzania to evaluate the feasibility of integrating a renewable energy hybrid system. Load classification, daily load profiling, and energy forecasting were employed to analyse consumption patterns across various sectors of the complex. A detailed assessment of current demand and projected future requirements was undertaken to ensure compatibility with hybrid system design. The results indicate four main load categories—residential, community, commercial, and small-scale industrial—each with distinct demand characteristics. Daily load profiles show two significant peaks occurring in the morning and evening hours, highlighting the need for optimised generation and storage strategies. Energy forecasting reveals an anticipated increase in electricity demand resulting from planned infrastructure expansions, including additional residential housing, water supply systems, and administrative facilities. The study recommends the implementation of a hybrid energy system integrating solar photovoltaic (PV) and micro-hydropower technologies, supported by efficient battery storage, to meet both current and future electricity needs. These findings provide valuable insights for enhancing energy reliability and sustainability in institutional facilities across Tanzania and similar contexts in East Africa. The HOMER Pro software was utilised to model and analyse the load profiles of different customer groups.

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1.0 Introduction

Electric load in any distribution system changes with time and area. Energy generation and distribution systems react to customers' load demand instantly. As such, the electric supply should meet customers' electricity needs without compromising the optimum cost (King, 2015). Load demand estimate is an important aspect in planning and the successful implementation of energy generation, transmission, and distribution. The 20th century saw the start of research on electrical energy systems to estimate power consumption. Due to the low demand for energy before this time, demand forecasting was not a significant problem in either industrialised or developing nations (King, 2015). Currently, 18% of the world's population lacks access to electricity (Fritsche *et al.,* 2009). Innovations like the solar home system have led to significant advancements (Boait *et al.,* 2015), but the full potential of electricity for lifting people out of poverty can only be achieved when it is available at the cost and capacity levels needed for commercial applications such as processing or storage of agricultural produce. The economies of scale offered by some kind of grid supply are the obvious means of lowering the price and expanding the supply of power. However, for a significant fraction of this population, especially in Africa, traditional grid connection is neither a viable nor a cost-effective option (Gaihre *et al.,* 2019). The urgent need to reduce carbon emissions further limits the applicability of large-scale fossil-fuel-based generation coupled with high-voltage transmission networks. Consequently, localised generation and distribution systems are becoming increasingly relevant in industrialised nations. (Abebe *et al.,* 2024). Mini- and micro-grids are particularly attractive for rural electrification (Riva *et al.,* 2018). Such grids will serve a local community and either have no connection to a national grid system at all (hence off-grid) or have a connection that may be either severely limited in capacity relative to the local demand or unreliable.

The potential for mini-grids to meet the needs of this unserved population has been shown by many practical demonstration projects and start-up enterprises (Mulugetta et al., 2019), but large-scale rollout of mini-grid technologies has not yet happened. One of the barriers to the exploitation of this potential is the need to sustain a balance between electricity supply and demand, which must be continually met during future operation after starting during the mini-grid project's planning and design phase. This is what the System Operator 1 (SO) does for a national grid system (Wang & Jiang, 2017). They will anticipate investing in a variety of expensive and advanced instruments to assist them in carrying out their crucial task (Oyedepo *et al.,* 2019). The same function must be carried out for a small grid, but with resources reduced appropriately and frequently, with the added limitations brought on by a distant or rural area (Singh *et al.,* 1970).

Several studies have been conducted across Sub-Saharan Africa, including Tanzania, to assess the feasibility of renewable energy hybrid systems in rural and institutional settings. For example, Mwasenga & Kamoleka (2024) implemented a solar-diesel-battery system (29.5 kW PV, 24 kW diesel) in Mwala Village. HOMER simulations showed annual generation of ~75,366 kWh, but daily, monthly, and seasonal load variations were not considered (History, 2024).

Marcel, Mutale & Mushi (2021) evaluated hybrid renewable energy systems (HRES) combining solar, wind, and battery energy storage in Ngw'amkanga, Tanzania. Solar + battery alone was optimal due to limited wind resources; the Levelised Cost of Energy (LCOE) was ~0.2718 Tshs/kWh. Temporal load resolution was low (Marcel *et al.,* 2021).

Using HOMER to optimise size and techno-economic performance, Mwakitalima *et al.* (2023), assessed a solar-PV+biogas hybrid in rural Mbeya; they obtained an LCOE of about US$0.11/kWh but relied on coarse annual load statistics without considering seasonal or hourly fluctuations. These studies highlight a significant gap: most prior research relies on average or static energy consumption, neglecting the critical impact of diurnal, monthly, and seasonal variations on hybrid system reliability (Mwakitalima *et al.,* 2023).

The present study aims to address this gap by performing a detailed assessment of the electricity demand at Kitai Prisons Complex.

Using HOMER Pro, this research models energy consumption with high temporal resolution, accounting for daily, monthly, and seasonal variations, as well as environmental factors. By analysing demand and resource availability on fine temporal scales, the study proposes a practical, efficient, and sustainable hybrid energy solution that ensures the elimination of energy deficits during seasonal peaks.

2.0 Material and Methods

2.1 Area of Study and Dataset Descriptions

2.1.1 Area of Study

Along the Songea-Mbinga major road, Kitai Prisons is situated 50 kilometres from Songea town in the Ruvuma Region and 50 kilometres from Mbinga (Utonga, 2022). It was created in 1969 as a camp for the cultivation of crops and cattle, covering 7,806 acres in total (Sw-1748954748-Shima Profile_11zon.Pdf, n.d.). The following categories apply to farmland use plans: 1,750 acres of arable land with grazing, 1,230 acres of pasture, 1,050 acres of residential area, and 3,476 acres of forestry and hills (natural forestry) (Hydro & Mapping, 2015)

2.1.2 Dataset Descriptions

The appliances that residents in the hamlet owned served as the basis for the study of electrical consumption in the Kitai jail complex. Structured interviews with village stakeholders, including the village executive officer, school administrators, religious leaders, and other villagers, were used to gather primary data on energy requirements. Additionally, houses, schools, churches, stores, supermarkets, and small local taverns were visited to gather this data. To make an informed decision on the necessary equipment installation, secondary data, such as equipment ratings, were gathered online, and some customers' appliances were located by visiting the Kitai Prisons Complex's few existing solar housing systems. Table 1 below indicates the types of consumers that are available in the village. Load analysis was performed by using the End-Use Method (King, 2015). The strategy was chosen because of the data's limited availability. This approach uses the customer's application for appliance ownership. This approach considers the appliances' power ratings and operating hours which estimates load as:

$$Load\ (kW) Appliance\ Power\ Rating\ (W) Operating\ Hours\ 1000.$$

This method accounts for appliance power ratings and assumed operating hours. Limitations include reliance on estimated hours and typical appliance ownership; these were mitigated by combining stakeholder interviews and on-site appliance surveys.
The number of clients in each category was used to compute the individual load. The lighting fixtures were arranged according to the space's measurements. Energy conservation was also considered through the use of energy-efficient lighting. It was believed that outside lighting would run for 12 hours, from 6 p.m. to 6 a.m., while inside illumination would run for 5 hours, from 6 p.m. to 10 p.m. and 6 a.m. to 7 a.m. To save generation costs, street lighting was disregarded in this analysis (King, 2015).

2.1.2.1 Residential Load

In this specific category, load analysis was carried out utilising typical household equipment found in rural areas, which is mostly utilised for communication, entertainment, and lighting. When calculating the electrical requirement for the Kitai prison complex, appliances such as energy-saving lighting, TVs, radios, iron boxes, cell phone chargers, and fluorescent tubes were considered.
Two presumptions were used to determine the household power demand: The first assumption was that a small rural community home would be a four-room family home, with one room designated for the parents, two for the children (boys and girls), and a fourth for the sitting room. It was also expected that all families would have the same energy needs. Second, every home in the entire hamlet was thought to be connected to the electricity source.

2.1.2.2 Community Load

The dispensary, village executive office, elementary and secondary schools, churches, and mosques were among the community's customers. Based on the building's size and the potential customer's energy needs, a load assessment profile was created for each customer.

2.1.2.3 Commercial Load

Among the commercial customers were grocery stores, taverns, stores, saloons (for women), and barbershops (for men). The appliance ownership approach was also used to analyse each establishment's workload. The size of the business determined who owned the appliances.

2.1.2.4 Small-Scale Industrial Load

A tiny training workshop employed by Kitai prisons for crafts like carpentry and power demand profile was included in the study's small-scale industrial load.

An estimated 20 kids might use the computer room. For studies, the electrical laboratory contained a single-phase induction motor, a three-phase induction motor, and a testing bench. In contrast, the workshop's carpentry department had a single lathe machine, a combination machine for cutting and curving, and other related equipment.

Table 1

Calculation of Load Energy Demand of Kitai Prisons Complex

No	Power consuming devices	Power Consumption /pcs in Watt	Qty	Total Load in Kw	Operating hours		Daily Energy Demand [kWh/d]
					Time interval	Hours/day	
For house hold purpose							
1	Lighting	3	360	1.08	18:00hr-24:00hr	6	6.48
2	Security Lighting	8	160	1.28	18:00hr-06:00hr	12	15.36
3	Television	80	41	3.28	18:00hr-22:00hr	4	13.12
4	Radios	80	34	2.72	17:00hr-21:00hr	5	13.6
5	Refrigerator	480	7	3.36	08:00hr-16:00hr	8	26.88
6	DVD player	20	37	0.74	17:00hr-21:00hr	4	2.96
7	Ceiling fan	15	17	0.255	12:00hr-21:00hr	9	2.294
SUB TOTAL				12.715			80.694
For school							
1	Lighting	3	15	0.045	18:00hr-21:00hr	3	0.135
2	Security Lighting	7	8	0.056	18:00hr-06:00hr	12	0.672
3	Computers	80	2	0.16	10:00hr-14:00hr	4	0.64
4	Printers	180	1	0.18	10:00hr-14:00hr	4	0.72
SUB TOTAL L				0.441			2.167
For church							
1	Lighting	3	4	0.012	18:00hr-21:00hr	3	0.036
2	Security Lighting	8	2	0.016	18:00hr-06:00hr	12	0.192
3	Music system	260	1	0.26	08:00hr-12:00hr	4	1.04
SUB TOTAL				0.288			1.268
For health center							
1	Lighting	3	6	0.012	18:00hr-21:00hr	4	0.048
2	Security Lighting	8	3	0.024	18:00hr-06:00hr	12	0.288
3	Television	120	1	0.12	18:00hr-21:00hr	10	1.2
4	Computers	80	2	0.16	08:00hr-15:00hr	8	1.28
5	Printers	180	1	0.18	10:00hr-14:00hr	6	1.08
6	Laboratory equipment	240	3	0.72	09:00hr-15:00hr	10	7.2
7	Refrigerator	480	1	0.48	08:00hr-18:00hr	18	8.64
SUB TOTAL				1.696			19.736
For office and prisoner accommodation room							
	Lighting	5	160	0.8	18:00hr-21:00hr	7	5.6
	Security Lighting	15	80	1.2	18:00hr-06:00hr	12	14.4
	Television	80	4	0.24	10:00hr-15:00hr	5	1.2
	Computers	80	2	0,16	09:00hr-15:00hr	6	0.96
	Printers	92	2	0.184	10:00hr-16:00hr	6	1.104
SUB TOTAL				2.584			23.264
For community hall							
	Lighting	13	16	0.208	18:00hr-21:00hr	4	0.832
	Security Lighting	10	8	0.08	18:00hr-06:00hr	12	0.96

	Television	120	2	0.24	18:00hr-00:00hr	8	1.92
	Radio	120	1	0.24	18:00hr-00:00hr	6	1.44
	Refrigerator	480	2	0.96	09:00hr-20:00hr	11	10.56
SUB TOTAL				1.728			15.712
For small scale industrial							
1	Single phase motor water pumps	380	2	0.76	07:00hr-12:00hr	5	3.8
2	Single phase motor for Carpentry workshop	560	3	1.68	09:00hr-16:00hr	7	11.76
3	Single phase motor for block machine	580	2	1.16	09:00hr-16:00hr	7	8.12
4	Portablegrinding machine	480	1	0.48	09:00hr-16:00hr	7	3.36
5	Portablecuttingmachine	420	2	0.84	09:00hr-16:00hr	7	5.88
SUB TOTAL				4.34			32.92
TOTAL	**20.629**			**23.79**			**175.76**

2.1.2.5 Daily Load Profile

The daily load curve, Figure 1, shows moderate variability, with peak usage occurring during daytime hours between 9:00 AM and 3:00 PM, corresponding to administrative operations and food preparation. Power consumption drops in the evening but remains steady due to security lighting and other essential services.

2.1.2.5.1 Monthly Load Profile

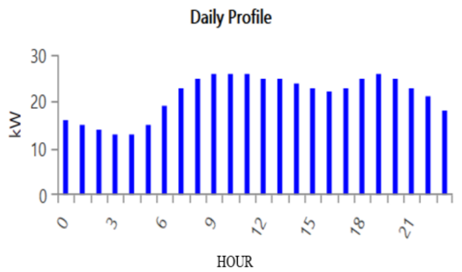
Power demand fluctuates slightly across months, Table 4, with minor increases during the rainy season (due to increased administrative and laundry operations) and holidays. However, the overall variation is minimal, with the monthly average ranging from 23.8 kW to 26 kW.

2.1.2.5.2 Yearly Load Profile

The annual energy demand shows a consistent load pattern, reflecting the steady nature of prison operations shown in Table 3. The average annual load is calculated to be 23.8 kW, with a peak demand of 26kW recorded during January and August.

Figure 1

The Daily Peak Power Demand of the Study Area



3.0 Results of Study

The analysis of the Kitai Prisons Complex electricity demand indicates that the average load is approximately 23.8 kW, with a peak load of 26.0 kW, as shown in Table 2. This relatively stable load pattern highlights the suitability of the site for the integration of hybrid renewable energy systems. The load characteristics demonstrate both daily and seasonal variations that reflect the institution's operational routine and the influence of climatic conditions typical of Tanzania's southern highlands.

Table 2

Daily (24-hour) Load Profiles for Each Month (in kW)

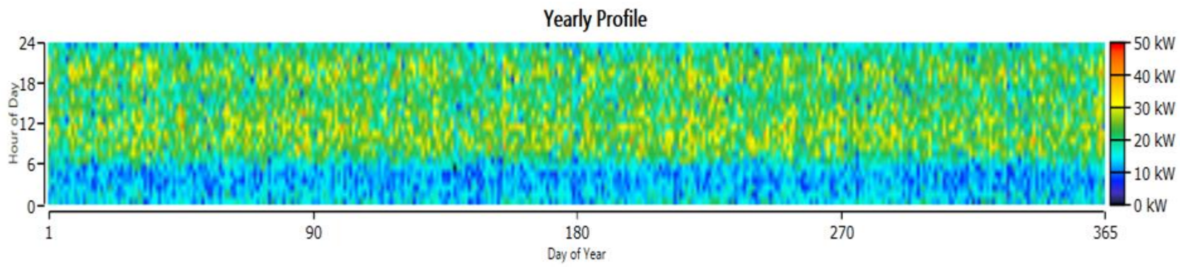
Hours	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
00:00	16	16	16	15	15	14	14	14	15	15	15	16
01:00	15	15	15	14	14	13	13	13	14	14	14	15
02:00	14	14	14	13	13	12	12	12	13	13	13	14
03:00	13	13	13	12	12	11	11	11	12	12	12	13
04:00	13	13	13	12	12	11	11	11	12	12	12	13
05:00	15	15	15	14	14	13	13	13	14	14	14	15
06:00	19	19	19	18	18	17	17	17	18	18	18	19
07:00	23	23	23	22	22	21	21	21	22	22	22	23
08:00	25	25	25	24	24	23	23	23	24	24	24	25
09:00	26	26	26	25	25	24	24	24	25	25	25	26
10:00	26	26	26	25	25	24	24	24	25	25	25	26
11:00	26	26	26	25	25	24	24	24	25	25	25	26
12:00	25	25	25	24	24	23	23	23	24	24	24	25

Hours	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
13:00	25	25	25	24	24	23	23	23	24	24	24	25
14:00	24	24	24	23	23	22	22	22	23	23	23	24
15:00	23	23	23	22	22	21	21	21	22	22	22	23
16:00	22	22	22	21	21	20	20	20	21	21	21	22
17:00	23	23	23	22	22	21	21	21	22	22	22	23
18:00	25	25	25	24	24	23	23	23	24	24	24	25
19:00	26	26	26	25	25	24	24	24	25	25	25	26
20:00	25	25	25	24	24	23	23	23	24	24	24	25
21:00	23	23	23	22	22	21	21	21	22	22	22	23
22:00	21	21	21	20	20	19	19	19	20	20	20	21
23:00	18	18	18	17	17	16	16	16	17	17	17	18

Based on the daily load curve presented in Figure 1, two distinct peaks are observed within a 24-hour cycle. The first peak occurs between 09:00 and 12:00 hours, corresponding to the daytime administrative and operational activities, such as office work, carpentry, food preparation, and general institutional functions. The second major peak occurs between 18:00 and 20:00 hours, which is associated with residential and community activities, including lighting, entertainment, and security services. These two pronounced peaks are separated by a moderate decline during the early afternoon hours (13:00–16:00), when outdoor tasks are dominant and appliance usage is minimal. Overnight, a steady base load persists, mainly due to security lighting and other essential services, indicating that the institution's operations continue throughout the day and night. This dual-peak characteristic reflects the energy behaviour of institutional environments, where power usage is strongly tied to scheduled activities and routine security needs.

The seasonal load characteristics, illustrated in Figure 2, show minor variations in total energy demand but clear differences in load behaviour across the dry and wet seasons. During the dry season (June to October), the energy demand tends to rise slightly above the annual average, particularly in the early morning and evening hours, where the peak demand reaches the maximum of 26 kW. The main reasons for this rise are longer nights, which need more lighting, and more water pumping to make up for low stream flow levels. The dry season also coincides with higher ambient temperatures and reduced cloud cover, leading to enhanced solar potential, which makes photovoltaic (PV) systems particularly effective in meeting daytime electricity demand.

Figure 2
Seasonal Load Characteristics in the Year



Conversely, the wet season (March to May and November) demonstrates a moderate decrease in power demand, especially during the midday hours (11:00–16:00). The reduction in energy usage during these hours results from abundant natural daylight, which reduces lighting requirements, and improved water availability, which minimises the operation of mechanical pumps.

The transitional months (December to February) exhibit balanced and steady energy demand throughout the day, with no sharp peaks or troughs. This consistency provides favourable conditions for evaluating the performance and stability of the hybrid system. Overall, the integration of solar PV and micro-hydro systems at Kitai Prisons Complex would ensure year-round energy reliability by exploiting the strengths of each resource during its respective season.

Furthermore, efficient battery storage and an automated control system are essential for maintaining energy stability, especially during transitional months and unpredictable weather variations.

The results indicate that while total energy demand at the Kitai Prisons Complex remains stable across seasons, resource availability and temporal load patterns vary, emphasising the need for a hybrid solar–hydro system with adequate storage capacity. The daily dual-peak profile (morning and evening) and the seasonal complementarity identified in Table 2, Figure 1, and Figure 2 are key considerations for system optimisation using HOMER Pro, ensuring that supply continuously matches the institution's operational and environmental conditions.

4.0. Conclusion

The study concludes that the Kitai Prisons Complex exhibits a stable and predictable energy demand profile, with an average load of 23.8 kW and a peak demand of 26 kW. Although the seasonal variation in demand is relatively minimal, there is a significant variation in renewable energy resource availability between the dry and wet seasons. The complementary nature of solar photovoltaic (PV) and micro-hydropower systems makes them ideal for integration into a hybrid configuration at the site. During the dry season, when solar irradiance is high but stream flow is reduced, solar PV should supply the majority of the load. Conversely, in the wet season, when hydrological conditions are favourable, micro-hydro generation can meet most of the energy demand while PV serves as a supplementary source.

A major finding of this study is the critical importance of energy storage as a stabilising component in the hybrid system. The inclusion of battery banks or equivalent storage devices will ensure continuous energy supply, particularly during transition periods (e.g., between seasons) and unexpected power fluctuations. Properly designed storage enhances the system's reliability and operational resilience, enabling smooth power delivery and effective utilisation of renewable resources across varying conditions.

The adoption of such an optimised solar PV–micro-hydro–battery hybrid system will significantly reduce electricity costs, eliminate outages, and improve energy security for the Kitai Prisons Complex. Furthermore, the findings form a foundation for further optimisation and system design using tools such as HOMER Pro, supporting replication in similar institutional settings across Tanzania.

5.0 Recommendations

Based on the study findings, it is recommended that the Kitai Prisons Complex implement a hybrid renewable energy system integrating solar PV, micro-hydro, and a robust energy storage system. The design should ensure seasonal complementarity with solar PV prioritised in the dry season and micro-hydro during the wet season. A well-sized battery storage system should be incorporated as a core component to maintain stability, reliability, and continuous power supply during transitional periods and unexpected outages. Further optimisation through simulation tools such as HOMER Pro is advised to achieve cost-effectiveness, sustainability, and long-term energy security for the complex.

6.0 Funding Statement

The study was financially supported by me as a student at Mbeya University of Science and Technology as part of postgraduate studies.

7.0 Acknowledgement

I would like to express their sincere gratitude to Mbeya University of Science and Technology (MUST) for providing academic support and guidance throughout this study. Special thanks go to the management and staff of Kitai Prisons Complex for their cooperation during data collection. The authors also acknowledge the invaluable contributions of colleagues and mentors who provided insights and encouragement during the research process.

8.0 References

Abebe, A., Shewarega, F., Bantyirga, B., Biru, G., & Lakeou, S. (2024). A stochastic approach to determine the energy consumption and synthetic load profiles of different customer types of rural communities. *Scientific African*, *24*(December 2023), e02172. https://doi.org/10.1016/j.sciaf.2024.e02172

Boait, P., Advani, V., & Gammon, R. (2015). Estimation of demand diversity and daily demand profile for off-grid electrification in developing countries. *Energy for Sustainable Development*, *29*, 135–141. https://doi.org/10.1016/j.esd.2015.10.009

Fritsche, U. R., Henneberg, K., Hünecke, K., Thrän, D., Witt, J., Hennig, C., & Rensberg, N. (2009). *IEA Bioenergy Task 40: Country Report Germany*. *February*, 1–52.

Gaihre, N. R., Pereira, R., & Systems, S. E. (2019). *Electrical Energy Demand in Rural India - A Case Study of Arunachal Pradesh and Uttar Pradesh*. *02002*.

History, A. (2024). *Storage for Rural Remote Area : A Case Study of Mwala Village Mbeya DistrictDesign Solar Photovoltaic Diesel Hybrid System with Battery*. *5*(2).

Hydro, S., & Mapping, R. (2015). *S ITE V ISITS R EPORT : E XISTING Small Hydro Resource Mapping in Tanzania* (Issue April).

King, C. K. (2015). *Electricity Demand Evaluation for Rural Electrification A Case Study of Kikwe Village in Tanzania*. *4*(06), 1025–1028.

Marcel, E. T., Mutale, J., & Mushi, A. T. (2021). *Optimal Design of Hybrid Renewable Energy for Tanzania Rural Communities*. *47*(5), 1716–1727.

Mulugetta, Y., Ben Hagan, E., & Kammen, D. (2019). Energy access for sustainable development. *Environmental Research Letters*, *14*(2). https://doi.org/10.1088/1748-9326/aaf449

Mwakitalima, I. J., Rizwan, M., & Kumar, N. (2023). *Integrating Solar Photovoltaic Power Source and Biogas Energy-Based System for Increasing Access to Electricity in Rural Areas of Tanzania*. *2023*. https://doi.org/10.1155/2023/7950699

Oyedepo, S. O., Uwoghiren, T., Babalola, P. O., Stephen, C., Kilanko, O., Leramo, R. O., Aworinde, A. K., Adekeye, T., Oyebanji, J. A., & Abidakun, O. A. (2019). *Assessment of Decentralized Electricity Production from Hybrid Renewable Energy Sources for Sustainable Energy Development in*. 72–89.

Riva, F., Tognollo, A., Gardumi, F., & Colombo, E. (2018). Long-term energy planning and demand forecast in remote areas of developing countries : Classi fi cation of case studies and insights from a modelling perspective. *Energy Strategy Reviews*, *20*, 71–89. https://doi.org/10.1016/j.esr.2018.02.006

Singh, S. N., Sharma, M. P., & Singh, A. (1970). Design of Mini Grid for SHP Plants. *Hydro Nepal: Journal of Water, Energy and Environment*, *7* (7), 38-47. https://doi.org/10.3126/hn.v7i0.4235 *sw-1748954748-Shima Profile_11zon.pdf*. (n.d.).

Utonga, D. (2022). Analysis of Maize Profitability among Smallholder Farmers in Mbinga District, Tanzania. *International Journal of Research Publication and Reviews*, *February 2022*, 1031-1035. https://doi.org/10.55248/gengpi.2022.3.2.13

Wang, R., & Jiang, Z. (2017). Energy consumption in China ' s rural areas : A study based on the village energy survey. *Journal of Cleaner Production*, *2016*. https://doi.org/10.1016/j.jclepro.2016.12.090