International Journal of Progressive Sciences and Technologies (IJPSAT)
ISSN: 2509-0119.

Vol. 39 No. 1 June 2023, pp. 325-338

Electricity Access In Goma And Bukavu City, Democratic Republic Of Congo

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Abstract – More than half of the least developed countries people (LDCs) live without access to electricity and this lack of electricity is a barrier to achieving some of the Sustainable Development Goals (SDGs). In this paper, we examine household access to electricity in Goma and Bukavu in the Democratic Republic of Congo (DRC) using survey data collected from April 14 to May 17, 2022. We find that (1) Goma with MTF has a high rate of access to electricity (83.03%), compared to Bukavu where only slightly more than half (58%) of the population has access to electricity. (2) In Tier 0, which corresponds to the absence of electricity, a significant percentage of households are connected to the electricity grid. (3) In Goma, there are several companies involved in grid-connected electricity supply, while in Bukavu 97.40% of households are supplied by SNEL.

Keywords – Electricity Access, Multi-Tier Framework, Electricity Access Index, Goma, Bukavu, DRC.

I. INTRODUCTION

In recent decades, electrification has become the main driver of development [1],[2],[3],[4],[5],[6] and its contribution to all spheres of life (income, labor productivity, education attainment [7], female employment [8], industrialization, etc. [9],[10]) can no longer be demonstrated.

Unfortunately, while electricity is ubiquitous in all developed countries [8], more than half of the people in the least developing countries (LDCs) live without access to electricity [11]. This lack of electricity is a barrier to achieving some of the Sustainable Development Goals (SDGs) [12],[13].

Consider the Democratic Republic of Congo (DRC), one of 46 LDCs [14]: With an estimated population of about 95.89 million (2021), only 19.1% (in 2020) of the population has access to electricity, and 4 % to clean fuels and technologies for cooking. In urban areas, access to electricity and clean fuels and technologies for cooking was estimated, at 40.7% [15] in 2020 (which is below the sub-Saharan average of 78.3% [16]) and 8.3 % [15] respectively. This access rate varies from city to city.

Households account for about 35% of electricity demand In DRC, making it the second most important sector after industry (55%) [17], but in energy consumption mix, it accounts for only about 1% of the total energy consumed in Households [18].

Since 2020, the DRC government has planned to increase access to electricity to 30% by 2024 by establishing some fund (like Mwinda Fund) to accelerate electrification [19]. Is there an improvement?

The objective of this study is to fill a knowledge gap by examining access to electricity in urban areas of RDC, particularly in the city of Goma and Bukavu. We examine and compare access to electricity, according to SDG target 7.1, indicator 7.1.1, which is

intended to indicate the proportion of the population with access to electricity [20],[21],[13]. Furthermore, we explore the electricity market in these cities.

This paper is therefore of interest to both energy policy makers and electricity suppliers, as it not only paints a picture of the electricity situation in Goma and Bukavu, where each electricity supplier finds its own place in this market but also identifies weaknesses in service provided by electricity suppliers that should be addressed.

In the rest of the paper, the sections are organized as follows. Section 2, Methods, discusses the study area, data collection, and analysis. Section 3 presents the results of binary and MTF analysis, index of electricity access, Electricity use, electrical appliances used, providers, and billing system. Section 4 summarizes the results.

II. METHODS

2.1. Study area

Goma islocated in the east of the Democratic Republic of Congo and is the capital of North-Kivu province [22][23] which lies at an average elevation of 1,504 meters, 1° 39' South of latitude and 29°12' East of longitude. It has an area of 66.42 km^2 and consists of two municipalities: Goma and Karisimbi with 18 neighborhoods [24]. The population is estimated at about one million [25][26].

Bukavu is the capital of South-Kivu province. It is located at an average altitude of 1,569 meters, at latitude 2° 30' south and longitude 28° 51 East. It has an area of 45 km^2 and consists of three municipalities: Bagira, Ibanda and Kadutu [27][28][29]. And has an estimated population of about 1.2 million [30][31][32].

2.2. Data collection and analysis

A primary date was collected from April 14 to May 17, 2022, in Goma and Bukavu city through a structured questionnaire using the kobo toolbox[1]. A total of 855 households (436 in Goma and 419 in Bukavu) were selected using the convenience sample method [33][34][35]

To analyze specific subsets of data, we used MS Excel for queries and transformations to generate statistical analyzes [36][37][38]. Binary and Multi-tier framework analysis was used to determine power access [39][40]. To summarize our results, we used charts, graph and Tables.

2.2.1. Binary and Multi-tier framework analysis.

Access to electricity can be measured by the binary system or the multi-tier framework. The binary measurement system, which has been used for many years, consists of answering *yes or no* if the households is connected to a particular grid [41][5].

In contrast, the multi-tier framework, is a new measurement approach, introduced by ESMAP [40]. It considers both energy quality and access [42] and redefines access to electricity as a continuum of service levels based on some key characteristics [43]. It also considers the off-grid system [41], which was not considered in the binary system.

Based on the seven attributes (Table 1) that characterize access to electricity [44], households can be classified into six (6) levels, ranging from level 0, which corresponds to no access to electricity, to level 5; as summarized in Table 1.

[1] https://www.kobotoolbox.org/

Table 1: multi-tier framework for electricity access

Attributes		TIER 0	TIER 1	TIER 2	TIER 3	TIER 4	TIER 5
Peak capacity	Power capacity ratings (in W or daily Wh)	< 3W	Min 3W	Min 50 W	Min 200 W	Min 800 W	Min 2 kW
			Min 12 kWh	Min 200 kWh	Min 1.0 kWh	Min 3.4 kWh	Min 82 kWh
	Or Services		Task lighting, phone charging, radio	Multipoint general lighting, television, computer, printer, fan	Air cooler, refrigerator, freezer, food processor, water pump, rice cooker	Washing machine, iron, hair dryer, toaster, microwave	Air conditioner, space heater, vacuum cleaner, water heater, electric cookstove
Availability (Duration)	Day	< 4 hrs.	Min 4hrs		Min 8 hrs	Min 16 hrs.	Min 23 hrs.
	Evening	< 1 hr.	Min 1 hr.	Min 2 hrs.	Min 3 hrs.	Min 4 hrs.	
Reliability	Frequency of disruptions per week	>14				Max 14	Max 3
	Duration of disruptions per week					>2hrs (if frequency ≤3	≤ 2 hrs.
Quality (Voltage problems affect the use of desired appliances		Yes				N0	
Affordability (Cost of a standard consumption package of 365 kWh/year)		≥ 5% of household's income			< 5% of household's income		
Legality (Bill is paid to the utility, prepaid card seller, or authorized representative)		No				Yes	
Health and safety						Absence of past accidents and perception of high risk in the future	

Source:[45][43]

2.2.2. electricity access Index.

To compile the information from the MTF matrix, an index of access to electricity is determined. This index is a number that represents household access to electricity in a selected geographic area. Access is assessed both by magnitude (how many households have access) and by its intensity (the degree to which households have access) [43]

The following formula was used to calculate the index:

$$Index = \sum_{k=0}^{5} 20 * Pk * K$$

Where:

- K is the number of levels

- Pk: proportion of households of Kth-level

III. Results

3.1. Binary system analysis

Figure 1 shows that 73.33% of households in Bukavu are connected to grid against 26.43% off-grid; while 26.43 are off-grid; in Goma, 69.50% are connected to a grid while 30.50% are off-grid. Therefore, according to the binary metric analysis, Bukavu city can be considered to have a higher percentage of electricity access than Goma.

Households that are not connected to an electricity grid (off-grid) are considered to be without electricity.

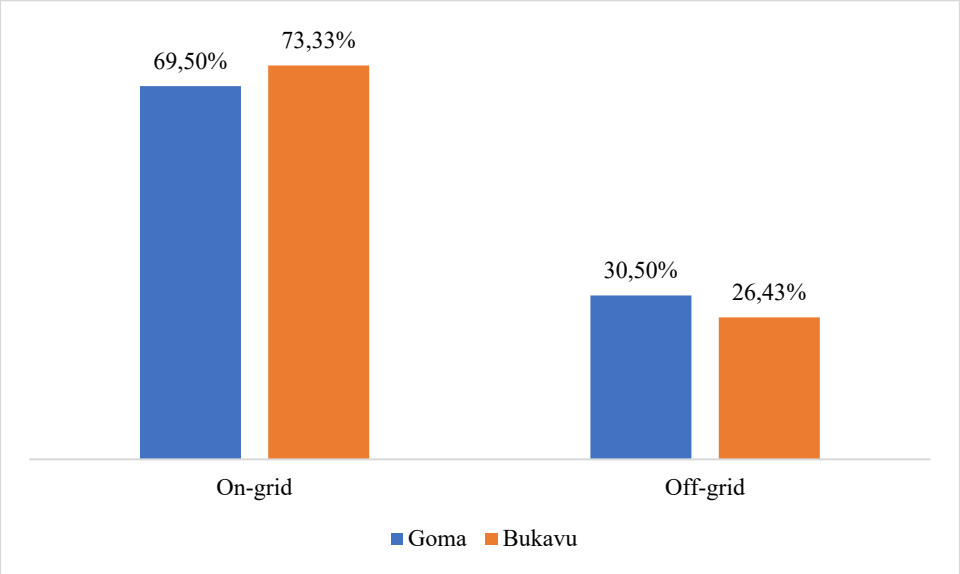


Figure 1: access to electricity based on the binary system.

3.1.1. Reasons for not being connected to the grid.

There are some reasons why a household may not be connected to the electricity grid, including being off grid [46], self-consumption [47][48], insufficient quantity and quality of electricity, monthly electricity bills, high connection fees [49][43], etc. In searching for the reasons why some households are not connected to the distribution network, we found (Fig.2) that solar self-consumption is the first reason for being off the grid in both Goma (37.59 %) and Bukavu (36.04%), followed by unavailability of power lines in Goma (24.81%) while connection fee (30.63%) is second in Bukavu.

Connection fees (19.55%) in Goma and lack of power line in Bukavu (13.51%) ranked the third. Fear of the monthly electricity bill and theft of electricity cables ranked fourth and fifth in both Goma and Bukavu, respectrively

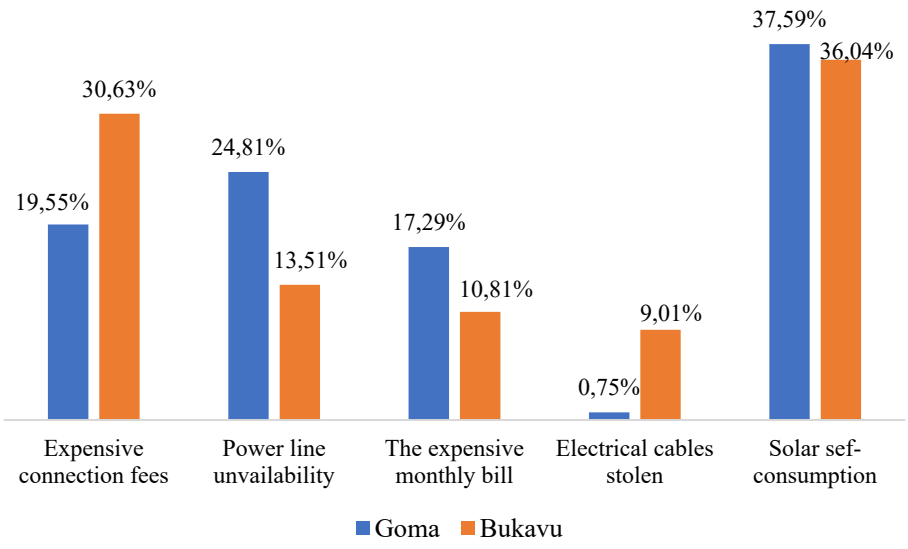


Figure 2. Reasons for not being connected to the grid.

3.2. Multi-tier Framework (MTF) Analysis

Two attributes were used In MTF analysis: availability of electricity (daytime and nightime) for the analysis of homes connected to the grid, and peak capacity (by service) for stand-alone homes. The result divides households, in both Goma and Bukavu into 6 groups (from Tier 0 to Tier 5).

Figure 3 shows that in Goma, a large important percentage of households (37.84%) belong to Tier 2, followed by Tier 0 (16.97%), Tier 5 (16.06%), Tier 3 (11.47%), Tier 4 (9.86%), and at least Tier 1 (7.80%). In Bukavu , on the othe hand, Tier 0 (42%) ranks first, followed by Tier 2 (26.73%), Tier 1 (15.99%), Tier 4 (9.79%), Tier 5 (3.10%), and at Tier 3 (2.39%) in last place.

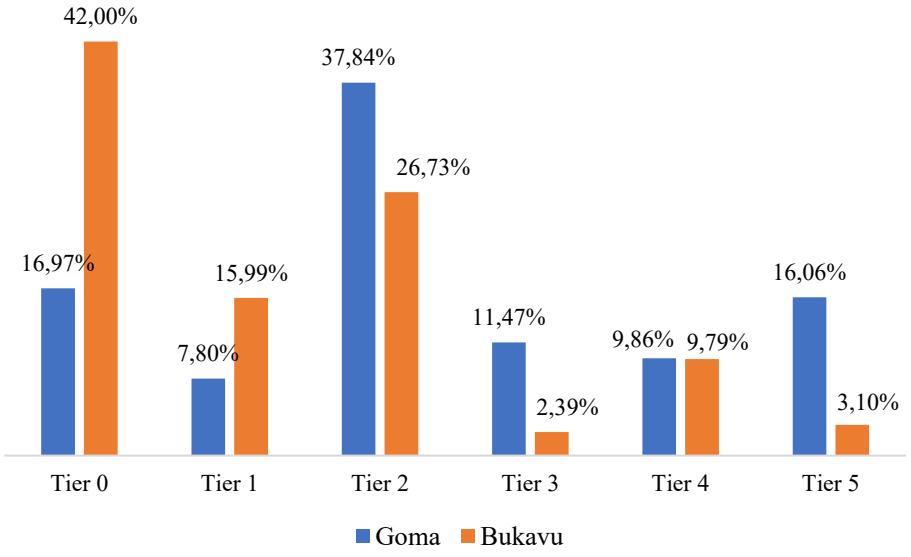


Figure 3: MTF electricity access.

When we sum all Ties (Tier 1 to 5) (Fig.4), we find that more households have access to electricity (83.03%) in Goma than in Bukavu (58.00%). Only 16.97 % of households in Goma do not have access to electricity, while 42% in Bukavu lack electricity.

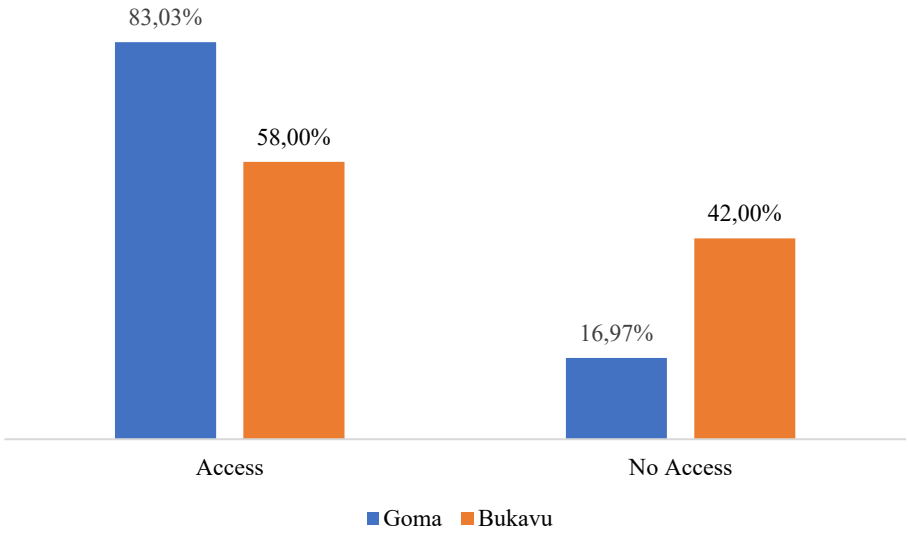


Figure 4.: access to electricity according to MTF.

Comparing these access scores to the urban access rate (40.7%) in the DRC, we find that both Goma and Bukavu have access rate above the urban average. If, when we compare the MTF result with the binary system result (Fig.1), we also find that electricity access in Goma increased by 13.53 %. This could be due to the fact that in the MTF, the stand-alone houses are considered to have access to electricity, which was not the case in the binary system. Most households in Tiers 1 and 2 use stand-alone solar, and according to the GEP scenarios [50], stand-alone solar PV will contribute significantly to electricity access in the DRC by 2030.

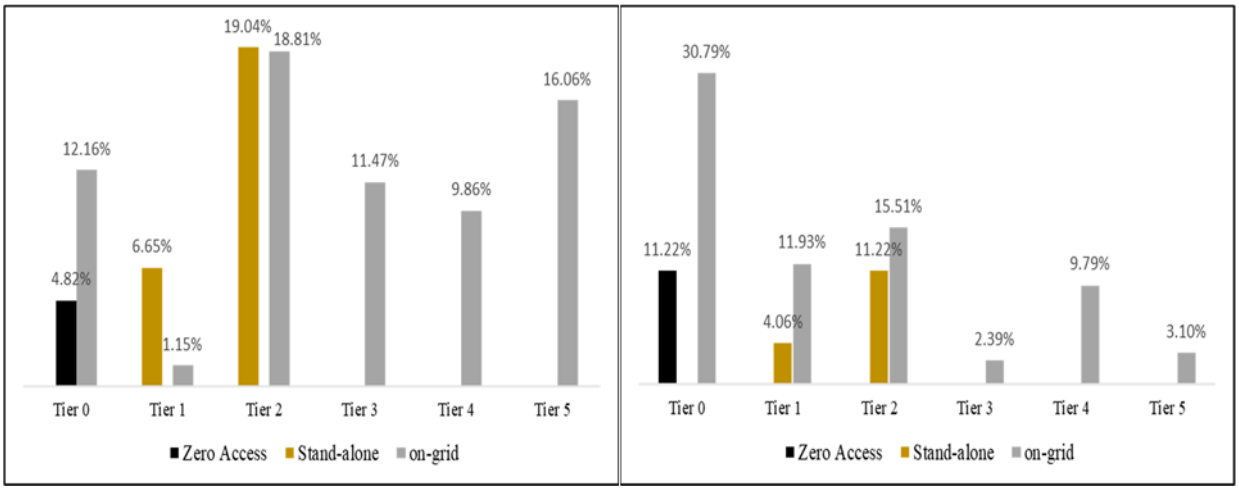
In Bukavu, however, electricity access decreased by 15.33% compared to the binary results, even when stand-alone houses were considered. This is due to the increase in grid connected households in Tier 0.

Note that for households using both grid electricity and solar, we only considered only the grid side in this MTF analysis.

When we look at the details of the MTF, we find (Fig.5) that in both Goma and Bukavu grid connected households are distributed across all Tiers, while stand- alone households are only found in Tiers 1 and 2.

In addition, we found that in Goma (Fig.5a) 4.82 % of households Tier 0 do not have access to electricity (Zero access[2]), and 12.16% of households are connected to a specific electricity grid but are considered off-grid households because they do not meet Tier 1 requirements (supplied with electricity for at least 4 hours per day). In Bukavu (Fig.5b), households with access to the grid outnumber those without. This confirms that access to electricity is not only defined by connection to an electricity grid [51], as electricity connection itself is not a guarantee of reliability, affordability, or adequate quality of energy delivered [20]. In addition, it should be noted that the stand-alone system can meet Tier 2 and Tier 3 requirements to some extent, but cannot achieve a higher level electrification [52][53]

[2] Zero access refers to a HH not connected to grid and without a solar panel.



a) Goma b) Bukavu

Figure 5: MTF electricity access details.

3.3. Index of electricity access

Based on the above results (Fig.3), we calculated the electricity access index and found that Goma has a higher electricity access rate (83.03%), but its electricity access index is still low (47.52 %). Bukavu's index is significantly lower (26.25%) than Goma's.

This low index is due to the high proportion of households in the lower strata (Tier 0, 1 and 2), which account for 62.61 % and 84.73 % of houses in Goma and Bukavu respectively.

And since we used availability to classify households, it means that most households in Goma and Bukavu have electricity less than 8 hours a day and less than 3 hours at night. This low index shows us that the service quality still needs to be improved.

3.4. Use of electricity

Figure 6 shows that houses connected to the electricity grid in both Goma and Bukavu use electricity for three purposes: Lighting (100% of households), running appliances (96.37% and 96.75%, respectively), and cooking (24.75% and 13.31%, respectively). In stand-alone houses electricity is used only for lighting (99.11% in Goma and 100 % in Bukavu), and appliances (83.04 % and 59.38 %, respectively).

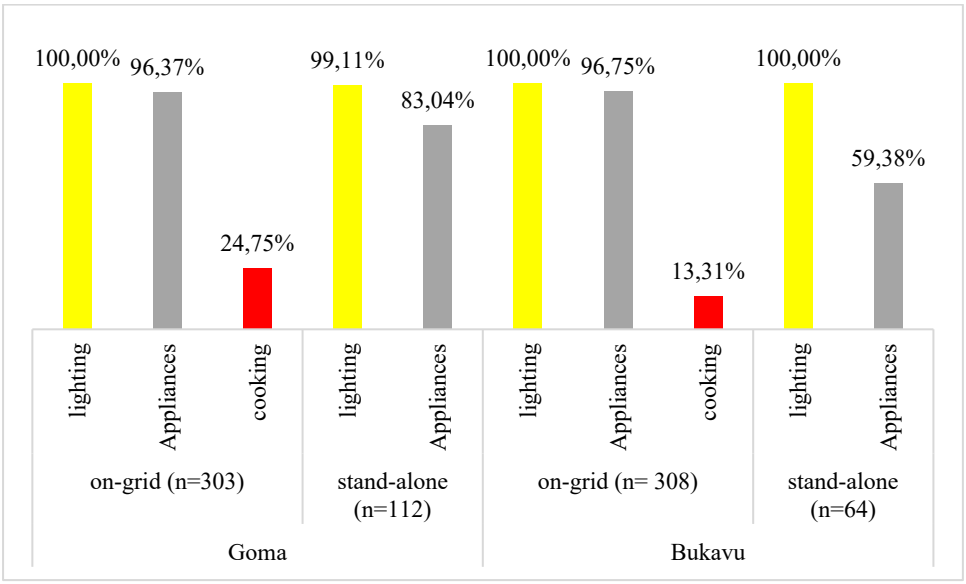


Figure 6: Use of electricity.

3.5. Electrical appliances used.

It is important to note that electrical appliances play a key role in the electrification rate [42]. In this section, we tried to find out which electrical appliances are most commonly used in Goma and Bukavu households and we found (Fig.7) that all types of appliances are used in grid-connected households, from low to high power consumption appliances, although low consumption appliances (telephone, radio, television and Computer charging) dominate in both Goma and Bukavu, while in stand-alone households can only operate telephones, radios, TV, and computers, which consume relatively little power, between 50 and 199 watts [45].

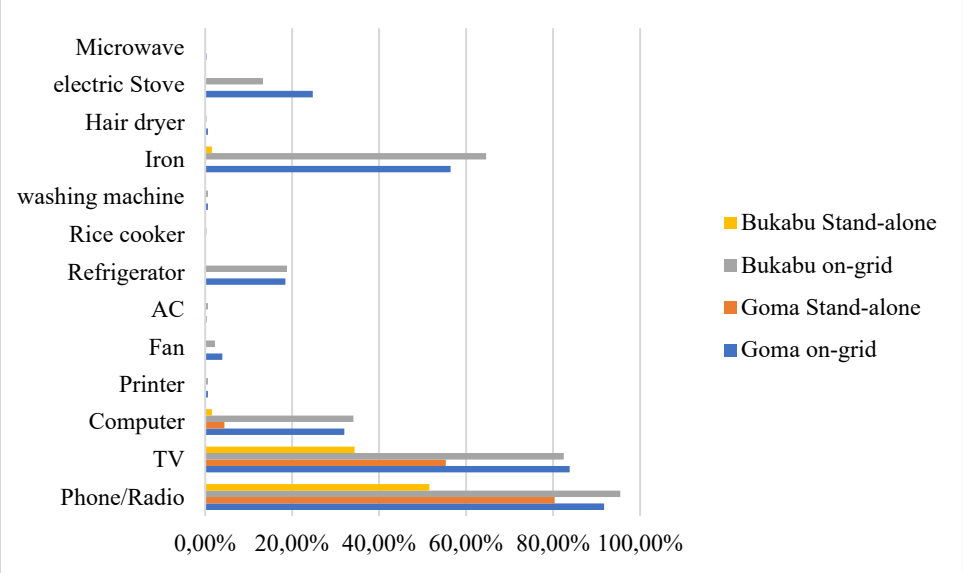
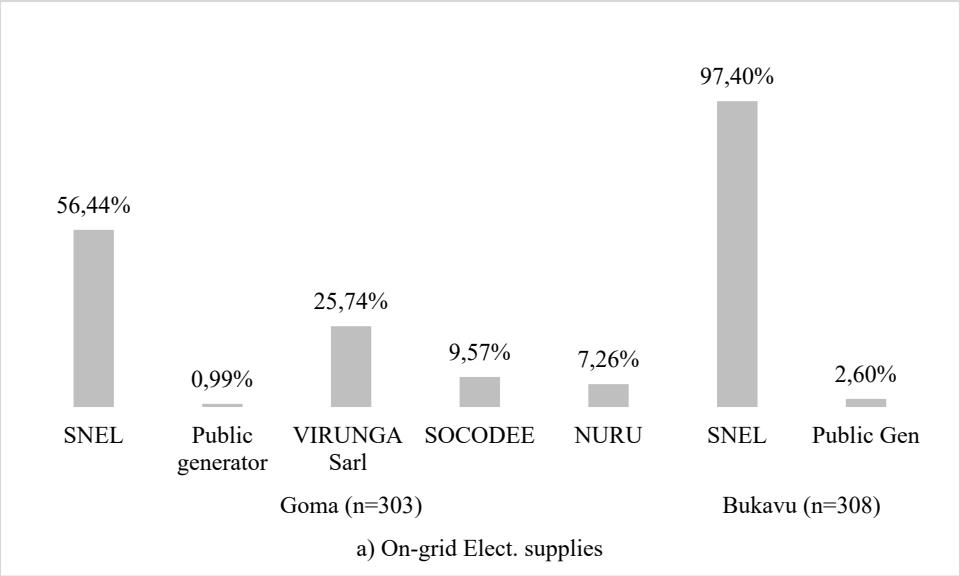


Figure 7: Electrical appliances used.

3.6. Supplier companies

A look at Figure 8 (a) shows that there are five electricity suppliers in Goma and only two in Bukavu. The main grid operator in both Goma and Bukavu is the national utility, SNEL, which suppliers 56.44 % of homes in Goma and 97.4% in Bukavu. In Goma, it is followed by Virunga (25.74 %), Socodee (9.57 %) and Nuru (7.27 %).

In Figure 8 (a) we found that the normal market is the main supplier of solar in both Goma (95.40%) and Bukabu (95.71%). The remaining share is accounted by compagnies operating in the energy sector (Altech, Bboxx in Goma and Bukavu, and Go_shop and Zola only in Goma)



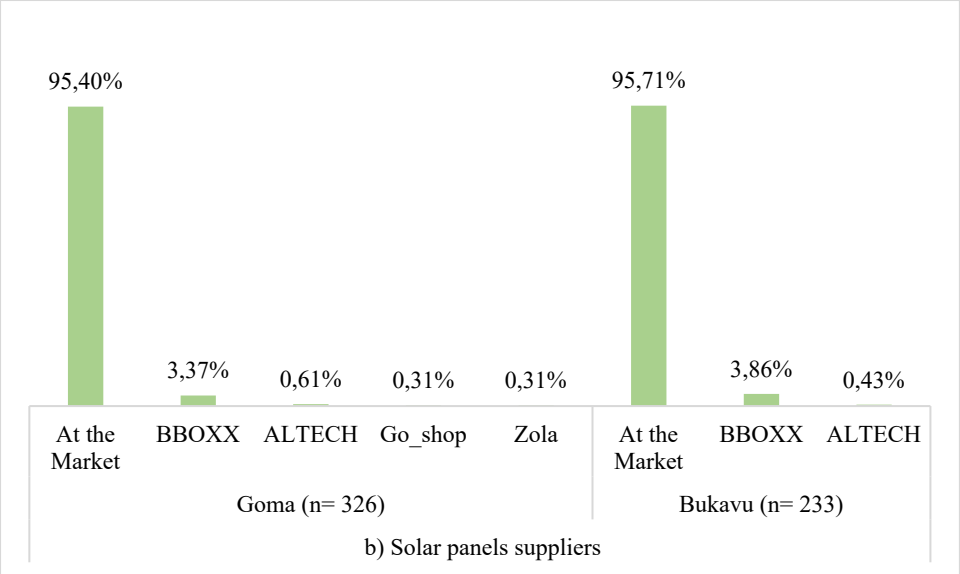


Figure 8: Electricity suppliers.

3.7. Satisfaction with service provided by suppliers.

In this section, we investigated whether consumers are satisfied with the service they receive from their electricity providers and if not, what could be the cause. The results (Fig.9) show that in Goma, 49.83% of households connected to the electricity grid are satisfied with the service, compared to 16.23 % in Bukavu. The high percentage of dissatisfaction is found in Bukavu, where more than half (69.48%) of households are dissatisfied with the service provided by the supplier.

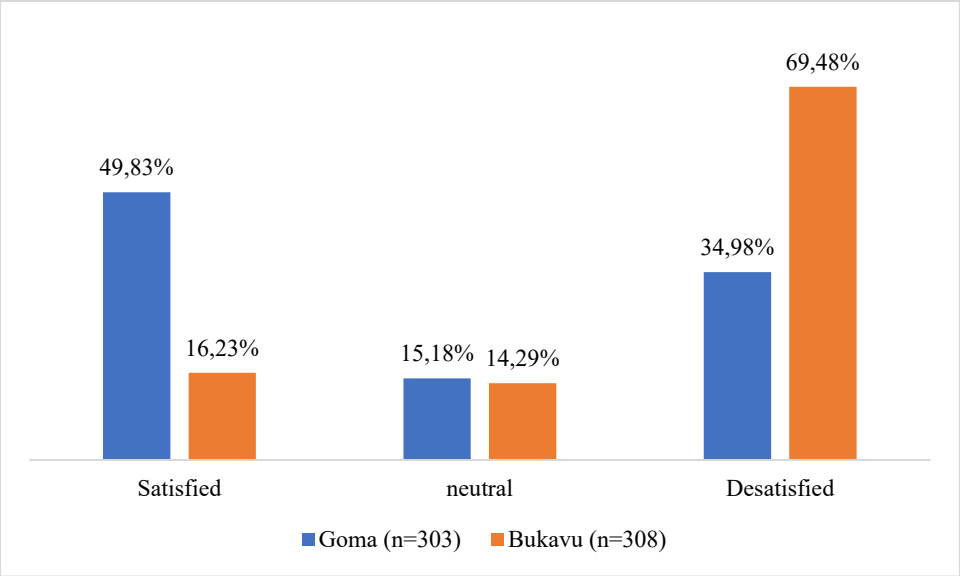


Figure 9: Satisfaction with utility service.

In terms of reasons for dissatisfaction, Figure 10 shows that unavailability of electricity is the main reason in both Goma and Bukavu, accounting for 87.74 and 88.32% respectively. Expensive electricity bills account for 39.63% in Goma and 13.55% in Bukuvu. The problem of electricity being available only at night accounts for 34.91% and 32.71%respectively, while poor quality of electricity is the last reason with 8.49% and 7.48% respectively.

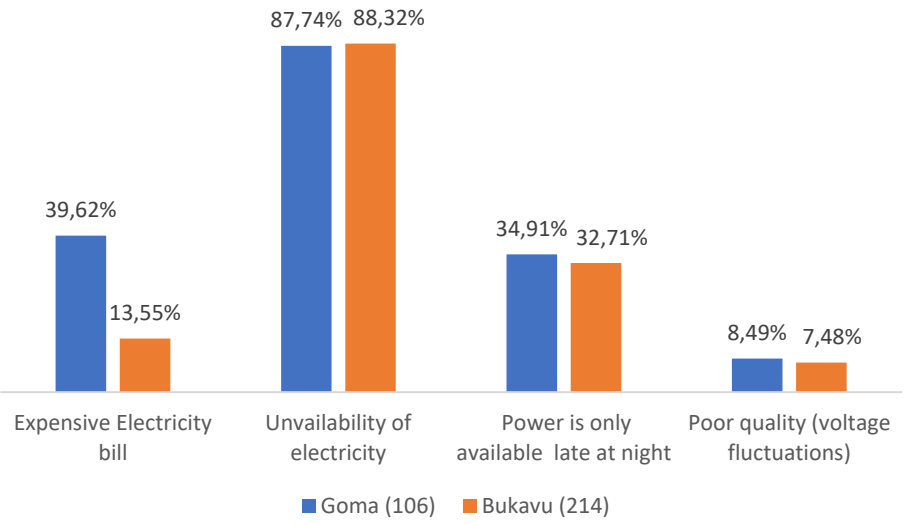


Figure 10: Reasons for dissatisfaction.

3.8. Electricity Costs and payment system

Table 2 shows the descriptive statistics of monthly electricity expenditure (in US dollars) of on-grid households in Goma and Bukavu. It can be seen that households in Goma spend more on electricity than in Bukavu. We found that the average monthly expenditure in Goma is $13.01, while in Bukavu it is $9.26, and Bukavu spends $20 less than Goma in terms of maximum household expenditure. In both Goma and Bukavu, the minimum is $0. The reasons for this are found in the next section.

Table 2: Descriptive Statistics.

	Obs.	Mean	Stand. Dev	Min	Max
Goma	303	13.01	8.81	0	60
Bukavu	308	9.26	5.90	0	40

Looking at the payment system, we see (Fig.11) that flat rates still dominate in both cities, but significantly more in Bukavu (69.48%) than in Goma (45.87%). In Goma, 42.24% of households use on prepaid plans, compared to only 17.53% Bukavu. Post-paid customers rank third in both Goma (11.22%) and Bukavu (8.44%). And interestingly, some of customers, albeit few (0.66% in Goma and 4.55% in Bukavu), do not pay for electricity.

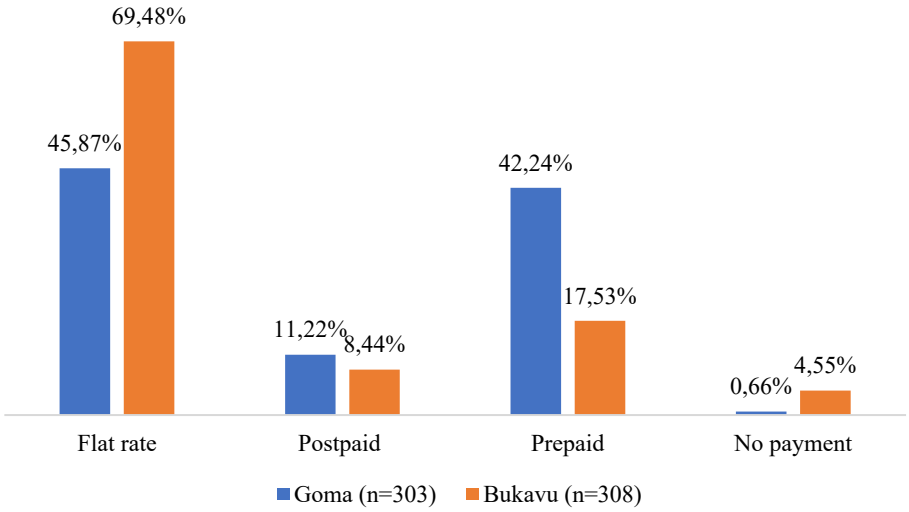


Figure 11. Th payment system.

IV. Conclusion

This study examined household access to electricity in Goma and Bukavu. First, our study found that in the MTF analysis, which considers both on-grid and stand-alone houses, Goma has a high rate of access to electricity (83.03%), compared to Bukavu where only slightly more than half (58%) of the population has access to electricity. Specially, the analysis showed that in Tier 0, which corresponds to not having to electricity, a significant percentage of households are connected to the electricity grid (especially in Bukavu: 30.79%).

Secondly, the results showed that in Goma there are several companies involved in grid-connected electricity supplier, while in Bukavu 97.40% of households are supplied by a single company, the national utility SNEL. For solar panels, the normal market ris the main supplier in both cities and far from other solar companies.

Third, our results show that electricity prices in Goma are higher than in Bukuavu with maximum monthly bills $20 higher than Bukavu. We also found that in both Goma and Bukavu the flat rate still dominates the payment system.

The findings suggest improving electricity access in both cities. Since the index of electricity access is low in Goma and very low in Bukavu, increasing the number of households in Tiers 3, 4 and 5 (especially in Bukavu) by improving electricity quality (availability of electricity) will not only increase the index but also reduce the rate of households' dissatisfaction.

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