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Drivers and barriers

Adoption of electricity and improved cooking ovens in Mainland Tanzania

TALL SOM FORTELLER

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Preface

The Impact of Access to Sustainable Energy Survey (IASES) 2021/22 was implemented by the National Bureau of Statistics (NBS) and Statistics Norway (SSB) in collaboration with the Ministry of Energy (MoE), Tanzania Electric Supply Company (TANESCO), Rural Energy Agency (REA) and Energy and Water Utilities Regulatory Authority (EWURA). The survey was jointly funded by the Government of Tanzania and the Norwegian Agency for Development Cooperation (Norad) through Statistics Norway.

According to the Tanzania National Energy Policy 2015, availability, affordability, reliability and access to modern energy services are considered key ingredients towards achieving desired socio-economic development in Tanzania. Access to sustainable energy is a critical issue with far-reaching impacts on communities, economies, and the environment. In today's world, energy is the backbone of development. It is essential for meeting the basic needs of people such as cooking, lighting and heating.

The main results from this survey are published in an overall report and available from the NBS website: https://www.nbs.go.tz/uploads/statistics/documents/en-1706803129-The%202021-22%20Impact%20of%20Access%20to%20Sustainable%20Energy%20Survey%20-%20Main%20Report.pdf (National Bureau of Statistics 2023).

This report presents the analysis of factors affecting the household access to sustainable energy and improved cooking solutions. First, the report shows how households are driven and pushed to connect to the national grid when possible or to install and use solar energy, or rather how households face barriers against connection to the national grid and barriers discouraging installation and use of solar energy. Second, the report presents factors encouraging households to opt for energy effective cooking solutions or rather making it too difficult to switch to energy effective cooking solutions.

Statistics Norway, September 2024
Lasse Sandberg

Abstract

Access to electricity and improved cooking solutions is dependent upon policy and available resources at the national level, the community level and the household level. This report focuses on the latter two. There are two main supply lines for electricity, connection to a grid or to a solar device with battery. TANESCO is the government agency running the electricity grid net. But in rural areas, the government agency REA will build the grid. When the REA network is extended to a community, connection to the house is free of charge and households only pay for internal wiring.

The main driver for connection to the grid at household level is access to the grid in the community. In Dar-es-Salaam 87 percent live in a community with access and 86 percent are connected. In other urban areas 70 percent have access at community level while 59 percent are connected. Even at rural level, 36 percent have access at community level.

REA usually only builds one customer voltage transformer in the central area of a community. More remote households will need a second transformer and today this requires a high connection fee. The only option in many rural areas is still solar power. But this may well be a cost-efficiency solution.

Households in Dar es Salaam, other urban areas and rural areas have distinctly different cooking solutions. The majority of rural households relies on a basic fireplace with three stones for cooking. In urban areas charcoal is the common fuel, while households in Dar es Salaam may even use LPG gas for cooking.

When identifying the main drivers for connection to the grid or solar power, it is important to disentangle the causality. Hence, we focused on the household who lived in communities with recent (last 5 years) access to the grid to learn who choose to connect. For households living in communities with no access to the grid, we focused on the households who did not have any solar power 5 years ago to learn the driving force to a recent access to electricity through solar power.

We identified four groups:

- Early birds establishing a solar device before a grid was possible.
- Mid-range households connecting to the grid, when the grid poles arrived.
- Late comers may be able to invest in a solar device at a later point in time.
- Outsiders with few resources or living in the outskirts of the village will often not be able to get access to electricity within the household.

An energy efficient cooking solution varied from area to area. In Dar es Salaam, the energy efficient option is to switch to LPG gas. In other urban areas, the energy efficient option is to switch to more energy efficient charcoal burner with proper air regulation and insulated burning chambers. Rural household will face a higher threshold when changing to a modern oven for solid fuel or to a charcoal option.

Policy recommendations:

- When REA extend the grid net to a community, they may consider building several transformers. Compared with the initial cost, the costs of one more transformer is low.
- If the government wants to expand the access to electricity, the most cost-efficient solution for remote areas may well be solar energy.
- In order to ensure an efficient market for solar energy panels and batteries, it is essential that communities and households have access to reliable information on technical options and a proper balance between solar panel capacity and battery capacity and alternative battery types. A government contribution in Tanzania may focus on establishing demonstration sites in cooperation with the business community.

Sammendrag

Tilgang til elektrisitet og energieffektive komfyrer for matlaging er avhengig av politiske rammebetingelser og tilgjengelige ressurser på nasjonalt nivå, samfunnsnivå og husholdningsnivå. Denne rapporten fokuserer på samfunns- og husholdningsnivå. De to viktigste kildene for elektrisitet er tilkobling til nettet eller til solcelleanlegg med batteri. Det offentlige elektrisitetsnettet drives av TANESCO. Men i distriktene bygger den statlige etaten REA ut nettet. Når REA-nettet utvides til et lokalsamfunn, er tilkobling til de enkelte hus gratis og husholdninger betaler kun for intern kabling.

Hoveddriveren for tilknytning til nettet på husholdningsnivå er tilgang til nettet i samfunnet. I Dar es Salaam bor 87 prosent i lokale kvartaler med tilgang og 86 prosent er tilkoblet. I andre byområder har 70 prosent tilgang på samfunnsnivå mens 59 prosent er tilkoblet. Selv på landlig nivå har 36 prosent tilgang på lokalsamfunnsnivå.

REA bygger vanligvis bare én kundespenningstransformator i det sentrale området av et lokalsamfunn. Flere avsidesliggende husstander vil trenge en transformator nummer to, og i dag krever dette en høy tilknytningsavgift. Det eneste alternativet i mange landlige områder er fortsatt solenergi. Dette er en kostnadseffektiv løsning, men krever jo en betydelig investering for den enkelte husstand.

Husholdninger i Dar es Salaam, andre byområder og landlige områder har tydelig forskjellige komfyrløsninger for matlagingen. Flertallet av landlige husholdninger er avhengige av et enkelt ildsted med tre steiner for matlaging. I urbane områder er trekull det vanlige drivstoffet, mens husholdninger i Dar es Salaam også kan bruke LPG-gass til matlaging.

Når man skal identifisere hoveddriverne for tilkobling til nettet eller solenergi, er det viktig med klare tidslinjer. Derfor fokuserte vi på husholdningen som bodde i lokalsamfunn med nylig (de siste 5 år) tilgang til nettet for å finne ut hvem som velger å koble til. For husholdninger som bor i lokalsamfunn uten tilgang til nettet, fokuserte vi på husholdninger som ikke hadde solenergi for 5 år siden for å lære drivkraften til en nylig tilgang til solenergi.

Vi identifiserte fire grupper:

- Early birds anskaffet en solcelleenhet før tilkobling til nettet var mulig.
- Vanlige husholdninger som koblet seg til nettet når nettstolpene ankom.
- Late comers som kanskje investerer i et solcelleanlegg på et senere tidspunkt.
- Utenforstående med få ressurser eller bosatt i utkanten av bygda får ofte ikke tilgang til strøm.

En energieffektiv komfyrløsning varierte fra område til område. I Dar es Salaam er det energieffektive alternativet å bytte til LPG-gass. I andre byområder er det energieffektive alternativet å bytte til en mer energieffektiv trekullbrenner med riktig luftregulering og isolerte brennkammer. Rurale husholdninger vil møte en høyere terskel for å bytte til en moderne ovn for fast brensel eller til et trekullalternativ.

Anbefalinger:

- Når REA utvider nettet til et lokalsamfunn, bør de vurdere å bygge flere transformatorer. Sammenlignet med startkostnaden er kostnadene for en transformator ekstra til lave.
- Dersom regjeringen ønsker å utvide tilgangen til elektrisitet, kan den mest kostnadseffektive løsningen for fjerntliggende områder godt være solenergi.
- For å sikre et effektivt marked for solcellepaneler og batterier er det viktig at lokalsamfunn og husholdninger har tilgang til pålitelig informasjon om tekniske alternativer og en riktig balanse mellom solcellepanelkapasitet og batterikapasitet og alternative batterityper. Et statlig bidrag i Tanzania kan fokusere på å etablere demonstrasjonssteder i samarbeid med næringslivet.

Contents

1. Drivers pushing and barriers tampering access to electricity and improved cooking solutions.

Access to electricity and improved cooking solutions may be dependent upon policy and available resources at the national level, the community level, and the household level. This report focuses on the situation at community and household level.

As documented in the report Access to Electricity and Modern Cooking solutions (National Bureau of Statistics 2023) and summarized with some information in the next chapter, a large share of communities is connected to the national grid, but many households in these communities are not connected. In communities not connected to the national grid, several households have access to electricity through solar power. But still around 3.5 million of 12.8 million households miss access to any electricity.

Likewise, several households do use energy efficient cooking solutions, usually either based upon LPG gas or improved charcoal burners. But still many households rely on an open fireplace for solid fuel demanding large quantities of firewood used with very low efficiency for each meal.

We present some main figures in the next chapter, but the reader who wants the actual numbers and shares of household with the various types of access to electricity and various cooking solutions are recommended to turn to the above-mentioned report (National Bureau of Statistics 2023).

Even in this report we focus on both access to electricity and energy efficient cooking solutions. First, we focus on why some, but not all households connect to the grid when there is grid in the community and why some, but not all install a solar device in community with no access to the grid. Second, we focus on why some, but not all households switch to more energy efficient cooking solutions.

The next chapter focuses on drivers and barriers for access to electricity. The shares of households willing to pay for electricity connection is remarkably high and it would be interesting to learn which factors drive the ability and willingness to pay for grid connection. We continue this chapter on drivers and barriers for the adoption of modern energy efficient cooking solutions. Based upon this documentation we combine the information for an analysis of how important the various factors are in driving or rather creating barriers for access electricity and energy efficient cooking solutions. This analysis allows us to provide some policy recommendations for future consideration on how to design a policy towards improved access to electricity and energy efficient cooking solutions.

2. Drivers for adoption of electricity

There are two main supply lines for electricity. One option is connection to a grid or to a solar device with battery. The other options being connection to a generator, a pico-hydro supply, a battery charged at a business or a neighbour, but these options are not common.

The possibility of household-connection to the grid requires of course that a government agency, i.e. Tanzania Electric Supply Company Limited (TANESCO) or the Rural Energy Agency (REA) has extended their grid to the community. Prices vary however considerably for connection to the grid depending on the location in the community and time of connection.

When the REA network is extended to a community, connection to the house has either required a small fee or been free in some periods. The household may expect to pay at least 50,000 TZS (approx. 20 USD) for internal wiring, but this still remains the most affordable option.

When REA has completed the grid net in a community, TANESCO will run the net supply and maintenance. TANESCO request a connection fee for households within a 30 meters range of a low voltage transformer of 272,000 TZS (approx. 100 USD) in urban areas and 150,000 TZS (55 USD) in rural areas, both excl. VAT[1]. Household with a further distance to a transformer may pay up to 590,398 TZS / 385,300 TZS (approx. excl. VAT) (approx. 220 – 140 USD) for up to 120 meters and two additional poles in urban and rural areas. A low tariff fee for consumption within 75kWh/month is 100 TZS (approx. 0.04 USD) per kWh and above 75kWh 350TZS (approx. 0.13 USD)[2]. The annual cost for 75kWh per month or 900 kWh a year is 9,000 TZS (approx. 3 USD). A consumption above 75kWh in three consecutive months will however increase the price to more than 31,500 TZS (approx. 12 USD).

Solar home systems are available in a range of capacities. Typical prices may be TZS 200,000 (approx. 75 USD) for a 30W panel and a 18Ah battery and TZS 300,000 (approx. 110 USD) for a 60W panel and a 75Ah battery[3].

Hence the price for getting access to electricity if connected with REA is just a fraction of the costs of connection with TANESCO of buying a solar home system.

2.1. Main driver to adoption of electricity - access to a grid in the community

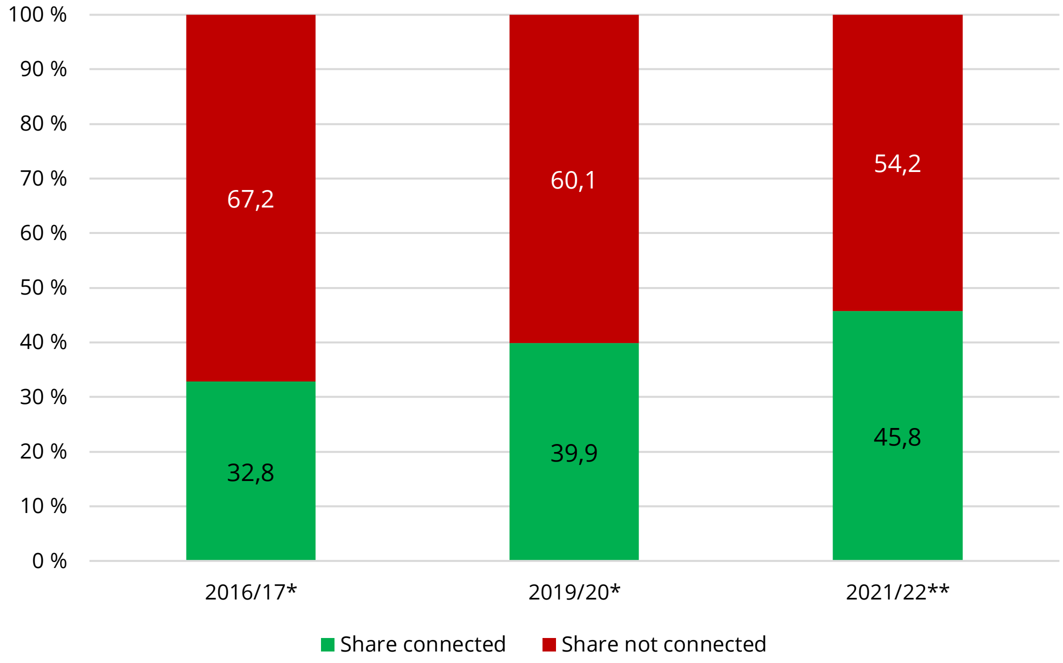
The main driver to get access to electricity through the grid is to have REA or TANESCO to build a low voltage line and one or more transformers in the community.

The REA definition of communities connected to electricity is calculated as households living in villages or hamlets connected to electricity.[4]

As shown in the main report the large majority of households (72%) are living in such communities.

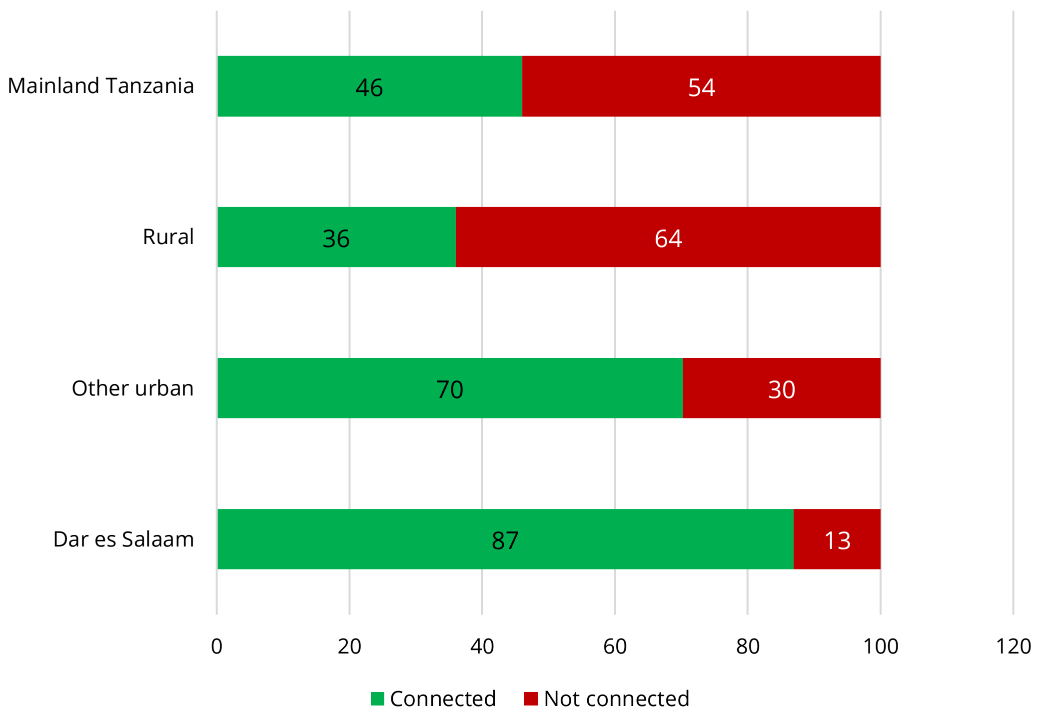
[1] https://www.tic.go.tz/pages/tanesco
[2] BEI ZA UMEME ZILIZOIDHINISHWA (tanesco.co.tz)
[3] https://jiji.co.tz/272-solar-panels
[4] REA definition: (If there) is an electric pole in the village, hamlet or mitaa and an electric bulb in the house (the household is connected to electricity). In the Impact of Access to Sustainable Energy Survey 2021/22, households connected to electricity referred to households whose source of electricity was either Tanzania Electric Supply Company Limited (TANESCO) /REA or a local private entity.
Source: Tanzania National Bureau of Statistics, R. E. A. (2017). Energy Access Situation Report, 2016 Tanzania Mainland. Dar es Salaam, Tanzania National Bureau of Statistics: 377, National Bureau of Statistics, R. E. A. (2020). Energy Access and Use Situation Survey II in Tanzania Mainland 2019/20, National Bureau of Statistics, Rural Energy Agency: 30.

Figure 2.1 Households living in Communities with Connection to Electricity* over Time, Mainland Tanzania. Shares in percent, 2016/17, 2019/20, 2021/22



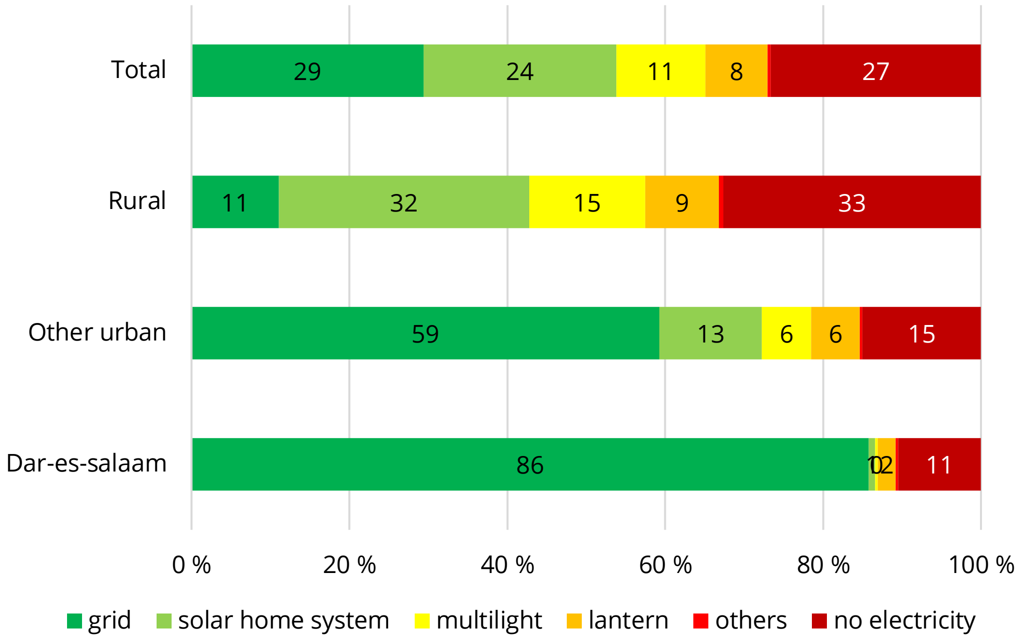
* REA definition: (If there) is an electric pole in the village, hamlet or mitaa and an electric bulb in the house (the household is connected to electricity).
Source: (Tanzania National Bureau of Statistics 2017, National Bureau of Statistics 2020, National Bureau of Statistics 2023)

Figure 2.2 Households living in Communities with Connection to Electricity* by Area, Mainland Tanzania. Shares in percent, 2021/22



* REA definition: (If there) is an electric pole in the village, hamlet or mitaa and an electric bulb in the house (the household is connected to electricity).
Source: (National Bureau of Statistics 2023)

Figure 2.3 Households by Main source of Electricity by Area, Mainland Tanzania, Shares in percent, 2021/22



Source: (National Bureau of Statistics 2023)

Figure 2.3. shows the distribution of the main source for electricity. The highest share of almost 1 of 3 (29%) has a grid connection. But for 1 of 4 (24 %) a solar home system is the main source and around 1 of 10 has a multilight system (11%) or a lantern (8%) as the main source. Only the last 1/3 (27%) are without any of these sources to electricity.

Jointly figures 2.1. to 2.3. show that there has been an impressive increase in the shares of households living in communities with access to the grid. These households can all enjoy some of the benefits of access to the grid. A large share of these households are connected at household level and the others may connect with neighbours to charge their cell phones and batteries and link up to increased economic opportunities.

The main driver for connection to the grid at household level is access to the grid in the community. As shown in figure 2.2., in Dar-es-Salaam 87 percent live in a community with access and 86 percent are connected. In other urban areas 70 percent have access at community level while 59 percent are connected. Even at rural level, 36 percent have access at community level. But only 11 percent are actually connected at household level.

With other words. Despite fulfilling the main driver of community access, the barriers stop a large proportion of 25 percent of rural households to get access and 11 percent of households in other urban areas to be connected.

2.2. Main Barriers to adoption of electricity

The main barrier to adoption of grid electricity is lack of community access.

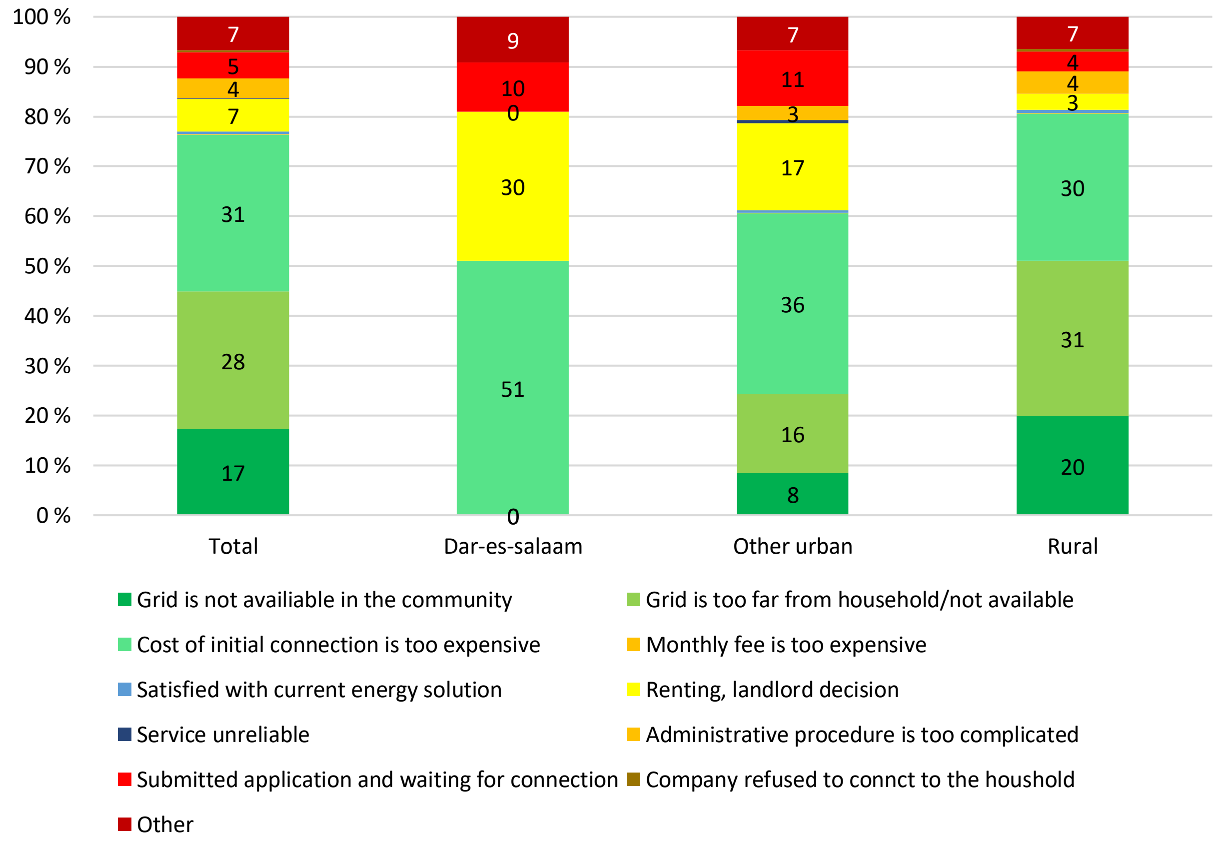
But there are also other barriers, as follows:

- Lack of capacity of the electric transformer in the community, either by the spatial capacity or the customer number capacity.
- Lack of economic capacity of the household on paying the connection fee, or the running costs.

An electric transformer station in the community may only deliver 230V power to households within a 600meter radius and to a given number of households. Households living further away from the transformer will not be able to connect.

The power grid lines in rural areas are built by REA. When the grid lines reach a community, REA has a given connection fee of TZS 27,000 and the modal connection fee paid by around 3 of 4 (76%) households falls between TZS 27,000 – 99,999 (National Bureau of Statistics 2020) p.63. Only around half (46%) of all households paid the full amount upfront and around 1/5 (20%) paid in installments, while the rest combined different methods of payment.

Figure 2.4 Barriers for not being connected to Electricity by Area, Mainland Tanzania, Shares in percent, 2021/22



Source: (National Bureau of Statistics 2023)

As figure 2.4 confirms, the main reason for not having access to electricity for Mainland Tanzania is lack of grid in community (35%). However, for around ¼ (27%), the main reason is that the grid or actually the transformer is too far away or not available to the household. For another ¼ (22%) of the households, the initial connection fee is too expensive.

In both Dar-es-Salaam and other urban areas, the main reason for not being connected is the cost of initial connection. In Dar-es-Salaam around 1/3 (30%) are renting from a landlord who do not ensure the connection. This also happens in other urban areas, but here the second most important reason for not being connected is that the grid and transformer is located too far away from the household or not being available.

2.3. Grid connection process

We may focus on households living in communities with access to electricity to learn more details about why households are not connected.

Table 2.1 Household Connection to Electricity by Area, Mainland Tanzania, Shares in percent, 2021/22

Connection	Area	Dar es Salaam	Other urban	Rural	Total
Is the community connected to the national grid or a local mini-grid?	Yes, both national grid and local mini grid	0	0	0	0
	Yes, national grid	100	100	100	100
	Yes, local mini grid	0	0	0	0
	No	0	0	0	0
	Total	100	100	100	100
Grid connection?	Yes	87	65	18	43
Is this the national grid or a local grid?	National grid	100	96	98	98
	Local grid	0	2	2	1
	Don't know	0	2	0	1
	Total	100	100	100	100
Which of these power sources is your main electrical power source?	Grid	91	71	21	48
	Solar Home System	1	10	36	22
	Electric generator	0	0	0	0
	Pico-Hydro	0	0	0	0
	Rechargeable Battery (Not linked to a solar system)	0	0	1	1
	Solar Multi-Light Product	0	7	14	9
	Solar Lantern	2	7	11	8
	Dry-cell battery	5	5	16	11
	Total	100	100	100	100
Which of these power sources is your main back-up source?	Grid	10	1	0	2
	Solar Home System	6	12	11	10
	Electric generator	6	2	1	2
	Pico-Hydro	0	0	0	0
	Rechargeable Battery (Not linked to a solar system)	6	4	1	3
	Solar Multi-Light Product	3	6	8	7
	Solar Lantern	9	15	10	11
	Dry-cell battery	46	46	58	54
	No electricity	14	13	11	12
	Total	100	100	100	100
Did you have any electricity five years ago? If yes, which was the main electrical power source in the household?	National Grid Connection	82	55	12	36
	Local grid connection	0	1	0	0
	Solar Home System	0	5	14	9
	Electric generator, pico-hydro, recharge battery	0	0	0	0
	Solar Multi-Light Product	0	2	4	3
	Solar Lantern	3	7	16	11
	No electricity	15	29	53	40
	Total	100	100	100	100
Main reason not connected to grid	Grid is not availiable in the community	0	8	20	17
	Grid is too far from household/not available	0	16	31	28
	Cost of initial connection is too expensive	51	36	30	31
	Monthly fee is too expensive	0	0	0	0
	Satisfied with current energy solution	0	1	1	1
	Renting, landlord decision	30	17	3	7
	Service unreliable			0	0
	Administrative procedure is too complicated	0	3	4	4
	Submitted application and waiting for connection	10	11	4	5
	Company refused to connct to the Household	0	0	0	0
	Other	9	7	7	7
	Total	100	100	100	100
Expect to get grid connection	Yes	45	58	64	62
	No	15	12	14	14
	Don't know	39	30	22	24
	Total	100	100	100	100
Time at grid connection	Less than 6 months	12	14	9	10
	6 - 12 months	38	19	16	17
	1-2 years	16	28	27	27
	More than 2 years	34	39	48	46
	Total	100	100	100	100
N in '000		3829	1221	3115	8166

Very few (1%) households are connected to a mini-grid. Only around (43%) of households with community access are themselves connected to the grid, varying from 6 of 7 (87%) in Dar to 1 of 6 (18%) in rural areas.

There has been a substantial increase in access to electricity during the last five years in all areas, increasing from 36 to 43 percent on average.

In both Dar and other urban areas, the main reason for households not being connected even if there is a community access is that the initial connection fee is too large. In rural areas almost the same shares (30-31%) report either living too far away from the transformer or too high connection fee as the main reason for not being connected.

The majority of households not connected (62%) report that they expect to get a grid connection, but around half (43%) report that this may take more than 2 years.

Lack of grid connection for some households in EAs with grid access

We now focus on the background reasons why some households miss a grid connection when living in communities with grid access.

Table 2.2 Categories of Households without Connection to Electricity Living in Communities with Access Mainland Tanzania, Shares in percent, 2021/22

Categories	Do you have a grid connection?	Yes	No	Total	N in '000
Residence	Dar es Salaam	87	13	100	1570
	Other urban	59	41	100	1994
	Rural	11	89	100	4602
Centrality	Max 10 km to town	61	39	100	3829
	11-25 km to town	21	79	100	1221
	More than 25 km to town	9	91	100	3115
Household per capita total annual expenditure quintile	1st (Lowest)	8	92	100	1327
	2nd	16	84	100	1491
	3rd	28	72	100	1512
	4th	43	57	100	1861
	5th (Highest)	53	47	100	1975
Highest education completed by any household member	Pre-school or other no formal education	15	85	100	425
	Primary 1-4	9	91	100	299
	Primary 5-8	18	82	100	3469
	Secondary or higher	47	53	100	3973
Self-employed/employer in farming/fishery		12	88	100	4639
Self-employed/employer in other production/service		58	42	100	3188
Employed in public sector		64	36	100	341
Employed in formal sector (privat owner/company)		47	53	100	1629
Not economically active		33	67	100	4971
Highest education completed by head of household	Pre-school or other no formal education	13	87	100	1475
	Primary 1-4	17	83	100	595
	Primary 5-8	27	73	100	4297
	Secondary or higher	62	38	100	1798
	Total	30	70	100	8166

As table 2.2. shows, strong drivers for households being connected to the grid is to live in Dar, in central area in general, a high income and secondary school or higher education for the head or one or more household members in general.

Households with one or more household member working in the formal private sector, in public sector or as self-employed or employer in other sectors than farming and fishery are more often connected to the grid.

With other words, households with high income, high education and working in secondary and tertiary sectors tend to more frequently being connected to the grid.

2.4. Solar home systems[5]

There are three main types of solar devices, from a single solar lantern, an integrated multi-light device with two bulbs, or a proper solar home system with a solar panel and a separate battery. As we saw from table 2.3. for 1 of 4 (24 %) a solar home system is the main source for electricity. For around 1 of 10 a multilight system (11%) is the main source. For another 1 of 10, a lantern (8%) is the main source for electricity.

Solar home systems are a common alternative in rural areas where a larger share of around 1/3 (36%) have access to solar home systems. Even in urban areas outside Dar es Salaam, 1 of 10 households have access to electricity by a solar home system.

As addressed in chapter 2, solar panels are available in a range of capacities. Typical prices may med TZS 200,000 for a 30W panel and a 18Ah battery and TZS 300,000 for a 60W panel and a 75Ah battery[6]. Hence such a package is at the same cost level as the connection fee to Tanesco. But a solar panel will provide the household for electricity (at a low level) for no costs.

On the other hand, when a REA grid net is reaching a new community, there is no connection fee. The payment for internal wiring may be done at around 50,000 TZS.

This means that the price for getting access to electricity if connected with REA is just a fraction of the costs of connection with Tanesco of buying a solar home system.

Hence from an economic point of view, the best approach would be to connect to the REA grid when it becomes available. When Tanesco start to run the electricity supply, grid and solar have similar costs. Of course, if no grid in the community, solar power is the only option.

[5] We follow the tier classification as outlined in Bhatia, M. (2015). Beyond Connections : Energy Access Redefined . . Washington, DC, World Bank. And used in National Bureau of Statistics, S. N. (2023). Impact of Access to Sustainable Energy Survey (IASES 2021/22). Access to Electricity and Modern Cooking Solutions. Dar es Salaam, Oslo, National Bureau of Statistics, Statistics Norway: 148.

[6] https://jiji.co.tz/272-solar-panels

Box 2.1: Solar systems, solar panel and battery capacity

For a solar system we measure both how much power is produced and how much current (DC or direct current) is being stored and available for consumption.

A **solar panel** may typically be able to produce a **potential of 12V**. A common solar panel may deliver 60w in bright sunshine for something like **4 hours per day**.

The same formula applies, but may be turned around: A = W / V. Hence the solar panel may deliver 60W / 12V = 5A. Over 4 hours that amounts to 5A x 4 h = 20Ah per day and 7 days x 4 hours/day x 5A = 140Ah over a week.

That **current** may be stored in **a chargeable battery** with a **capacity** of up to **140 Ah**. Due to standard loss in charging and storage it may often take 2 weeks to load the battery.

A common sales-trick is to express the capacity in Wh giving a larger figure. Since the standard voltage of such rechargeable battery is typically 12V, the capacity may be given as Wh = Ah x V or **1680 Wh = 140 Ah x 12 V**. Hence a rechargeable battery with a capacity of 1680 Wh is equivalent to a rechargeable battery of 140 Ah.

The goal of this report is to learn and document drivers the households are facing in order to get access and the barriers they meet. Hence the focus is on the two main supply lines, connection to a grid or a solar device with battery storage.

We have both asked for information to classify the capacity of the solar cell panels in W and for information for the battery capacity in Ah or Wh. We then use the formulas in the frame for calculation of the power capacity given by the solar cell capacity or by the battery storage capacity measured in Wh. Each of these dimensions are measured in tiers reflecting the electric power capacity with Tier 0 < 12 Wh, Tier 1 - 12 Wh or more, Tier 2 - 200Wh or more, Tier 3 – 1000Wh or more, Tier 4 3.4 kWh or more, Tier 5 8.2 kWh or more.

If you want to have light from 2 LED bulbs of 5W for 4 hours every evening, you need a capacity of 40Wh. Hence a capacity of 100Wh allows you to have proper light even in seasons with reduced hours of sunlight such as the rainy season.

We have then calculated the capacity of the battery for storing electricity. On average the battery may deliver around 75% of the potential, hence the real capacity is 75% of the nominal capacity. Batteries are usually 12V, hence this level is used in no information is recorded.

The real capacity of a solar system is the minimum capacity of the solar cell and the solar battery. The most economic combinations are with similar real capacity for solar cells and battery, as marked with yellow color in the table.

Table 2.3 AE Tier Solar Cell and Battery Capacity. Shares in percent, 2021/22

			AE Tier Solar Battery Capacity in Wh				Total
		Tier	0	1	2	3-5	
	Tier	Wh	< 12wh	12-199Wh	200-999Wh	1000Wh+	
AE Tier Solar Panel Capacity in Wh	0	< 12Wh	0	0	0	0	0
	1	12-199Wh	0	14	3	0	17
	2	200-999Wh	0	22	4	1	27
	3-5	1000Wh+	0	48	6	2	56
Total			0	84	13	3	100

Only 1/5 (20%) of the households have a proper balance between the capacity of the solar panel and the battery. Around ¾ (76%) have a too small battery capacity for their solar cell panel and hence risk missing the electricity supply too early in the night. A few (4%) of the households are rather not able to charge their battery on days with rainfall or shadow.

The overall level of solar energy capacity is determined by the minimum capacity of the solar panel and the solar battery.

Table 2.4 Overall AE Tier Solar Cell and Battery Capacity. Shares in percent, 2021/22

AE Tier Solar Battery Capacity in Wh					Total	
Tier	0	1	2	'3-5		n
Wh	< 12wh	12-199Wh	200-999Wh	1000Wh+		
	0	87	11	2	100	6.8 mill.

There are around 6.8 million households with some solar power. Of these 6.8 million households, 87 percent have a solar capacity between 12 and 200 Wh allowing them to use one standard LED bulb of 4W for 3 hours every night or even up to two larger LED bulbs of 10W and a LED TV of 20W for 5 hours on an average day. 13 percent have even a larger capacity.

2.5. Solar panel and solar battery capacity across all households

Solar panels and solar batteries come either as a solar home system or a multilight system and may be combined with other power options. Hence, we compare the distribution across all households.

Table 2.5 Solar energy capacity by level of community remoteness. Shares in percent, 2021/22

		Centrality			All
Tier	Energy in Wh	Max 10 km to town	11-25 km to town	More than 25 km to town	
0	< 12Wh	92	81	74	81
1	12-199Wh	8	16	23	16
2	200-999Wh	1	2	3	2
3-5	1 kW or higher	0	0	0	0
All		100	100	100	100

Both in central and less central communities, the main level of solar energy is at level 1 i.e. from 12 to 199 Wh which is enough for a proper light and charging mobiles and even for a limited use of a TV. But it is not enough for additional power for electric appliances or business opportunities. Around 1 of 6 households have this volume of solar based electricity.

In remote areas, the share is substantially higher with around ¼ of the households at this or a higher level.

With other words, remoteness is a main driver for a decent level of solar power. The next table may tell us whether economic level, occupation and education are equally important driver for acquiring solar energy.

Table 2.6 Solar energy capacity by area, economic level, occupation and education. Shares in percent, 2021/22

		Solar energy in tiers				
		0 0-11Wh	1 12-199Wh	2 200-999Wh	3-5 1kWh+	Total
Residence	Dar es Salaam	100	0	0	0	100
	Other urban	90	9	1	0	100
	Rural	76	21	3	0	100
Centrality	Max 10 km to town	92	8	1	0	100
	11-25 km to town	81	16	2	0	100
	More than 25 km to town	74	23	3	0	100
Household per capita total annual expenditure quintile	1st (Lowest)	77	21	2	0	100
	2nd	74	22	4	0	100
	3rd	81	17	2	0	100
	4th	84	14	2	0	100
	5th (Highest)	90	8	1	0	100
Highest education completed by any household member	Pre-school or other no formal education	86	13	1	0	100
	Primary 1-4	85	15	0	0	100
	Primary 5-8	77	20	2	0	100
	Secondary or higher	85	13	2	0	100
Self-employed/employer in farming/fishery		76	21	3	0	100
Self-employed/employer in other production/service		89	9	1	0	100
Employed in public sector		87	5	7	0	100
Employed in formal sector (privat owner/company)		86	12	2	0	100
Highest education completed by head of household	Pre-school or other no formal education	83	15	2	0	100
	Primary 1-4	79	19	2	0	100
	Primary 5-8	78	19	2	0	100
	Secondary or higher	89	9	2	0	100
	Total	81	16	2	0	100

As we already have seen, households in more remote communities are more likely to have access to electricity through fsolar power.

However, we do not find that households with higher income are more likely install solar power. On the contrary, the likelihood of having access to electricity through solar power is lower for high income households.

We find a similar effect for type of occupation. We find the highest share of access to electricity through solar power among households in farming or fishing.

Households with primary school education has the highest level of access to electricity through solar power. Households with no formal education may not be able to afford a solar system and households with secondary or higher education may have access to the grid and hence not the same need for solar power.

The level of remoteness seems to be more important than income, occupation and education whether the households choose to install solar power or not.

2.6. Barriers and problems with the electricity source

Barriers and problems with grid connection

We have learned from the main report(National Bureau of Statistics 2023) that even household with connection to the grid face problem with the electricity supply. Hence, we have addressed the two main problems households are facing.

Table 2.7 Primary problem with grid electricity by type of residential area. Shares in percent, 2021/22

	Residential area			
	Dar es Salaam	Other urban	Rural	Total
Supply shortage/ not enough hours of electricity	1	1	2	1
Low/high voltage problems or voltage fluctuations	5	4	5	5
Unpredictable interruptions	52	49	60	53
Unexpectedly high bills	1	3	5	3
High cost of electricity	12	12	8	11
Do not trust the supplier		0		0
Cannot power large applications	0			0
Maintenance/ service problems	1	1	1	1
Unpredictable bills	0	0	0	0
Other	3	0	1	1
No problems	27	30	17	26
Total	100	100	100	100
N in million	1.4	1.4	1	3.8

Table 2.8 Secondary problem with grid electricity by type of residential area. Shares in percent, 2021/22

	Residential area			
	Dar es Salaam	Other urban	Rural	Total
Supply shortage/ not enough hours of electricity	1	5	10	5
Low/high voltage problems or voltage fluctuations	3	8	8	6
Unpredictable interruptions	9	16	15	13
Unexpectedly high bills	1	7	10	6
High cost of electricity	22	21	19	21
Do not trust the supplier		0	1	1
Cannot power large applications	1	1	0	1
Maintenance/ service problems	3	2	4	3
Unpredictable bills	1	1	1	1
Other	3	1	2	2
No problems	59	37	31	43
Total	100	100	100	100
N in millions	1	1	0.8	2.8

Only 1 of 10 households report more than one problem and ¼ (26%) report no problems at all. But more than ½ (54%) of the household report that unpredictable power interruption is the primary or secondary main problem. The unpredictable power supply is more often a problem in rural areas (60%), but even ½ (50-51%) of the households in urban areas face this problem.

For 1/6 (16%) of the households, high costs or unexpected high bills is the main problem.

Only a few (7%) face technical problems like voltage fluctuations and maintenance problems.

Table 2.9 Receive information load shedding schedule of grid by type of residential area. Shares in percent, 2021/22

	Residential area			
	Dar es Salaam	Other urban	Rural	Total
Yes	5	10	4	7
No	82	78	89	82
Sometimes	13	13	7	11
No load-shedding in this area	-	0	0	0
Total	100	100	100	100
N in millions	12	14	10	35

The problematic power interruption does not appear as a well-informed load-sharing system. Around 1 of 10 (11%) of the household report that they sometimes receive information of an informed load-sharing.

Table 2.10 Hours of electricity 6 pm to 10 pm typical month by type of residential area. Shares in percent, 2021/22

	Residential area			
Hours	Dar es Salaam	Other urban	Rural	Total
0	6	3	2	4
1	2	3	2	3
2	10	19	18	16
3	19	23	22	21
4	60	50	55	55
Don't know	2	3	2	2
Total	100	100	100	100
N in millions	8	8	5	22

Only just above ½ (55%) of the household have electricity throughout the evening in a typical month. Around 1/4 (23%) of the households have power supply for half the evenings in a typical month and another 1/5 (21%) have power supply to typically only ¾ of the evenings.

This is a serious situation for the power supply and businesses may have to ensure an alternative power supply if they want to provide their services from a bar, a restaurant, or a hair or beaty saloon during evening hours.

Table 2.11 Most serious problem with solar device by type of residential area. Shares in percent, 2021/22

	Residential area			
	Dar es Salaam	Other urban	Rural	Total
Duration of service too short	0	10	10	10
Too expensive	17	2	1	1
Cannot power large appliances	0	13	11	11
Breaks too often	8	5	4	4
Maintenance and availability of spare parts	0	1	2	2
Quality of light	0	14	12	12
Battery problems	25	18	24	23
Too low capacity	17	17	17	17
Other	0	1	1	1
No problems	33	19	18	18
Total	100	100	100	100
N in '000	48	495	4113	4656

Barriers and problems with solar power

Power supply from a solar system face other problems.

Half the households (50%) face problems with too short service period, lack of ability to power large appliances, lack of quality of the light, or too low capacity.

The other common problem is the battery. ¼ (23%) of the household face battery problems. Old battery types require proper maintenance to last, and all battery types have a limited life expectancy. The owner will experience a reduced capacity already after a couple of years with old battery types and after 3-5 years even for newer battery types.

2.7. Alternative sources for light and low energy appliances

More than half (54%) of the households are either connected to the grid or have a solar home system supplying them with power for light. But how is the total coverage of energy for light and low energy appliances such as cell phone and battery charging?

Table 2.12 Main source of lighting in the household. Shares in percent, 2021/22

	Residence			
	Dar es Salaam	Other urban	Rural	Total
Candle	21	5	1	2
Open wick lamp	4	11	9	9
Wick lamp with glass cover	9	2	0	1
Pressurized mantle lamp	2		1	1
Solar powered light source	21	52	53	52
Battery-operated light source	34	20	24	24
None	5	6	7	7
Other	4	4	4	4
Total	100	100	100	100
N in '000	206	672	5029	5907

More than half the households without grid connection rely on solar power for light in their home. This adds up to more than ¾ (54% + 52% * 46% = 78%) of the households relying on grid or solar power. If we include battery operated light source, we may see that on some kind of electricity for the light for 6 of 7 (54% + 72% * 46% = 87%) of the households.

Table 2.13 Main source of lighting for children's homework. Shares in percent, 2021/22

	Residence			
	Dar es Salaam	Other urban	Rural	Total
Electric lighting/lamp	85	50	9	22
Solar powered light source		30	53	46
Battery-operated light source		4	9	7
Street lighting			0	0
Kerosene lamp		1	0	0
Candles		2	0	1
Open wick lamp		3	2	2
Other	3	2	4	4
Studying and homework only during daylight hours	12	9	22	19
Total	100	100	100	100
N in '000	142	404	1636	2182

More than 2 million households have children doing homework. 3 of 4 of these households manage to ensure electric light for their schoolchildren, but in almost 1 of 5 households the schoolchildren have to complete their homework during the daylight period.

2.8. Willingness to pay is a booster option for REA and Tanesco

It is difficult to figure out the payment for grid connection. When a REA based grid is reaching a community, they will build a few or only one transformer station. Households within reach of the transformer station is offered a low-cost connection. Household living further away, usually more than 600 meters, are not offered any low-cost connection. They may have the option of asking for an extra transformer, but usually on a pay the costs basis. That in only an option for a business and not for households.

Households with the reach of a transformer may even connect at a later stage, but then at a higher cost.

When REA has completed the network in the community, they hand the running service to TANESCO. TANESCO ask for a considerably larger connection fee, primarily an option for business or well-off households. Hence, we asked whether households without connection would be able to pay the connection fee if paying in installments.

Table 2.14 Willingness to pay for el grid. Shares in percent, 2021/22

	Residence			
	Dar es Salaam	Other urban	Rural	Total
Ready to pay upfront	43	48	71	68
Pay over 12 month	26	18	14	14
Not willing to pay	31	34	15	18
Total	100	100	100	100
N in ‘000	144	935	7672	8751

It actually turns out that 2 of 3 households are ready to pay upfront for connection to the grid and if the payment could be made in installments over a 12 month period, a total of 5 of 6 households (82%) would be ready to pay.

The shares of households willing to pay for electricity connection in remarkably high and it would be interesting to learn which factors drive the ability and willingness to pay for grid connection.

Table 2.15 Willingness to pay for electricity-connection . Shares in percent, 2021/22

		Ready to pay upfront	Pay over 12 months	Not willing to pay
Residence	Dar es Salaam	43	27	31
	Other urban	48	18	34
	Rural	71	14	15
Centrality	Max 10 km to town	61	18	22
	11-25 km to town	69	12	19
	More than 25 km to town	70	14	16
Household per capita total annual expenditure quintile	1st (Lowest)	63	15	21
	2nd	70	14	16
	3rd	69	16	16
	4th	71	12	17
	5th (Highest)	71	13	16
Highest education completed by any household member	Pre-school or other no formal education	59	13	28
	Primary 1-4	52	16	32
	Primary 5-8	68	15	17
	Secondary or higher	75	13	12
Highest education completed by head of household	Pre-school or other no formal education	62	15	23
	Primary 1-4	61	18	20
	Primary 5-8	71	13	15
	Secondary or higher	77	12	11
Self-employed/ employer in farming/fishery	At least one	70	14	16
Self-employed/ employer in other production/service	At least one	68	14	18
Employed in public sector	At least one	79	5	17
Employed in formal sector (privat owner/company)	At least one	71	16	13

There are several driving forces for willingness to pay for el connection. 3 of 4 households with high education are ready to pay upfront. But also any household living in rural areas or with at least one member employed in the public sector is more than average ready to pay upfront for el connection.

We do not find a positive effect from better economics means increasing the willingness to pay.

Households living in urban areas or close to a town are less likely to be ready to pay to el connection. We may expect that these household either have already connected or do not have the financial means to pay. Even households without or with low education are less likely to be ready to pay. We may expect these households to lack the necessary economic means.

In rural areas, solar power may be the best option for getting access to electricity.

Table 2.16 Willingness to pay for solar home system. Shares in percent, 2021/22

	Residence			
	Dar es Salaam	Other urban	Rural	Total
Ready to pay upfront	21	40	44	40
Pay over 12 month	39	13	18	20
Not willing to pay	39	47	38	40
Total	100	100	100	100
N in '000	1482	2016	5795	9293

The willingness to pay for a solar home system is quite large both in rural areas and urban areas outside Dar-es-Salaam. As for grid, the share increases considerably if the households get the option of pay in installments over a 12 months period.

Table 2.17 Willingness to pay for solar home system. Shares in percent, 2021/22

		Ready to pay upfront	Pay over 12 month	Not willing to pay
Residence	Dar es Salaam	21	39	39
	Other urban	40	13	47
	Rural	44	18	38
Centrality	Max 10 km to town	35	23	42
	11-25 km to town	44	19	37
	More than 25 km to town	43	18	39
Household per capita total annual expenditure quintile	1st (Lowest)	39	20	41
	2nd	43	19	38
	3rd	37	22	41
	4th	39	21	40
	5th (Highest)	40	20	40
Highest education completed by any household member	Pre-school or other no formal education	39	20	42
	Primary 1-4	40	18	41
	Primary 5-8	40	20	40
	Secondary or higher	40	21	39
Highest education completed by any household member	Pre-school or other no formal education	39	20	42
	Primary 1-4	40	18	41
	Primary 5-8	40	20	40
	Secondary or higher	40	21	39
Highest education completed by head of household	Pre-school or other no formal education	39	19	41
	Primary 1-4	42	21	37
	Primary 5-8	40	21	39
	Secondary or higher	38	21	41
Self-employed/employer in farming/fishery	At least one	46	19	35
Self-employed/ employer in other production/service	At least one	34	24	43
Employed in public sector	At least one	45	16	39
Employed in formal sector (privat owner/company)	At least one	37	22	41

The main driving force for willingness to pay for a solar home system is geography. Households living in rural areas and towns apart from Dar-es-Salaam are more ready to pay. Also, households living well away from towns are more ready to pay upfront or in 12 months installment.

3. Adoption of improved cooking ovens

3.1. Introduction

The efficiency of a cooking solution is dependent upon both the type of oven and type of fuel. For other urban areas 1 of 6 households use the very energy inefficient open three-stone fireplace, tables 3.3 and 3.4. In rural areas almost 2 of 3 households (63%) use this type of fireplace demanding a large volume of firewood, table 3.5. This type of cooking solution represents a large potential for improved energy efficiency and reduced deforestation.

In rural areas and towns most households will be able to collect firewood. In some areas deforestation may have made the collection more time-consuming, but this is usually a no-cash option and hence selected despite the increasing time for collection.

In urban areas, collection of firewood is often more time-consuming, charcoal is sold in both large and small quantities and more than half the households use charcoal for cooking.

In Dar-es-Salaam it is possible to buy or refill LPG gas-container and more than 1 of 4 households rely on LPG gas for cooking.

With this fuel environment we focus on two main challenges on cooking solutions. First, how to balance low emission and high efficiency. The standard solution is a traditional cooking oven with large emission balanced by an open kitchen. Second, we focus on which households stick to a traditional design with low efficiency and who change to more efficient cooking ovens.

3.2. Cooking oven types

Firewood cooking ovens

We find firewood ovens at all levels of efficiency and emission in Mainland Tanzania. They may use firewood, dung, twigs and leaves as fuel from tier 0 to tier 4, but not in tier 5.

- Three-stone, tripod, flat mud ring – tier 0
- Conventional improved cooking solutions (ICS) closed oven with separate openings for firewood etc. and for pots – tier 1
- ICS with Chimney, possibly with a chimney or a rocket stove with conventional material for insulation tier 2
- Rocket stove with high insulation, rocket stove with chimney (not well sealed) tier 3
- Rocket stove with a well-sealed chimney, rocket stove gasifier (rocket stove with two chambers, one for firewood and one for the burning gas), batch feed gasifier (burning solid fuel which is added to the burning chamber in batches) – tier 4

Charcoal cooking ovens

We also find charcoal ovens at all levels of efficiency and emission in Mainland Tanzania. They use charcoal as fuel from tier 0 to tier 4, but not in tier 5.

- Traditional charcoal stoves – tier 0
- Old generation ICS with open chamber for charcoal – tier 1
- Conventional ICS closed oven with separate chambers and openings for charcoal and pots – tier 2
- Advanced insulation charcoal stoves – tier 3
- Advances secondary air charcoal stoves with tightly closed burning chamber with controlled entry of air – tier 4

Other cooking ovens

There are also other ovens used in Mainland Tanzania, especially in urban area.

- Natural draft gasifier ovens for pellets and briquettes – tier 3
- Kerosene ovens – tier 3
- Forced air gasifier ovens for pellets and briquettes and husk – tier 4
- LPG gas ovens – tier 5
- Biogas – tier 5
- Electric ovens – tier 5

Cooking ovens in Mainland Tanzania

The cooking ovens registered in the IASES in Mainland Tanzania may be presented in the following table.

Figure 3.1 Detailed description of draft cooking stove typology

Type of fuel	Description of level	Tier
Firewood, dung, twigs and leaves	Three-stone, tripod, flat mud ring	0
	Conventional improved cooking solutions (ICS)* (closed oven with separate openings for firewood etc. and pots)	1
	ICS with Chimney (as conventional ICS plus chimney), rocket stove with conventional material for insulation	2
	Rocket stove with high insulation, rocket stove with chimney (not well sealed)	3
	Rocket stove with chimney (well-sealed), rocket stove gasifier (rocket stove with two chambers, one for firewood and one for the burning gas), batch feed gasifier (burning solid fuel which is added to the burning chamber in batches)	4
Charcoal	Traditional charcoal stoves	0
	Old generation ICS (with open chamber for charcoal)	1
	Conventional ICS (closed oven with separate chambers and openings for charcoal and pots)	2
	Advanced insulation charcoal stoves, kerosene oven	3
	Advances secondary air charcoal stoves (tightly closed burning chamber with controlled entry of air)	4
Rice husks, pellets and briquettes	Natural draft gasifier (only pellets and briquettes)	3
	Forced air	4
LPG and biogas, electricity (grid or solar), solar oven (non-electric)		5

*ICS: Improved Cooking Stove may be improved in several steps, separate intake of air and fuel, regulate the air flow, insulate the burning chamber, forced flow of burning gases and smoke.

Figure 3.2 **Percent of Households by Main cooking stoves by type of fuel and efficiency by Area, Mainland Tanzania, 2021/22**

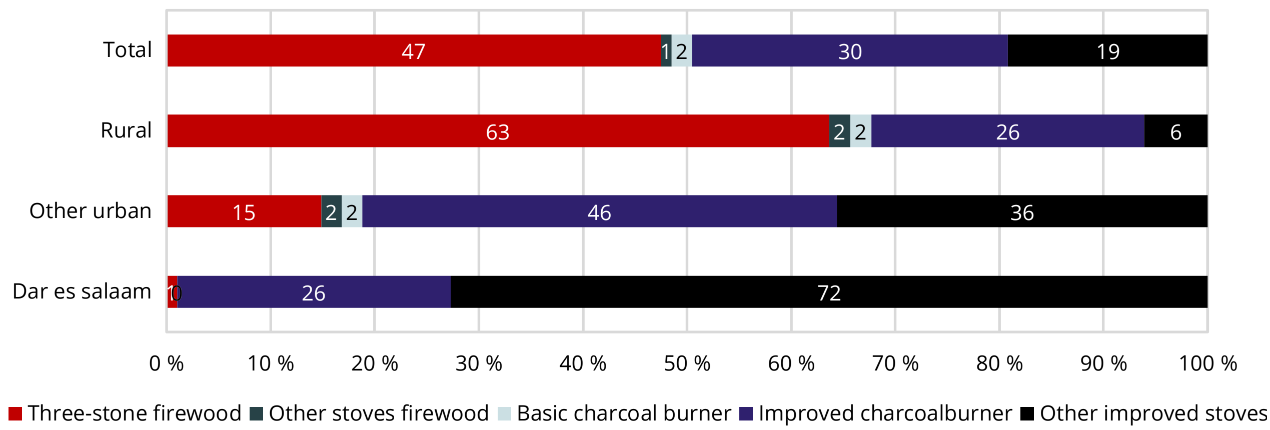


Table 3.1 **Main cooking oven types by area. Shares in percentage, 2021/22**

	Residence			
	Dar es Salaam	Other urban	Rural	All
Three stone fire	1	15	63	47
Round mud stove	0	0	2	1
Rocket stove	0	0	0	0
Open charcoal burner	0	2	2	2
Charcoal burner w/air-stop	2	11	10	9
Charcoal burner v/ceramic lining	23	33	15	20
Charcoal burner w/ceramic insulation	1	2	1	1
Kerosene cooking oven	1	0	0	0
Gas and El oven	71	36	6	19
All	100	100	100	100
N in '000	1442	2362	8670	12474

The common types of cooking oven are quite different in the three types of areas.

In Dar-es-Salaam almost 3 of 4 households (72%) use gas or kerosene-based cooking ovens[7]. But even charcoal ovens are common and used by around 1 of 4 households (26%). The main type is a moderately improved cooking oven, but both less and more efficient ovens are used.

In other urban areas charcoal ovens are the common types used by almost half the households (48%). Even here the moderately improved cooking ovens are most common, but both less and more efficient charcoal ovens are used by some households. More than 1 of 3 (36%) households have gas or electric ovens.

In rural areas around 2 of 3 (65%) households use firewood for cooking. The large majority use an open fire for cooking. Just very few (2%) use an improved oven for firewood.

There is however almost 1 of 3 households who use charcoal ovens (28%) for cooking and various types of improved ovens are used.

These substantial differences across the country will guide our analysis of drivers and barriers for more efficient cooking ovens. Hence this analysis is presented separately for each type of area.

[7] The share using an electric oven is negligible or less than 0.1 percent.

3.3. Drivers for more efficient cooking ovens

The main driver for both firewood ovens and charcoal ovens towards a more efficient oven is the availability of a series of alternative ovens.

There are several alternatives ranging from low efficiency and high emission ovens to very efficient ovens with low emission.

Our focus will vary across areas. But in each type of area, we will study who moves to a more efficient and low emission solution. What are the most important factors, economic opportunities in the area (region and remoteness), family (employment), knowledge (education), own income, modernity focus (age) or access to electricity (in village or own connection).

The focus will be as follows:

- In Dar the standard is a gas or LPG oven. We look into who rely on charcoal ovens and who are using LPG ovens. We focus on economic and social household factors in Dar.
- In other urban areas the standard is a moderately efficient charcoal oven. We look again into who would rely on just a basic charcoal oven and who would rather use a more efficient charcoal oven or even use an LPG oven. We focus both on geographical factors/region and economic and social household factors,
- In rural areas the large majority stick to three stone firewood cooking places. We look into who moves to more energy efficient low emission firewood cook stoves and who move rather to charcoal and other ovens. We focus both on geographical factors as region and remoteness and economic and social household factors.

Table 3.2 Main cooking oven in Dar-es-Salaam by background factors. Shares in percentage, 2021/22

		Three stone fire	Round mud stove	Rocket stove	Open charcoal burner	Charcoal burner w/air-stop	Charcoal burner w/ceramic lining	Charcoal burner w/ceramic insulation	Kerosene cooking oven	Gas and El oven	All	N in ' 000
Centrality	Max 10km to town	1	-	-	-	2	22	2	-	73	100	1267
	11-25km to town	-	-	-	-	2	35	-	-	63	100	164
	More than 25km to town	-	-	-	-	-	-	-	-	-	-	0
Household per capita total annual expenditure quintile	1st (Lowest)	-	-	-	-	-	14	-	-	86	100	31
	2nd	-	-	-	-	7	22	3	-	67	100	104
	3rd	4	-	-	-	3	28	2	-	63	100	238
	4th	1	-	-	-	2	23	2	-	72	100	475
	5th (Highest)	1	-	-	-	1	22	1	-	75	100	583
Highest education completed by any household member	No formal education	-	-	-	-	-	36	33	-	31	100	22
	Primary 1-4	-	-	-	-	-	67	-	-	33	100	12
	Primary 5-8	2	-	-	-	3	26	2	-	67	100	334
	Secondary or higher	1	-	-	-	2	22	1	-	74	100	1064
Self-employed/employer in farming/fishery		-	-	-	-	-	36	-	-	64	100	98
Self-employed/employer in other production/service		1	-	-	-	2	23	2	-	72	100	1064
Employed in public sector		-	-	-	-	-	10	4	-	86	100	78
Employed in formal sector (privat owner/company)		1	-	-	-	1	28	1	-	69	100	592
Highest education completed by head of household	No formal education	-	-	-	-	7	42	7	-	44	100	102
	Primary 1-4	12	-	-	-	10	27	-	-	51	100	42
	Primary 5-8	1	-	-	-	3	27	1	-	68	100	676
	Secondary or higher	1	-	-	-	-	16	1	-	82	100	611
Village connected to electricity		1	-	-	-	2	23	1	-	72	100	1432
REA: Households connected to electricity		1	-	-	-	1	21	1	-	76	100	1261
Total	Total	1	-	-	-	2	23	1	-	72	100	1432

Drivers for more efficient cooking ovens in Dar-es-Salaam

In Dar, almost 3 of 4 households (73%) use LPG gas for cooking. The efficiency of gas ovens does not vary much with the design, but they are all both more efficient and more convenient than charcoal ovens. Hence there is a clear economic driver on the daily basis moving from a charcoal oven to an LPG oven. On the other hand, there is a substantial investment, both when buying the gas-cylinder and the gas burner and for the regular filling of the gas-cylinder. It is possible to rent a gas-cylinder and pay tokens for the consumption of a given volume of gas, but this option is not very common. Henc there is a substantial investment barrier for moving from less efficient charcoal to more efficient LPG fuel.

We could then expect a larger share of the better off households moving up to LPG gas, but this is hardly the case. The driver seems to be higher education and employment in sectors with better access to information. Households with higher education and households working in the public sector who may have an easier access to information are more likely to move up to LPG gas. The share is also higher for households who are living in communities with access to electricity.

Table 3.3 Main cooking oven in other urban areas by background factors. Shares in percentage, 2021/22

		Three stone fire	Round mud stove	Rocket stove	Open charcoal burner	Charcoal burner w/air-stop	Charcoal burner v/ceramic lining	Charcoal burner w/ceramic insulation	Kerosene cooking oven	Gas and El oven	All	N in ’ 000
Centralilty	Max 10km to town	13	-	-	2	9	32	2	-	42	100	1818
	11-25km to town	23	-	-	1	15	43	3	-	16	100	190
	More than 25km to town	28	-	-	1	17	35	3	-	17	100	349
Household per capita total annual expenditure quintile	1st (Lowest)	45	-	-	1	15	27	3	-	9	100	218
	2nd	22	-	-	4	19	35	3	-	17	100	358
	3rd	17	-	-	2	11	41	2	-	28	100	500
	4th	10	-	-	2	10	37	2	-	39	100	594
	5th (Highest)	7	-	-	2	6	26	2	-	58	100	689
Highest education completed by any household member	No formal education	30	-	-	1	9	33	5	-	21	100	130
	Primary 1-4	36	-	-	5	12	30	2	-	16	100	48,8
	Primary 5-8	21	-	-	2	15	37	2	-	22	100	827
	Secondary or higher	10	-	-	2	9	31	2	-	47	100	1352
Self-employed/ employer in farming/ fishery		34	-	-	3	14	32	2	-	14	100	863
Self-employed/employer in other production/service		7	-	-	2	9	35	2	-	44	100	1272
Employed in public sector		3	-	-	1	3	15	1	-	78	100	152
Employed in formal sector (privat owner/company)		12	-	-	1	11	33	1	-	41	100	501
Highest education completed by head of household	No formal education	33	-	-	1	15	34	3	-	15	100	353
	Primary 1-4	25	-	-	5	9	38	4	-	20	100	145
	Primary 5-8	17	-	-	2	14	37	2	-	28	100	1182
	Secondary or higher	3	-	-	1	4	25	1	-	65	100	677
Village connected to electricity		13	-	-	2	10	34	2	-	39	100	2159
REA: Households connected to electricity		7	-	-	2	9	34	2	-	46	100	1658
Total		16	-	-	2	11	33	2	-	36	100	2358

Table 3.4 Main cooking oven in other urban areas by remoteness and region. Shares in percentage, 2021/22

		Three stone fire	Open Charcoal burner	Charcoal burner w/air-stop	Charcoal burner w/ ceramic lining	Charcoal burner w/ ceramic insulation	Gas and el oven	All	AN in ’ 000ll
	Max 10km to town	13	2	9	32	2	42	100	1818
Centrality	11-25km to town	23	1	15	43	3	16	100	190
	More than 25km to town	28	1	17	35	3	17	100	349
	Dodoma	25	-	11	22	3	40	100	97
	Arusha	19	-	6	10	2	63	100	164
	Kilimanjaro	24	-	4	18	3	51	100	128
	Tanga	6	2	12	47	-	32	100	122
	Morogoro	23	2	11	53	-	11	100	197
	Pwani	3	-	5	46	3	42	100	116
	Dar es Salaam	-	-	-	-	-	-	100	-
	Lindi	15	2	11	38	2	32	100	58
	Mtwara	10	8	19	44	-	20	100	83
	Ruwuma	24	-	6	47	3	21	100	99
	Iringa	4	-	2	28	4	62	100	83
	Mbeya	22	-	5	30	1	42	100	190
	Singida	34	-	20	29	-	17	100	44
Region	Tabora	10	2	45	16	4	23	100	66
	Rukwa	23	24	-	22	2	29	100	64
	Kigoma	20	3	41	14	-	23	100	89
	Shinyanga	10	-	17	23	3	47	100	60
	Kagera	19	4	11	34	2	31	100	66
	Mwanza	4	1	10	35	4	46	100	223
	Mara	5	-	8	39	-	48	100	75
	Manyara	51	2	9	16	-	22	100	56
	Njombe	20	-	4	39	3	34	100	52
	Katavi	12	5	36	33	6	7	100	38
	Simiyu	6	3	5	43	-	43	100	22
	Geita	15	-	11	47	-	28	100	61
	Songwe	3	7	1	42	8	39	100	102
	Total	16	2	11	33	2	36	100	2358

Drivers for more efficient cooking ovens in other urban areas

In other urban areas the two main common cooking solutions are LPG gas ovens and a moderately improved charcoal oven. Around half (48%) use charcoal for cooking and around 1 of 3 (36%) use LPG gas. A small share of 1 of 6 households (16%) use firewood.

There are three drivers towards more efficient cooking solutions. Households in central areas of a town and especially with larger towns like Arusha, Iringa, Mbeya, and Mwanza are more likely to have access to gas stations and use an LPG oven. But also households with good access to information from higher education or work in the public sector are more likely to move up to LPG gas.

As already discussed, LPG gas may be cheaper than charcoal in the long run, but the necessary investment in a gas cylinder may be a main barrier. This is reflected in a substantially higher share of LPG gas ovens among the better off households.

Households living slightly less central, with mid-level education and mid-level income are more likely to use a moderately improved charcoal oven.

The third group are poorer households in the outskirts of urban areas, with less education. They stick to less efficient charcoal ovens or firewood ovens.

Table 3.5 Main cooking oven in rural areas by background factors. Shares in percentage, 2021/22

		Three stone fire	Round mud stove	Rocket stove	Open charcoal burner	Charcoal burner w/air-stop	Charcoal burner v/ceramic lining	Charcoal burner w/ceramic insulation	Kerosene cooking oven	Gas and El oven
Remoteness	Max 10km to town	52	2	0	4	12	17	1	1	11
	11-25km to town	63	2	-	1	8	14	1	-	11
	More than 25km to town	66	2	0	2	10	16	1	0	4
Household per capita total annual expenditure quintile	1st (Lowest)	77	2	0	2	5	11	0	0	1
	2nd	66	1	0	3	10	15	2	0	2
	3rd	57	3	0	2	13	19	1	0	6
	4th	55	3	-	1	12	18	1	0	11
	5th (Highest)	50	1	-	2	10	17	2	0	17
Highest education completed by any household member	No formal education	82	3	-	1	3	7	2	-	1
	Primary 1-4	78	-	-	3	5	10	1	-	3
	Primary 5-8	65	2	0	2	9	17	1	0	3
	Secondary or higher	54	2	0	2	12	16	1	0	13
Self-employed/employer in farming/fishery		67	2	0	2	9	14	1	0	4
Self-employed/employer in other production/service		39	1	-	3	14	24	2	0	16
Employed in public sector		15	2	-	4	15	26	1	-	37
Employed in formal sector (privat owner/company)		63	1	-	2	10	14	1	1	9
Highest education completed by head of household	No formal education	82	2	0	2	4	8	1	0	1
	Primary 1-4	69	2	0	2	9	15	0	-	3
	Primary 5-8	59	2	0	2	12	18	1	0	5
	Secondary or higher	37	1	0	2	13	21	2	-	24
Village connected to electricity		57	2	0	3	10	18	1	0	8
REA: Households connected to electricity		49	2	0	3	12	19	2	0	12
Total		63	2	0	2	10	15	1	0	6

Drivers for more efficient cooking ovens in rural areas

In rural areas the large majority stick to three stone firewood cooking places. We investigated who moves to more energy efficient low emission firewood cook stoves and who move rather to charcoal and other ovens. We focus both on geographical factors as region and remoteness, and economic and social household factors.

There is a clear drive towards more efficient cooking ovens for households living in suburban areas less than 10km from a town. This is also reflected in lower shares of three-stone-fire in villages and household connected to electricity.

Both in suburban areas with less than 10km to town and in areas with 10-25 km to town a substantial share (11%) use LPG gas for cooking.

Across the areas both higher income and higher education are important drivers towards more energy efficient charcoal burners with air-stop or even ceramic lining.

Only around half (50-55%) of the households in the three highest income quintiles use a three-stone-fireplace for cooking. Both charcoal ovens and LPG gas ovens are used by almost the same share. Almost 1 of 3 households (29-33%) in the two highest income quintile households use a charcoal oven with air-stop or better efficiency and 1 of 7 (11-17%) use an LPG gas oven.

As in Dar es Salaam, the driver seems to be higher education and employment in sectors with better access to information. Only 1 of 6 households (17%) with a member employed in the public sector use wood for cooking, almost half (46%) use a charcoal oven, and more than 1 of 3 households (37%) have even moved to an efficient LPG oven.

Still more than half of households (54%) with at least one household member with secondary school are still relying on a three-stone-fireplace for cooking. If the head has a secondary school or higher only slightly more than 1 of 3 (37%) use a three-stone-fireplace. The same share of households, that is 1 of 3 households (38%) use a charcoal oven while 1 of 4 households (24%) use an LPG gas oven.

3.4. Willingness to pay

For all households without an ICS we asked for willingness to pay for a more efficient cooking stove, up front or in installments.

Table 3.6 Willingness to pay for improved cook stove by area. Shares in percent, 2021/22

		Area			
		Dar es Salaam	Other urban	Rural	Total
Willingness to pay by area	Have ICS already	96	70	17	36
	Ready to pay for ICS	0	8	20	15
	Ready to pay over 12m for ICS	1	5	16	12
	Cannot afford ICS	2	13	35	27
	Trad oven better	-	0	3	2
	Other rejection	1	4	9	7
	N in ‘000	1570	2435	8840	12845
Total		100	100	100	100

Most households in Dar-es-Salaam and in other urban areas have already an Improved Cook Stove (ICS), but in all types of areas there are households able to move up to more efficient cooking by changing to an ICS stove.

When looking at household without an ICS, the situation is the same across the area types. Half the households answer they cannot afford to buy a new oven, while the other half is ready to pay either upfront or over 12 months in installments.

We try identifying whether this willingness to pay vary across economic and information dimensions.

Table 3.7 Willingness to pay for improved cook stove by area. Shares in percent, 2021/22

		Ready to pay for ICS	Ready to pay over12m for ICS	Cannot afford ICS	Trad oven better	Other rejection	N in '000	Total
Centrality	Max 10km to town	23	21	43	2	11	8174	100
	11-25km to town	32	17	38	2	11		100
	More than 25km to town	22	19	44	5	11		100
Household per capita total annual expenditure quintile	1st(Lowest)	19	15	51	5	10	8174	100
	2nd	23	20	42	4	11		100
	3rd	26	22	38	3	10		100
	4th	26	23	37	3	11		100
	5th(Highest)	32	18	37	1	11		100
Highest education completed by any household member	No formal education	20	14	55	3	7	8174	100
	Primary1-4	19	17	54	1	8		100
	Primary5-8	21	19	45	4	11		100
	Secondary or higher	30	21	34	3	12		100
Self-employed/ employer in farming/fishery		24	19	42	4	10	8174	100
Self-employed/ employer in other production/service		27	22	35	3	13	8174	100
Employed in public sector		49	11	24	3	13	8174	100
Employed in formal sector (privat owner/company)		27	25	36	4	8	8174	100
Highest education completed by head of household	No formal education	21	15	53	4	8	8174	100
	Primary1-4	24	21	44	4	7		100
	Primary5-8	24	20	39	4	13		100
	Secondary or higher	35	25	25	4	11		100
Village with access to electricity		20	20	45	3	11	8174	100
REA:Household connected to electricity		26	19	37	4	14	8174	100
Total		24	19	43	4	11		100
N in '000		1961	1566	3481	298	868	8174	

As you would expect, a large share i.e. 1 of 2 wealthy households (50%) are ready to move to an ICS by upfront pay or in installments, but even 1 of 3 low-income households (34%) are interested in buying an ICS.

In households where the head has secondary education or higher, or one household member is employed in the public sector as many as 3 of 5 households (59-60%) are interested in investing in an ICS.

3.5. Time used for fuel acquisition and stove preparation

Time used for collection of firewood

What are the links between time spent on collection of firewood and type of cooking oven?

Table 3.8 Time used for collection of firewood, 2021/22

	Collection of firewood Minutes per week	Mean	N in '000
Cooking stove	Three stone fire	299	5889
	Round mud stove	407	170
	Rocket stove	120	17
	Open charcoal burner	328	223
	Charcoal burner w/air-stop	285	1122
	Charcoal burner v/ceramic lining	259	2449
	Charcoal burner w/ceramic insulation	175	169
	Kerosene cooking oven	551	13
	Gas and El oven	198	2407

Before interpreting the table on time used for collection of firewood, we need to remind of four dimensions of obtaining solid fuel:

- Firewood is of course the main fuel for any cooking with a wood-based oven. The share of other sources like husk and briquettes is small.
- Firewood may also serve as the base for own production of charcoal and hence even households with charcoal burners may collect firewood.
- For many households, the firewood and charcoal is a mix of own collection/processing and purchasing.
- Access to firewood which may be collected is likely to be better in remote area and hence require less time.

Contrary to what you would expect, households with a more efficient round mud stove tend to use more time for collection of firewood. A possible reason is that these households may be located in areas with more cumbersome collection of firewood. But as you would expect households with an efficient rocket stove spend less than half that time.

As expected, households with charcoal burners are likely to spend less time collection firewood, the more efficient charcoal oven they use.

Cook stove preparation

Independent of the type of cookstove, households usually spend quite some time for cooking, both to grow or buy the food and for the cooking process.

Acquiring the fuel and making the cook stove ready for use may vary with the type of fuel and cookstove. We have summarized the time spent for fuel acquisition and for preparing the stove for cooking.

Table 3.9 Convenience – Fuel and Stove-preparation time by type of main oven, 2021/22

Convenience	1	2	3	4	5
Fuel acquisition (collection or purchase) and preparation time (h/w)	More than 7 hours	Less than 7 hours	Less than 3 hours	Less than 1.5 hours	Less than 0.5 hour
Stove preparation time (minutes per meal)	More than 15 minutes	Less than 15 minutes	Less than 10 minutes	Less than 5 minutes	Less than 2 minutes

Shares in each tier in percent	Tier	Three stone fire	Round mud stove	Rocket stove	Open charcoal burner	Charcoal burner w/air-stop	Charcoal burner w/ceramic lining	Charcoal burner w/ceramic insulation	Kerosene cooking oven	Gas and El oven	All
Convenience – Fuel and Stove-preparation time'	1	44	51	33	43	44	35	28	46	19	37
	2	21	14	-	19	18	23	24	15	12	19
	3	20	16	67	10	22	28	35	-	24	23
	4	11	11	-	21	13	12	10	-	11	11
	5	4	8	-	7	3	3	3	38	34	10
	Total	100	100	100	100	100	100	100	100	100	100
N in '000		5888	170	18	222	1122	2448	169	13	2408	12458

The majority of households (51%) with a round mud stove for cooking seem to spend more than 7 hours on average for acquisition of firewood and preparation of the cooking oven. On the other hand, among households with an efficient rocket stove for firewood or an efficient charcoal burner only around 1 of 3 (28-35%) spend 7 hours or more.

As one would expect, almost half the households (45%) with an LPG gas oven spend less than 1½ hours on fuel and stove preparation time.

3.6. Kitchen

Cooking is a time-consuming task for most of the households in Mainland Tanzania across all areas.

Table 3.10 Cooking Exposure - Contact time by type of main oven, 2021/22

Contact time	0	1	2	3	4	5
Contact time	7.5 hours <	< 7.5 hours	< 6 hours	< 4.5 hours	< 3 hours	< 1.5 hours
Percent	0	4	7	19	48	22

Shares in each tier in percent	Tier	Three stone fire	Round mud stove	Rocket stove	Open charcoal burner	Charcoal burner w/air-stop	Charcoal burner w/ceramic lining	Charcoal burner w/ceramic insulation	Kerosene cooking oven	Gas and El oven	All
'Cooking Exposure-Contact time'	1	4	10	-	5	4	4	4	-	1	4
	2	8	6	17	7	12	7	4	-	5	8
	3	21	27	-	17	23	23	20	15	13	20
	4	50	46	83	53	49	52	55	38	45	49
	5	17	11	-	19	12	14	17	46	35	19
	Total	100	100	100	100	100	100	100	100	100	100
	N in '000	5748	157	18	216	1078	2416	168	13	2391	12205

The households tend to spend several hours around the oven. 2 of 3 households (68%) spend up to 4 ½ hours in the cooking area. Hence it is important either to ensure an open or well-ventilated area or a cook stove with low emission.

Ventilation

The survey captures detailed information of the cooking facilities whether this is a separate open kitchen house or a room within the main house.

The link between type of kitchen, contact time and fuel and stove preparation time by type of cooking oven(s) are summarized in table 3.11.

Table 3.11 Cooking exposure – Overall ventilation level by type of main oven, 2021/22

Ventilation tier		0	1	2	3	4	5
Cooking exposure	Ventilation: Volume Kitchen	< 5 m3	5 m3 <	10 m3 <	20 m3 <	40 m3 <	Open air
	Percent	5	12	18	20	14	31
	Ventilation: Structure	No	1 window	1 window <	Significant openings	Veranda	Open air
	Percent	4	45	19	7	8	16
	Overall ventilation in percent	5	19		14	61	

Shares in each tier in percent	Tier	Three stone fire	Round mud stove	Rocket stove	Open charcoal burner	Charcoal burner w/air-stop	Charcoal burner v/ceramic lining	Charcoal burner w/ceramic insulation	Kerosene cooking oven	Gas and El oven	All
'Cooking Exposure- Overall Ventilation Level'	0	-	-	-	-	-	-	-	-	23	4
	1	-	-	-	-	-	0	-	-	5	1
	2	19	28	50	9	15	17	15	15	23	19
	3	7	5	17	7	8	9	7	-	5	7
	4	0	-	17	-	0	0	1	-	0	0
	5	73	67	17	84	77	74	77	85	43	68
	Total	100	100	100	100	100	100	100	100	100	100
N in '000		5889	171	18	222	1122	2449	169	13	2407	12460

Households in Mainland Tanzania have a very good ventilation level. More than 2 of 3 households (68%) have an open-air kitchen and 3 of 4 households (75%) have at least a kitchen of 20 m3 (such as 4m x 2.5m x 2m height) with at least one window. k

There is a clear correlation between lack of efficiency of the cooking oven and the ventilation level. Households with a very efficient and low emission rocket stove or an LPG gas oven may however have smaller kitchens. Half of these households (50-51%) have a small kitchen of 10m3 or less with only one window.

3.7. Attitudes towards cooking oven options

We have asked each household for their attitude towards replacing a traditional cooking oven with a more efficient one. For these types of stoves, the number of households are too few to present figures with the necessary accuracy. For these we only present summary figures.

Table 3.12 Attitudes towards stoves and cooking in Mainland Tanzania , 2021/22

		Three stone fire	Round mud stove	Rocket stove	Open charcoal burner	Charcoal burner w/air-stop	Charcoal burner w/ceramic lining	Charcoal burner w/ceramic insulation	Kerosene cooking oven	Gas and El oven
Smoke from stove is good at chasing insects away	Agrees	19	34	-	9	12	16	23	-	14
	No opinion	37	25	-	16	31	33	38	-	35
	Disagree	44	41	-	75	57	52	39	-	52
	Total	100	100	-	100	100	100	100	-	100
Certain food tastes better when cooked with biomass	Agrees	25	33	-	14	20	26	25	-	37
	No opinion	48	48	-	55	44	43	49	-	41
	Disagree	26	19	-	31	36	31	26	-	22
	Total	100	100	-	100	100	100	100	-	100
The stove is needed for lighting up the house in the evening	Agrees	18	27	-	10	10	13	14	-	13
	No opinion	42	41	-	44	38	42	48	-	40
	Disagree	40	32	-	46	53	46	38	-	47
	Total	100	100	-	100	100	100	100	-	100
	N in '000	5886	170	17	223	1122	2448	168	13	2403

Table 3.13 Attitudes towards stoves and cooking in Dar es Salaam, 2021/22

		Three stone fire	Round mud stove	Rocket stove	Open charcoal burner	Charcoal burner w/air-stop	Charcoal burner w/ceramic lining	Charcoal burner w/ceramic insulation	Kerosene cooking oven	Gas and El oven
Smoke from stove is good at chasing insects away	Agrees	-	-	-	-	-	9	-	-	14
	No opinion	-	-	-	-	-	48	-	-	33
	Disagree	-	-	-	-	-	42	-	-	53
	Total	-	-	-	-	-	100	-	-	100
Certain food tastes better when cooked with biomass	Agrees	-	-	-	-	-	45	-	-	47
	No opinion	-	-	-	-	-	31	-	-	36
	Disagree	-	-	-	-	-	24	-	-	17
	Total	-	-	-	-	-	100	-	-	100
The stove is needed for lighting up the house in the evening	Agrees	-	-	-	-	-	7	-	-	12
	No opinion	-	-	-	-	-	50	-	-	38
	Disagree	-	-	-	-	-	44	-	-	50
	Total	-	-	-	-	-	9	-	-	14
	Total	18	0	0	0	34	334	21	0	1022

Table 3.14 Attitudes towards stoves and cooking in other urban areas, 2021/22

		Three stone fire	Round mud stove	Rocket stove	Open charcoal burner	Charcoal burner w/air-stop	Charcoal burner w/ceramic lining	Charcoal burner w/ceramic insulation	Kerosene cooking oven	Gas and El oven
Smoke from stove is good at chasing insects away	Agrees	19	-	-	-	10	18	-	-	12
	No opinion	39	-	-	-	30	31	-	-	31
	Disagree	42	-	-	-	60	51	-	-	57
	Total	100	-	-	-	100	100	-	-	100
Certain food tastes better when cooked with biomass	Agrees	26	-	-	-	20	23	-	-	27
	No opinion	57	-	-	-	42	45	-	-	44
	Disagree	17	-	-	-	38	33	-	-	29
	Total	100	-	-	-	100	100	-	-	100
The stove is needed for lighting up the house in the evening	Agrees	17	-	-	-	8	13	-	-	9
	No opinion	48	-	-	-	39	37	-	-	39
	Disagree	19	-	-	-	10	18	-	-	12
	Total	39	-	-	-	30	31	-	-	31
	N in '000	366	0	0	47	258	780	48	0	853

Table 3.15 Attitudes towards stoves and cooking in rural areas, 2021/22

		Three stone fire	Round mud stove	Rocket stove	Open charcoal burner	Charcoal burner w/air-stop	Charcoal burner w/ceramic lining	Charcoal burner w/ceramic insulation	Kerosene cooking oven	Gas and El oven
Smoke from stove is good at chasing insects away	Agrees	19	34	-	10	12	16	32	-	15
	No opinion	37	25	-	15	30	30	34	-	44
	Disagree	44	41	-	75	58	54	34	-	41
	Total	100	100	-	100	100	100	100	-	100
Certain food tastes better when cooked with biomass	Agrees	25	33	-	14	20	24	23	-	32
	No opinion	48	48	-	52	44	44	50	-	47
	Disagree	27	19	-	34	36	32	27	-	21
	Total	100	100	-	100	100	100	100	-	100
The stove is needed for lighting up the house in the evening	Agrees	18	27	-	10	10	14	20	-	19
	No opinion	41	41	-	41	37	42	57	-	46
	Disagree	41	32	-	50	53	44	23	-	35
	Total	100	100	-	100	100	100	100	-	100
	N in '000	5502	170	17	176	830	1335	98	13	529

4. Analysis

4.1. The causality challenge.

The paragraphs above show that both geography, economics, and education are correlated with improved access to electricity and acquisition of energy efficient ovens.

But we still do not know whether these issues are driving factors making households more likely to give priority to ensure access to electricity and energy efficient ovens, or rather the opposite. Better access to electricity and the use of more energy efficient ovens may increase the opportunities to income generating activities and allow for more time spent on education.

Geography and the educational level in each household is usually established before any access to electricity or acquisition of energy efficient ovens and hence be a direct or spiraling causal driver.

Income and economic welfare may however both allow the households to invest in better access to electricity and energy efficient ovens and vice versa.

In order disentangle the possible causal effects we focus the analysis on communities with a recent access to electricity, such as during the last 1 to 5 years. Access to electricity may give the households better income opportunities, but this will take some years to materialize. During these first years, the causal direction will rather be that household with high income are more likely to invest in improved access to electricity. All communities in Dar es Salaam have been connected to the grid for more that 5 years, hence the focus of this analysis will be on communities and households in other urban areas and rural areas.

While some communities may have political connections and the ability to lobby for grid to their communities, this will only be exceptional cases, not reflected in the statistical analysis.

Usually, the households will have to take the decisions of TANESCO and REA for building consumer access to the national grid into their own community for granted. Hence even the community access to electricity is usually a causal driver for the household access to electricity and the acquisition of energy efficient cooking ovens.

When REA builds the grid with one or more transformers in the community, the connection fee has been low or even free for all households living within a proper distance from the transformers, within 300 to 600 meters. But the households have to pay themselves for the internal wiring and hence poor households may decide not to connect. While the community access to electricity is a driver for household connection, this driver may be affected by the economy of each household.

Some households may already have installed solar energy when the grid is built in their community. Some of these households will then decide not to connect to the grid, some will go for only the grid, while the rest decide to use both energy sources.

When the grid is well established in the community the running of the grid will be transferred from REA to TANESCO. At this stage TANESCO will demand a higher connection fee for additional households to connect.

The TANESCO fee for households close to existing low voltage transformers is TZS 272,000 in urban and TZS 150,000 in rural, while a solar home system would cost around the same, like TZS 300,000 for 60W/75Ah and TZS 200,000 for 30W/18Ah. Grid connection will of course require paying for the consumption, while the consumption of power from a solar home system is free.

Hence, the main alternatives for households which are not connected to the grid are an expensive connection fee to TANESCO or a cheaper solar solution based upon a multilight system. Buying a solar home system is not an alternative. As already shown in table 2.15-2.17 economy is one of the drivers for a proper solar home system or a smaller solar multi device.

Switching to more energy efficient cooking ovens will always require a smaller or larger investment in a more energy efficient oven. A change from one closed oven to another closed and more efficient oven may foremost be a matter of an economic investment which will pay off over time. But a change from an open solution which also give light to household and keep the mosquitos away may also require a new solution for light and mosquito protection.

A change in fuel, such as from charcoal to LPG gas may also change cooking habits and as shown in table 3.12 – 3.15 some households find the food prepare by a solid fuel oven may taste better. The question is whether a high preference for food cooked on biomass ovens is a barrier against moving to more efficient ovens.

In Dar es Salaam the move from less to more efficient ovens will be from charcoal ovens to LPG gas ovens. The share of households with a preference for food prepared on a biomass oven is larger among households with an LPG oven. Hence it is not likely that the taste preference has been a barrier for the move to a more efficient cooking option.

In other urban areas the move from less to more efficient cooking ovens could be any step from three stone woodfire to improved charcoal burners to LPG gas ovens. The share of households who state it is important that the oven can chase insects, with a preference for food prepared on a biomass oven and providing light at night is slightly higher among households with a three stone woodfire place than for those with charcoal burners or LPG gas. Hence all these factors may be a barrier for some of the households.

Even in rural areas the move from less to more efficient cooking ovens could be any step from three stone woodfire to improved charcoal burners to LPG gas ovens. The share of households who state it is important that the oven can chase insects, with a preference for food prepared on a biomass oven and providing light at night is only a tiny fraction higher among households with a three stone woodfire place than for those with charcoal burners and at the same level as those with an LPG gas oven. These factors may still be a barrier for some of the households, but this is not likely to be the case for the majority.

In this context we will now like to analyze which factors are the main drivers for access to electricity and acquisition of energy efficient oven.

4.2. Household connection to grid when the national grid is extended to the community

As discussed, the community grid connection is decided by the national authorities. When the community is connected to the national grid, households do not need to pay any fee for the connection if they live within a technically appropriate distance of 300 to 600 meters from the transformer. They will have to pay for internal wiring in the house, often estimated to around TZS 50,000. This is still just a small amount compared with the costs for any solar energy device.

Since we focus on the drivers for making this connection and want to avoid any feedback causal effect from a previous access to the grid we limit the analysis to communities with a recent access to the national grid i.e. during the last 5 years.

At that time, all communities in Dar es Salaam had already access to the grid, hence we focus on other urban areas and rural areas. Since the households face a very different situation in urban versus rural communities, we need to do this analysis separately for urban and rural areas.

For each area we test whether the household grid connection is affected by:

- For rural areas only: How far away the community is located from markets and towns,
- Whether they have access to solar energy (solar lantern, a multi solar device or a solar home system),
- Income level measured by the annual expenditure quintile,
- Highest education completed by any household member,
- Highest education completed by head of household,
- Household member self-employed/employer in farming/fishery,
- Household member self-employed/employer in other production/service,
- Household member employed in public sector
- Household member employed in formal sector (private).

This relationship is tested in a linear stepwise regression. The factors are tested one by one in a tolerance test and included if the F-probability within 0.05 and excluded if the F-probability is above =.10 in a stepwise manner. The factors which correlate within these ranges are listed in table 4.1 – 4.2.

Table 4.1 Stepwise regression analysis of whether households are connected to grid if grid became available in village during last 5 years for households in other urban areas

	Standardiszed Beta	t	Sig.
(Constant)		20.236	0.000
Solar energy (home system/ multilight	-0.312	-5.941	0.000
Highest education completed by head of household	0.238	4.712	0.000
Grid is too far away for no fee connection	-0.201	-3.913	0.000
Self-employed/employer in farming/fishery	-0.160	-2.909	0.004
Total household per capita annual expenditure (TZS)	0.121	2.278	0.024
Adj R sq 0.368 n=265			

The strongest effect for *not* connecting to the grid is for households with installed solar devices. As discussed, households who live more than 300-600 metes from the transformer would need an extra transformer and are not offered a free connection. Hence as you would expect households living too far from the transformers built in the community are less likely to connect to the grid. Households with at least one member doing farming or fishing are less likely to connect.

The only positive factors for household connection to grid when the grid net reach the community are high education by the head and the household income.

Table 4.2 Stepwise regression analysis of when households are connected to grid if grid in village for households in rural areas

	Standardized Beta	t	Sig.
(Constant)		36.421	0.000
Solar energy (home system/ multilight	-0.254	-9.349	0.000
Grid is too far away for no fee connection	-0.206	-7.641	0.000
Highest education completed by any household member	0.121	4.350	0.000
Self-employed/employer in other production/service	0.102	3.778	0.000
Total household per capita annual expenditure (TZS)	0.083	3.066	0.002
Centrality	-0.071	-2.645	0.008
Employed in public sector	0.067	2.441	0.015
Adj R sq 0.155 n=1196			

Just the same factors are important drivers for whether a household decided not to connect when the community got access to the grid in rural areas as in urban. Again, the strongest effects are that households who already have access to solar energy or live too far away from the transformer (and hence face a very high connection fee) tend *not* to connect.

Likewise, households living further away from towns and markets tend *not* to connect.

In rural areas there are however also more positive drivers to connect to the grid. Households where the highest education level by any household member and for households where at least one member is an employer/ self-employed in other production or service than farming/fishing and for households with at least one member employed in the public sector tend to connect more frequently.

Summarizing the main drivers for households to be connected to the grid when grid in community.

Deciding the type of electrical supply is a stepwise process. Before there was any grid in the village a few households may have been able to ensure a solar power device. They may find the additional gain from grid connection too small to connect when the grid poles came to the village/ quarter. At that point in time all households are likely to consider the possible gain and costs of grid connection. The connection fee is low at that point in time, but internal wiring may well add up to 50.000 TZS. The fee to connect at a later point in time or for households in the outskirts of the village or quarter may be quite large.

Based upon the analysis of household connection when the grid is extended to a community, we may talk about four groups, based upon how fast they act on new technological options:

- **Early birds** establishing a solar device before a grid was possible. This would require both a high information or educational level and financial resources to afford the devices. Some early bird households may be squeezed when the grid becomes available and decide not to connect. Others are able to utilize both options.
- **Mid range** households living in the central areas of the village/quarter connection to the grid, when the grid poles came to the village/quarter.
- **Late comers** with resources and information may be able to invest in a solar device at a later point in time. The barrier to move to grid connection at that point in time may be very high and only be an option for rich households or households using the grid for business.
- **Outsiders** with few resources or living in the outskirts of the village will often not be able to get access to electricity within the household.

The large advantage with the current no fee connection to the grid when the grid net comes to the community is to ensure almost all groups a proper access to energy. The main losers are however the outsider households living in the outskirts of the community.

Ensuring a wider connection to electricity would require a policy capturing all these groups.

4.3. Households with solar home system and multilight solar device when no grid in the community

Solar energy is an important energy source in different types of communities. In chapter 4.2 we saw that when the national grid is extended to a community, several households have already installed a solar device, either a solar home system or a multilight device, and hence decide not to connect to the national grid. Some households may also decide to go for a dual supply. A solar device may both serve as a cheap additional source for minor energy needs and a backup source during grid power black outs and brown outs.

The main focus in this report is however rather to identify the main drivers for ensuring any access to electricity. Chapter 3 focused on the drivers for households to connect to the grid when the national grid is extended to their community. In this chapter we focus on the drivers for solar power for households living in communities with no access to the grid.

In the second half of chapter 2, we have analysed which factors are associated with a range of solar devices. As for the grid, solar energy may improve the economic situation and welfare of a household and hence start a spiral process of increasing the level of solar supply.

Hence, in order to estimate the drivers causing a household to purchase and install solar energy we would again need to focus on recent access. We focus on factors which have caused some households to buy and install a solar device during the last 5 years by analysing the causal factors for households who did not have any solar device 5 years ago.

As discussed in chapter 4.1. solar devices still have a high cost, but when installed, the power is delivered for free.

Table 4.3 Households by community grid connection by type of residence in number of households in '000, 2021/22

	Residence			
	Dar es Salaam	Other urban	Rural	Total
No grid in community	0	206	3430	3636
Grid in community	1570	2229	5410	9209
Total	1570	2435	8840	12845

Table 4.4 Households living in communities with no grid connection by solar energy 5 years ago by type of residence in number of households in '000, 2021/22

	Residence			
	Dar es Salaam	Other urban	Rural	Total
Other electric power	0	62	821	883
Solar Lantern	0	24	583	607
No electricity	0	119	2026	2145
Total	0	205	3430	3635

Table 4.5 Households living in communities with no grid connection and no solar energy 5 years ago by solar energy today by type of residence in number of households in '000, 2021/22

	Residence			
	Dar es Salaam	Other urban	Rural	Total
No solar device today	0	79	1467	1546
Solar home system	0	54	688	742
Solar multilight	0	10	455	465
Solar home system or multilight	0	64	1143	1207
Total	0	143	2610	2753

There is access to the grid in all communities in our sample in Dar es Salaam, hence we only run the test in other urban areas and in rural areas.

In other urban areas, 143.000 households did not have neither grid in community nor any solar device 5 years ago. Of these around half or 64.000 households did buy a solar home system or a multilight system during the last 5 years. We have analysed whether any of the following drivers have served to cause the household to purchase a solar device during the last 5 years:

- Income level measured by the annual expenditure per capita
- Highest education completed by any household member
- Highest education completed by head of household
- Household member self-employed/employer in farming/fishery
- Household member self-employed/employer in other production/service
- Household member employed in public sector
- Household member employed in formal sector (private)
- For rural areas only: How far away the community is located from markets and towns

Table 4.6 Stepwise regression analysis of why households have purchased or acquired a solar home system or multilight device if grid not in village during the last 5 years for households living in other urban areas

	Standardized Beta	t	Sig.
(Constant)		9.211	0.000
Employed in formal sector (privat owner/company)	0.259	3.178	0.002
Adj R sq 0.067 n=143			

With a very small sample of 98 households, we are usually only able to find strong factors significant. It turns out that the only drive which has a significant causal effect is whether at least on household member is employed in the formal sector. Such households are in general better off than the average, but on the other hand total household-income or total consumption does not cause a similar effect.

Table 4.7 Stepwise regression analysis of why households have purchased or acquired a solar home system or multilight device if grid not in village during the last 5 years for households in rural areas

	Standardized Beta	t	Sig.
(Constant)		1.993	0.046
Highest education completed by head of household	0.105	4.553	0.000
Highest education completed by any household member	0.069	2.996	0.003
Centrality	0.050	2.579	0.010
Adj R sq 0.026 n=1047			

In rural areas, a sample of a reasonable size as 1047 did live without a grid connection in the community nor a household solar device 5 years ago. There are two types of factors with a significant causal effect to purchase a solar device. The main factor is the educational level in the household, but even centrality is important. Households being located in a more remote communities further away from towns, are more likely to purchase or acquire a solar device. 3 of 5 (60%) of these household have been able to invest in a real solar home system with both solar panels and batteries.

Summarizing the main drivers for households for a solar home system or multilight device when no grid in community.

In the tabulation analysis we identified three types of potential drivers to ensure connection to electricity from the grid or solar devices, being factors related to education and access to information, the economic situation and remoteness. With only limited panel data, it is difficult to identify sub-groups allowing for causal analysis. But by identifying households with no solar devices in communities with no grid connections, it was possible to analyse the drivers causing these household to purchase a solar device during the last 5 years – or not.

All the three types of drivers are drivers for either households in other urban or rural areas, but not both.

Households living in other urban areas where at least one household member is employed in the private formal sector are likely both to be better off and have large access to information on the technological development and price level than others. They tend to purchase a solar device more often than other households.

Households living in rural areas education and centrality are the important drivers. If either the head of the household or any other member has higher education, the household tend to be able to buy and install a solar device. And as one might expect, living in remote areas is an important drive to purchase a solar device. Households living in remote areas know well that they cannot expect REA to reach to many remote areas with a line of line of electricity net poles.

4.4. Households switching to more energy efficient stoves

For generations the common type of cooking solution in rural areas has been the three-stone fireplace burning firewood or other solid fuel. This way of cooking ensures the traditional flavor to the food, light in evenings and smoke chasing insects. The problem of too heavy smoke is handled by cooking in special open air kitchen design. If men are responsible for building or buying more efficient ovens and women responsible for collecting firewood, the incentive for moving to more energy efficient solutions may not materialize .

On the other hand, a high population density in urban areas, deforestation requiring more time for collection of firewood and a system for buying LPG gas in cities and larger towns, and electricity for light after sunset have served to change the situation.

Still, the large majority of households in rural areas, stick to some type of three stone fireplaces in rural areas, while in Dar es Salaam and other urban areas, charcoal burners and LPG gas ovens are common.

So why do some households switch to more energy efficient cooking solutions?

Households using solid wood-based fuel may move to more efficient ovens, such as rocket stoves to improve energy efficiency and reduce the volume of fuel. The large number of households using charcoal burners may move step by step to more energy efficient ovens and reduce the volume of charcoal needed and save money. There is a long range of charcoal burners available, from an open burner to a burner with air-stop, air-regulation and burning chamber with lining or even insulation. In both Dar es Salaam and many other cities, LPG gas would also be an option.

In all areas, we tested whether the choice of cooking solution and improved cooking stoves was affected by:

- Remoteness
- Household per capita total annual expenditure quintile
- Highest education completed by any household member
- Self-employed/employer in farming/fishery
- Self-employed/employer in other production/service
- Employed in public sector
- Employed in formal sector (private)
- Highest education completed by head of household
- Household solar (home system/ multi) energy

Dar es Salaam

Table 4.8 Stepwise regression analysis of why households have more energy efficient stoves for households in Dar es Salaam

	Beta	t	Sig.
(Constant)		4,199	0,000
Household grid connection	0,266	5,727	0,000
Highest education completed by head of household	0,137	2,937	0,003
Adj R sq 0.091 n=423			

In Dar es Salaam the most energy efficient stove in common use is an LPG oven. The fuel cost of LPG gas is not higher than buying charcoal or firewood, but you need to invest in an LPG-gas tank and a gas oven. When you are to refill or replace the gas tank the unit cost is considerable, hence you need to be able to pay for fuel in bulk rather than small quantities.

There is however a rent option available with an LPG-gas tank with a meter. Then you may pay with your smart phone in small quantities in advance. This option is however more expensive per unit of LPG-gas and not very common.

Despite the investment costs, the most important reason why households choose to use LPG-gas is not income level, but rather the education level by the head of household. This may indicate that such a common option is used even by poorer households learning about the LPG-gas option by their neighbors.

Other urban areas

Table 4.9 Stepwise regression analysis of why households have more energy efficient stoves for households in other urban areas

	Beta	t	Sig.
(Constant)		0,211	0,833
Household grid connection	0,277	11,114	0,000
Self-employed/employer in farming/fishery	-0,168	-7,662	0,000
Highest education completed by head of household	0,117	4,924	0,000
Household per capita total annual expenditure quintile	0,194	9,876	0,000
Remoteness	-0,100	-5,340	0,000
Employed in public sector	0,100	5,286	0,000
Highest education completed by any household member	0,070	3,044	0,002
Self-employed/employer in other production/service	0,050	2,412	0,016
Household solar (home system/ multi) energy	0,052	2,294	0,022
Adj R sq 0.371 n=1984			

In other urban areas, the most common type of cooking is by charcoal ovens. The most common version is a charcoal burner with ceramic lining. These charcoal burners have also a system of air regulation and are quite energy efficient.

Hence in other urban areas there are several options for moving to more efficient ovens, either to an LPG-gas oven or to a more efficient charcoal burner. Obviously more remote households may not have a proper access to an LPG-gas station and hence would rather stick to charcoal burners.

We have analyzed what kind of households have already moved to a more efficient oven. In other urban areas it turns out that households in farming or living in more remote areas are less likely to has moved to more efficient ovens.

On the other hand, three other types of factors may have pushed or tempted the households to invest in more energy efficient ovens. A proper source for electric light is the more important factor. The factor with the strongest impact is access to the grid, but even a households with a proper solar system have moved to a more efficient oven.

Even the income level and various indicators of education and access to information are also important factors for households living in other urban areas to move to more efficient cooking ovens.

Rural areas

Table 4.10 Stepwise regression analysis of why households have more energy efficient stoves for households in rural areas

	Beta	t	Sig.
(Constant)		-0,426	0,670
Household grid connection	0,205	12,332	0,000
Highest education completed by head of household	0,123	6,673	0,000
Self-employed/employer in farming/fishery	-0,117	-6,615	0,000
Household per capita total annual expenditure quintile	0,148	9,446	0,000
Employed in public sector	0,114	7,279	0,000
Household solar (home system/ multi) energy	0,093	5,855	0,000
Self-employed/employer in other production/service	0,091	5,409	0,000
Highest education completed by any household member	0,071	3,826	0,000
Remoteness	-0,047	-3,135	0,002
Adj R sq 0.225 n=3521			

In rural areas, two of three households (63%) rely on a three stone fireplace cooking solution with very low efficiency, such as 10-15 percent compare with 50 percent and above for energy efficient ovens for solid fuel. Around one of four households have moved to more efficient charcoal ovens with air-stop or even a charcoal burner with ceramic lining and air regulation.

We have analyzed the factors for household in rural areas having moved to a more efficient oven. That is the same factors as for households in other urban areas. Farming and fishery households and households living in more remote areas have not moved to more efficient cooking solutions. Having access to electricity is again the most important factor for households moving to a more efficient cooking solution. Also high income and access to education and information are important.

Summarizing the main drivers for households to switch to more energy efficient cooking solutions

The main factor for households having ensured a more energy efficient cooking solution across communities in all areas is a household connection to the grid. A reason could be that with a grid connection and electric light, there is no need for the cooking solution to deliver light in the evening.

The other common driver across the country is a higher educational level. A higher education may fuel the knowledge of energy efficient cooking solutions either a more energy efficient oven for charcoal or firewood or even a gas oven for LPG fuel.

In Dar es Salaam we could not identify any other driver than education. This may be because LPG gas ensures a reasonable price, stable and convenient access to fuel when a household has managed to invest in the gas container and gas oven.

In other urban and rural areas, both income and education/ access to information are important drivers. On the other hand, remote households are less likely to have switched to energy efficient ovens. Many households would of course hesitate to switch to an oven not providing light in the kitchen area before they get access to the grid or install a solar power solution. Hence, if they have access to collection of firewood within a reasonable distance, they may rather stick to the less efficient woodfire alternatives.

5. Policy recommendations

The goal of this report was to learn and document drivers and barriers that households meet to gain access to electricity and more energy efficient cooking solutions.

For access to electricity, we focused on both grid connection and solar energy through a solar home system and multilight systems.

For cooking solutions, we focused on two main challenges. First, how to balance low emission and high efficiency. Second, to identify the drivers and barriers for households changing to more efficient cooking ovens.

5.1. Access to the grid

The Ministry of Energy is responsible for the development of the energy sectors, the implementation is left to two different entities. Since 2007 the Rural Energy Agency (REA) has been in charge of planning and building the electric network, while TANESCO run and maintain the energy supply.

When REA builds the network to a community, they establish one or more transformers with consumer voltage. At that point in time, the households may connect for free to the network if they are located within 600 meters from the transformer. Households only pay for the electricity meter, fuse panel and internal wiring.

Households living further away from the transformer will have to pay more to have REA to build an additional transformer in the community.

When REA has completed the installation in a community, TANESCO takes care of running and maintenance. Households will then have to pay a higher connection fee to TANESCO for being connected to the network.

Households living in communities with a grid connection, two reasons are important for not being connected to the grid. Either they live too far from the transformer and/or they may not afford to connect. To give all households an equal opportunity to connect to the grid, two policy options may be considered:

- When REA extend the grid net to a community, they may consider building several transformers. Compared with the costs of reaching the community, the costs of one or two more transformers are low.
- The households who can afford to connect to the grid when the grid reaches their community are paying either a low fee or no fee at all. Some households will not connect, either because they cannot afford the connection fee or are not sure the price justify the advantage. Over time more households have learned about the benefits, and some are better off and can afford to connect. Today such households will have to pay a higher connection fee. REA and TANESCO may consider a policy of welcoming new customers for the same low connection fee after a few years. To keep installation costs at a low level, this offer may be given the community at a fixed point in time, such as 3 years after the first connection.

5.2. Solar energy

Solar energy may come through solar energy parks supplying the national grid or at household level. Here we focus on household level solar energy. Solar energy comes from a solar home system with one or more solar panels and one or more batteries, from a multilight system being an integrated device with both a solar panel and a battery solution, or just a single solar lantern. The solar energy is mainly used for light in the household and for the use of different devices with low energy consumption. A solar multilight system or a solar lantern may also provide energy for charging cell phones and smart phones. A solar home system may even provide energy for low consumption electric devices such as a 12v TV or 12v tools.

Over the last few years, the capacity of solar panels has increased rapidly while prices have fallen equally rapid. With electric inverters it is also possible to gain access to AC 230V power. The capacity and quality of batteries have increased, but the prices remain high both for traditional led (AGM) batteries and especially for the new lithium batteries. Today most households in Mainland Tanzania have a proper balance between the capacity of the solar panels and the batteries, but it is usually the batteries which are the minimum factor. Traditional led batteries will reduce in capacity after 4-6 years. Lithium batteries have a longer life span but may be exposed to severe fire if they are damaged and still used.

In communities with access to the grid, solar energy may still be the option for households in the outskirts of the community.

Even in communities with no access to the grid, a main driver is remoteness. The more remote, the higher share of households have managed to ensure access to electricity through solar power. In rural areas, households with higher education are more likely to buy a solar home system or device, while you do not find such an effect in urban areas.

In some countries such as Mongolia[8], donors have supported program to increase access to solar panels and energy in rural areas by donation of solar panels. In other countries, such as India the focus is more on how solar energy may be combined with energy efficient products from LED lights and charging mobiles to income generating devices such as solar pottery wheels.[9]

- If the government wants to expand the access to electricity, the most cost-efficient solution for remote areas may well be solar energy.
- In order to ensure an efficient market for solar energy panels and batteries, it is essential that communities and households have access to reliable information on technical options and a proper balance between solar panel capacity and battery capacity and alternative battery types. A government contribution in Mainland Tanzania may focus on establishing demonstration sites in cooperation with the business community-

5.3. Energy efficient cooking solutions

The main driver for encouraging households in Mainland Tanzania to switch to more energy efficient cooking solution across the country is a household connection to the grid. With a grid connection and electric light, there is no need for the cooking solution to deliver light in the evening. Another common driver is education. Knowledge may encourage the household to consider a more energy efficient oven for charcoal or firewood or even a gas oven for LPG fuel.

Outside Dar es Salaam both income and education/ access to information are important drivers. On the other hand, remote households living further way from towns may rather stick to the less efficient woodfire alternatives. Only quite few rural households have switched to energy efficient

[8] Mongolia's Clean Energy Transition: A Pathway to Sustainable and Inclusive Development | United Nations Development Programme (undp.org) - 2024
[9] Decentralised solar is transforming rural India, needs extra push (mongabay.com) - 2023

ovens for solid fuel such as for sticks and pellets. A proper alternative in rural areas may be the combination of solar energy and energy efficient ovens for solid fuels.

In urban areas outside Dar es Salaam, several households have already switched to more energy efficient option. In smaller cities and larger towns, several households have switched to LPG gas. In such areas, the government may want to promote LPG gas stations and LPG gas tanks with meters for smart phones and advance payment.

In towns, several households have switched to more energy efficient charcoal burners. But still few have switched to a charcoal burner with isolated burning chambers with an even higher efficiency.

Neither the need to chase insects, a better taste or the need for light were important barriers for most households for switching to closed and more energy efficient cooking solutions.

The main driver for efficient cooking solutions is ensuring access to light, either based upon grid connection or solar energy. The main barriers in the cities are lack of access to LPG gas and lack of information of the most efficient ovens for charcoal.

For rural households to switch to more energy efficient firewood solutions, they probably need a stepwise approach. First, to improve access to electricity-based light with a proper solar lantern, a multilight solar device or even a solar home system. Second, they need both to build or by a more energy efficient oven and to start cutting the need for firewood. Hence rural households have a longer way to go and are more likely to stick to open fireplace options. With a free access to collection of firewood, only a few rural households have switched to more energy-efficient pellet ovens or charcoal burners.

A government promotion of energy efficient cooking solutions would need to include different strategies to different types of area.

- In cities, the government may promote the use of LPG gas in cooperation with the business community.
- In towns, the government contribution may focus on information of the energy efficiency of the various types of charcoal-burners and jointly with the business community to establish demonstration sites for the range of energy efficient charcoal burners with a focus on charcoal-burners with insulated burning chambers.
- In rural areas, the government may need a double focus. First, to demonstrate cheap solar devices such as solar lanterns and multi-light devices. Second, to focus on areas with reduced access to firewood. In such areas, the government may cooperate with civil society organisations to establish promotion sites for more energy efficient ovens for solid fuel like pellets and sticks ovens or charcoal burners, either community built or cheap.

Abbreviations

AE	Access to energy
Ah	Ampere-hour
IASES	Impact of Access to Sustainable Energy Survey
ICS	Improved cooking solutions/stoves
kW	Kilowatt
kWh	Kilowatt-hour
LED	Light-emitting diode, light source
LPG	Liquefied petroleum gas
MoE	Ministry of Energy
NBS	National Bureau of Statistics
Norad	Norwegian Agency for Development Cooperation
REA	Rural Energy Agency
SDG7	Sustainable Development Goal number 7
SSB	Statistics Norway
TANESCO	Tanzania Electric Supply Company
TZS	Tanzanian Shilling
V	Volt
W	Watt
Wh	Watt-hour

Key Terms

Power plant – A production facility for electric power based upon sustainable production such as hydro-generated electricity, solar panel generated electricity, and wind mill generated electricity; or diesel generated electricity.

Electric grid – Electric lines or wires capable of transmitting of electric charge at various levels from high to consumer voltage.

High voltage power transmission lines – Grid lines from power plants to community transformers from 147,000 to 1000 volts.

Transformer stations and transformers – Facilities reducing voltage step by step from the highest level at 147,000 volts to consumer levels at 220/230 V (consumer households) or 340 V (business consumers).

Connection to electricity – A household (or business) is connected to the electric grid by wires to the location.

Access to electricity – A household with their own connection to electricity, with the possibility to get connected to electricity or by gaining from neighbours connected to electricity, such as by being able to charge the mobile (for a fee).

Electric charge – The potential electric energy measured in volt or kilovolt abbreviated as V or kV.

Electric current or flow – The amount of electricity flowing in a circuit such as a wire. It is measured in ampere, abbreviated as A.

Electric power – The electric energy consumed such as for light or running a machine. It is measured in watts or kilowatts, abbreviated as W or kW. 1W=1V x 1A.

Electric power-consumption – The electric power consumed in a time period. It is measured in Wh or kWh.

Power capacity:

- From the grid there is no technical limitation. You pay per kW used in a time period in kWh.
- From a solar panel, there is electric energy limitation you usually get 95% of the panel capacity such as 19W from a 20W panel. You pay nothing and may consume for 10 hours during daytime in full sunshine.
- From a battery there is power limitation, you usually get 75% of the battery capacity. A 12V battery storing 20 Ah may give you 75% x 12V x 20Ah = 180 Wh. With a 20W solar panel you may theoretically recharge the battery in 1 day of full sunshine, but due to technical waste during charging, you may need 1.5 days. You may then light 2 x 5W LED bulbs for 18 hours or both 2 bulbs and a 20W TV for 6 hours.

Household – All members of a household living in one compound, one building, or one apartment and usually eating from the same pot.

Community – All households living in a village or a quarter where most households know each other and have a common knowledge or their location.

Region – The 26 official regions in Mainland Tanzania

Areas – In this report the communities are grouped in three levels of urban versus rural: Dar es Salaam, Other urban areas, and Rural areas.

Centrality – In this survey the rural communities and EAs are grouped in three levels of centrality: max 10 km to town, 11-25 km to town, more than 25 km to town.

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