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Measuring Energy Access With A Multi-tier Approach

ESMAP
Energy Sector Management Assistance Program

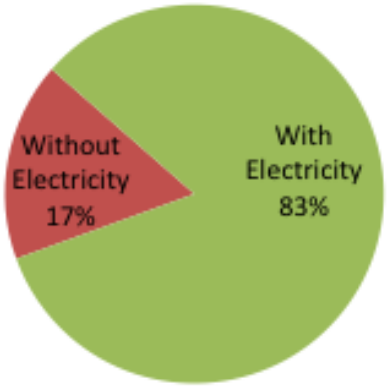
SUSTAINABLE
ENERGY FOR ALL

Definition Of Energy Access - Current vs New

Current Definition

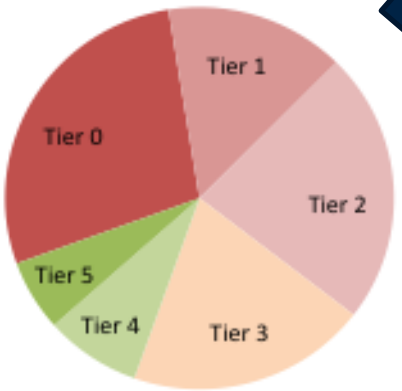
*'Having electricity **or** not having electricity'*

*'Cooking with non-solid fuels **or** cooking with solid fuels'*



New Definition

*Access to energy is the ability to avail energy that is **Adequate**, **Available when needed**, **Reliable**, **of good Quality**, **Convenient**, **Affordable**, **Legal**, **Healthy & Safe**, for all required energy services across **Household**, **Productive** and **Community** uses*



Multi-tier Framework –
Access To Household Electricity Supply

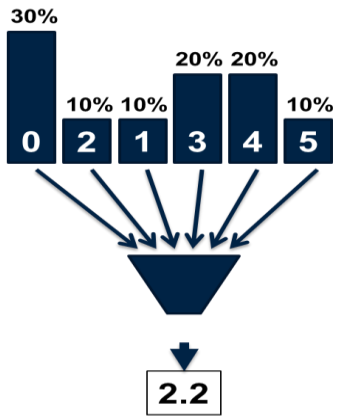
			Tier-0	Tier-1	Tier-2	Tier-3	Tier-4	Tier-5
Attributes	1. Peak capacity	Power	No Electricity	V. Low Power Min 1 W	Low Power Min 50 W	Medium Power Min 200 W	High Power Min 2 kW	
		Daily capacity		Min 4 Wh	Min 200 Wh	Min 1.6 KWh	Min 4 KWh	
	2. Duration	Hours per day	< 4 hrs	Min 4 hrs		Min 8 hrs	Min 16 hrs	Min 23 hrs
		Hours per evening	< 2 hrs	Min 2 hrs		Min 2 hrs	Min 4 hrs	Min 4 hrs
	3. Reliability					Max 3 disruptions **per day**	Max 7 disruptions per week	Max 3 disruptions **per week** of total duration < 2 hours
	4. Quality					Voltage problems do not prevent the use of desired appliances		
	5. Affordability				Cost of a standard consumption package of 365 kWh per annum is less than 10% of household income			
	6. Legality					Bill is paid to the utility / pre-paid card seller / authorized representative		
	7. Health and Safety					Absence of past accidents and perception of high risk in the future		

Tier-rating for the household is calculated by applying the lowest of the tier-ratings across all attributes.

Index of Access to Energy
$\sum(P_i \times K)$

P_i = Proportion of households at the k^{th} tier
K = Tier number {0,1,2,3,4,5}

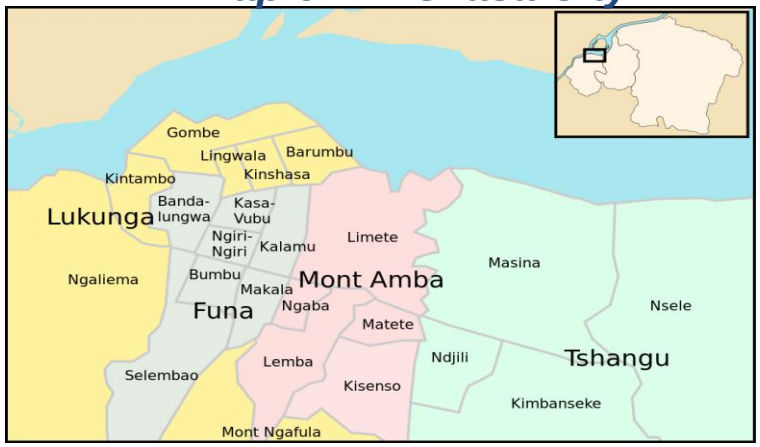
- Can be aggregated across geographies (Village, district, province, country or region)
- Can be tracked over time



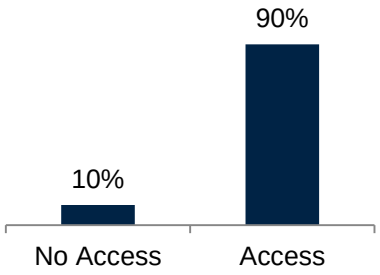
Pilot - Kinshasa City

- Household energy survey done in Aug-Sept, 2013
- Covered all four districts : Lukunga, Funa, Mont Amba, Tshangu
- Sample of 2505 Households
- Data used for multi-tier analysis
- Data also used to prepare a draft Energy Access Diagnostic Report

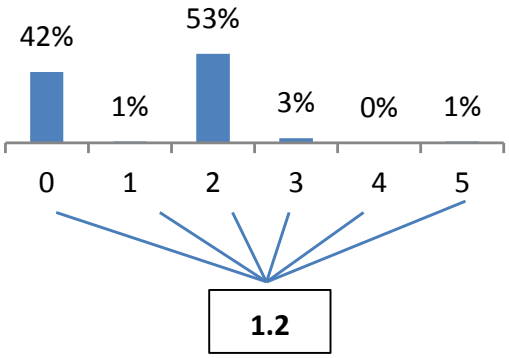
Map of Kinshasa City



Binary Measurement

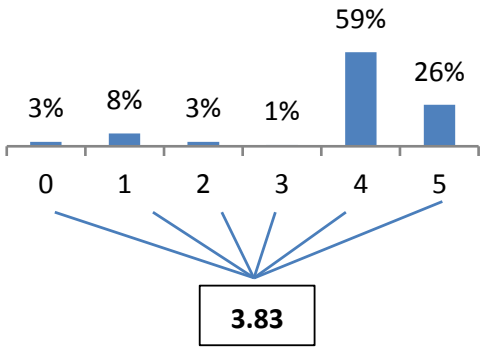


Multi-tier Measurement Of Access To Electricity Supply



Index of Electricity Access

Multi-tier Measurement of Access to Electricity Appliances



Index of Access to Appliances

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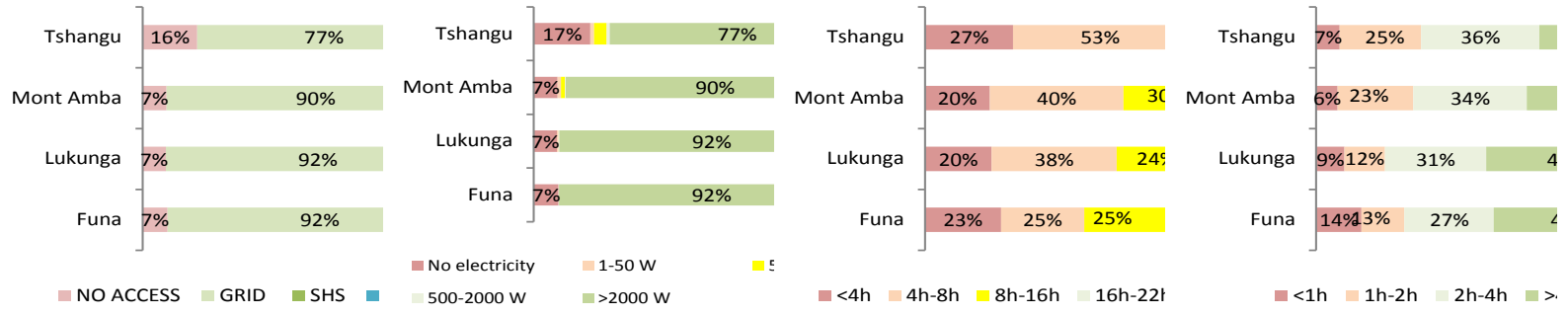
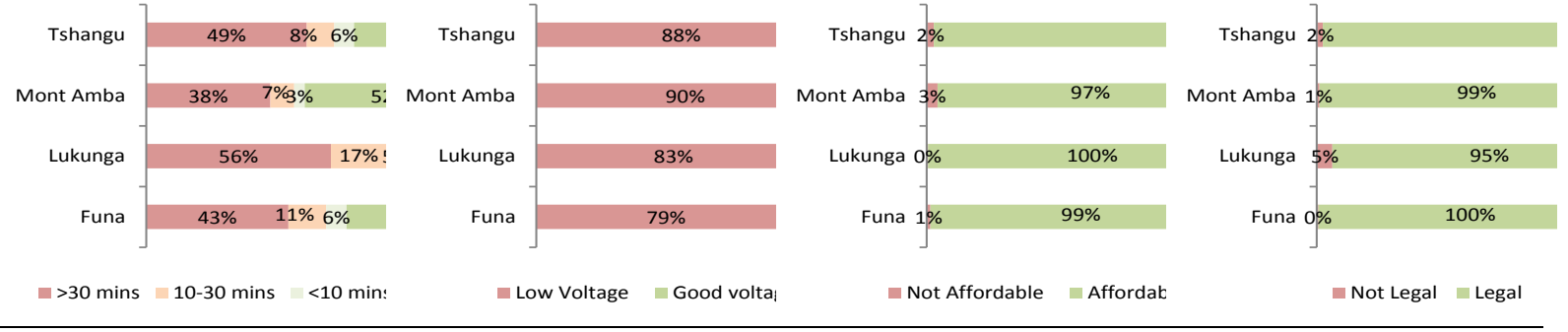
SUSTAINABLE ENERGY FOR ALL

Access to Household Electricity: Attributes Summary Sheet by District

Electricity Source	Capacity	Duration	Duration
Source	Wattage	Out of 24 Hours	Evening Supply



Reliability	Quality	Affordability	Legality
Duration of Interruptions (mins)	Low Voltage Problems	Cost of 30 kWh < 5% of Monthly Income	Based on Bill Payment



Problem of lack of grid-connectivity is most acute in Tshangu district where almost 17% of the households do not have a grid-connection, compared to about 7% in the other districts.

Problem in duration of supply is also acute in Tshangu where 70% of households have less than 8 hours of supply per day. In general Tshangu and Mont Amba districts receive less supply during the day as also in the evening compared to Lukunga and Funa districts.

Problem of reliability is most acute in Mont Amba district, even though other districts also do not fare well.

Problem of poor voltage is equally intense in all districts and affects the regular use of appliances.

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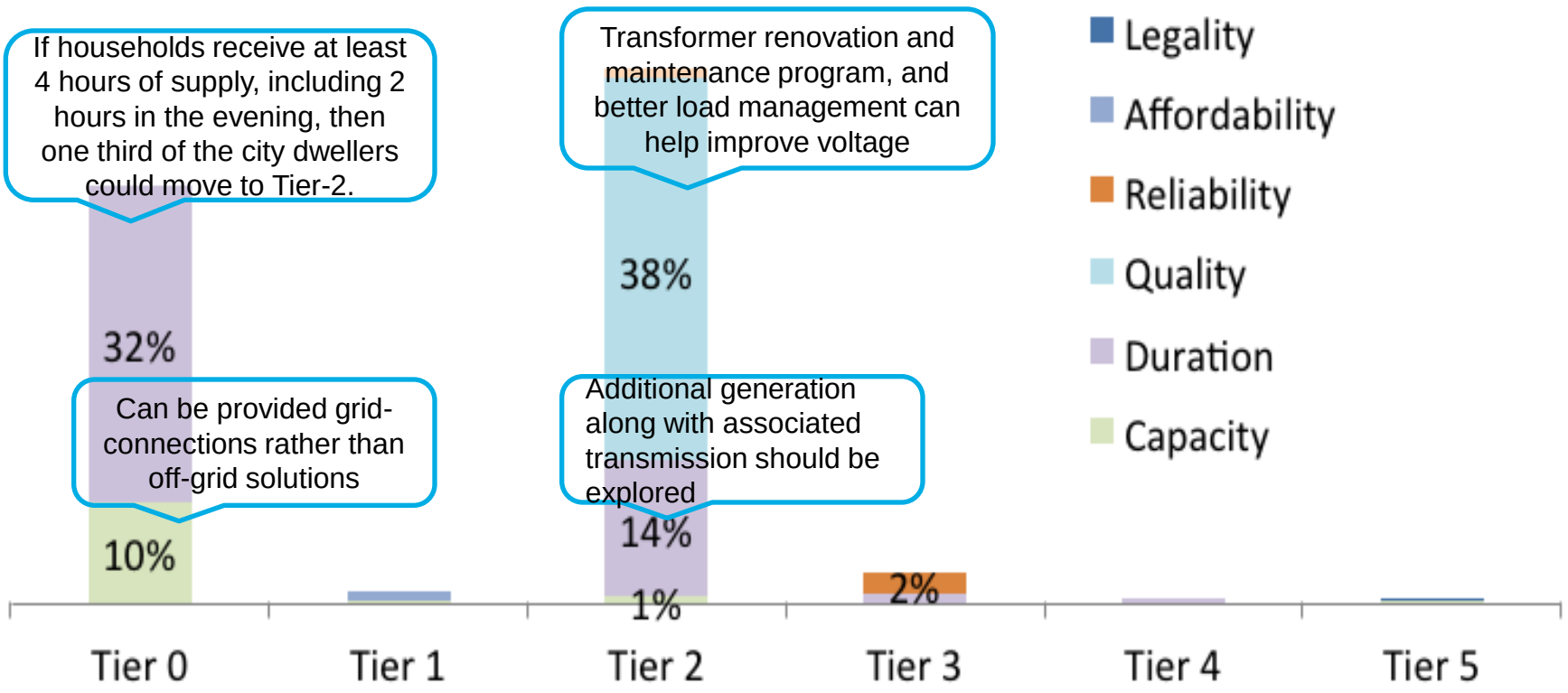
Electricity – Gap Analysis and Interventions



Gap analysis at Glance:

32% of people in tier 0 had less than 4 hours during the day or less than one hour in the evening) and 10% of them do not have electricity

Tier 1 represents people with some affordability problems

In tier 2 most of the people (38%) experienced low voltage problems in the last year and 14% of them have less than 8 hours of supply during the day or less than 4 in the evening.

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Technical Assistance Package

As part of this effort, ESMAP will provide support for:

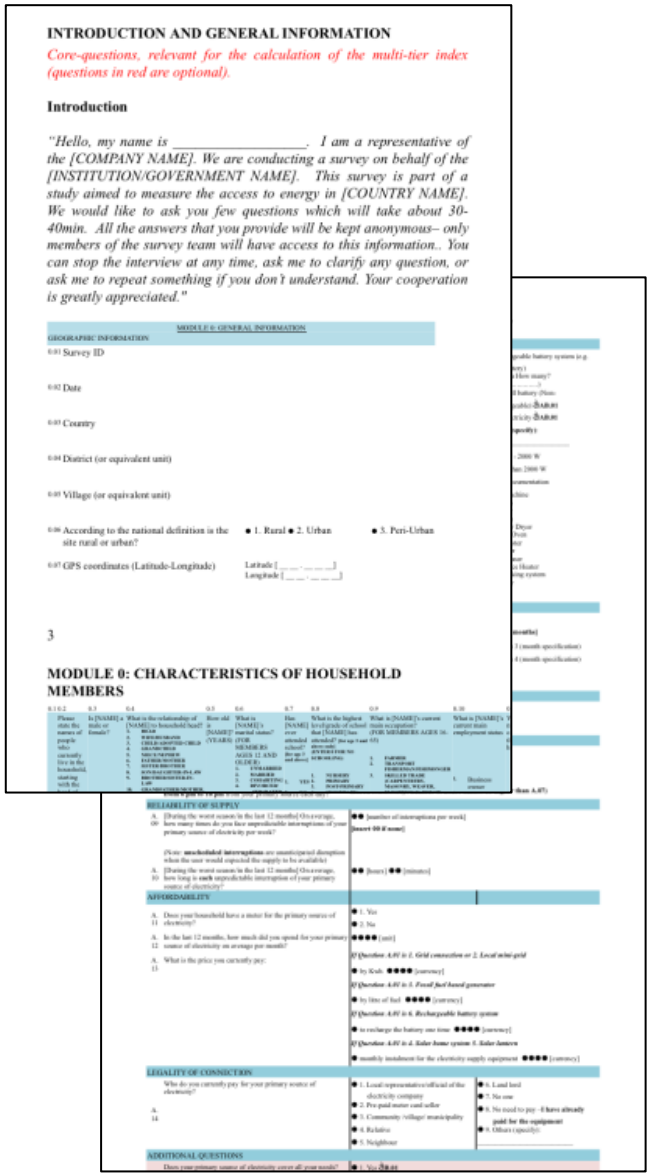
1. **Theoretical framework:** providing concept frameworks, multi-tier definition and measurement methodology
2. **Implementation of household energy surveys:** providing a standardized household energy questionnaires, and assistance with survey administration and data cleaning.
3. **Energy access diagnostic assessment:** by applying the multi-tier measurement of energy access to household, productive, and community uses of energy. The diagnostic report will include gap analysis, highlighting deficiencies in energy supply performance and possible interventions.

Questionnaire:

Contains core questions for the tier calculation related to:

1. **Electricity: => capacity, quality, duration, reliability, affordability, legality**
2. **Electricity services => usage of electricity appliances**
3. **Lighting => no electricity sources and details on solar applications (SHS, Solar lantern…)**
4. **Cooking solutions => room ventilation, primary stove and fuel, secondary stove an fuel, convenience, capacity, affordability, availability**
5. **Productive use of energy=> capacity, quality, duration, reliability, affordability, legality**
6. **Community use of energy=> capacity, quality, duration, reliability, affordability, legality**

Time: around 45-60 minutes



INTRODUCTION AND GENERAL INFORMATION

Core-questions, relevant for the calculation of the multi-tier index (questions in red are optional).

Introduction

"Hello, my name is _____. I am a representative of the [COMPANY NAME]. We are conducting a survey on behalf of the [INSTITUTION/GOVERNMENT NAME]. This survey is part of a study aimed to measure the access to energy in [COUNTRY NAME]. We would like to ask you few questions which will take about 30-40min. All the answers that you provide will be kept anonymous– only members of the survey team will have access to this information.. You can stop the interview at any time, ask me to clarify any question, or ask me to repeat something if you don't understand. Your cooperation is greatly appreciated."

MODULE 0: GENERAL INFORMATION

GEOGRAPHIC INFORMATION

0.01 Survey ID

0.02 Date

0.03 Country

0.04 District (or equivalent unit)

0.05 Village (or equivalent unit)

0.06 According to the national definition is the site rural or urban? ● 1. Rural ● 2. Urban ● 3. Peri-Urban

0.07 GPS coordinates (Latitude-Longitude) Latitude [ ] Longitude [ ]

3

MODULE 0: CHARACTERISTICS OF HOUSEHOLD MEMBERS

RELIABILITY OF SUPPLY

AFFORDABILITY

LEGALITY OF CONNECTION

ADDITIONAL QUESTIONS

Additional Information

MEASURING ENERGY ACCESS

ESMAP

A New Approach

Universal access to modern energy services by 2030 is one of the primary goals of the Sustainable Energy for All (SE4ALL) initiative, and essential for ending poverty and boosting shared prosperity. Achieving this goal, however, will require a concerted international effort, substantial new investment, the deployment of new technologies, and a wide range of interventions targeted to the needs and potential of the countries in question.

The success of such interventions depends, to a great extent, on the ability to assess the level of energy access in a selected area—both at the initial stage of investment planning, and later, for monitoring and evaluation purposes. Detailed baseline data can help facilitate policy formulation, investment strategies, and project design. Similarly, data can be used to evaluate the impact of projects, and assess the linkages between energy access, poverty, and other factors such as gender equality.

EFFECTIVE MEASUREMENT OF ENERGY ACCESS

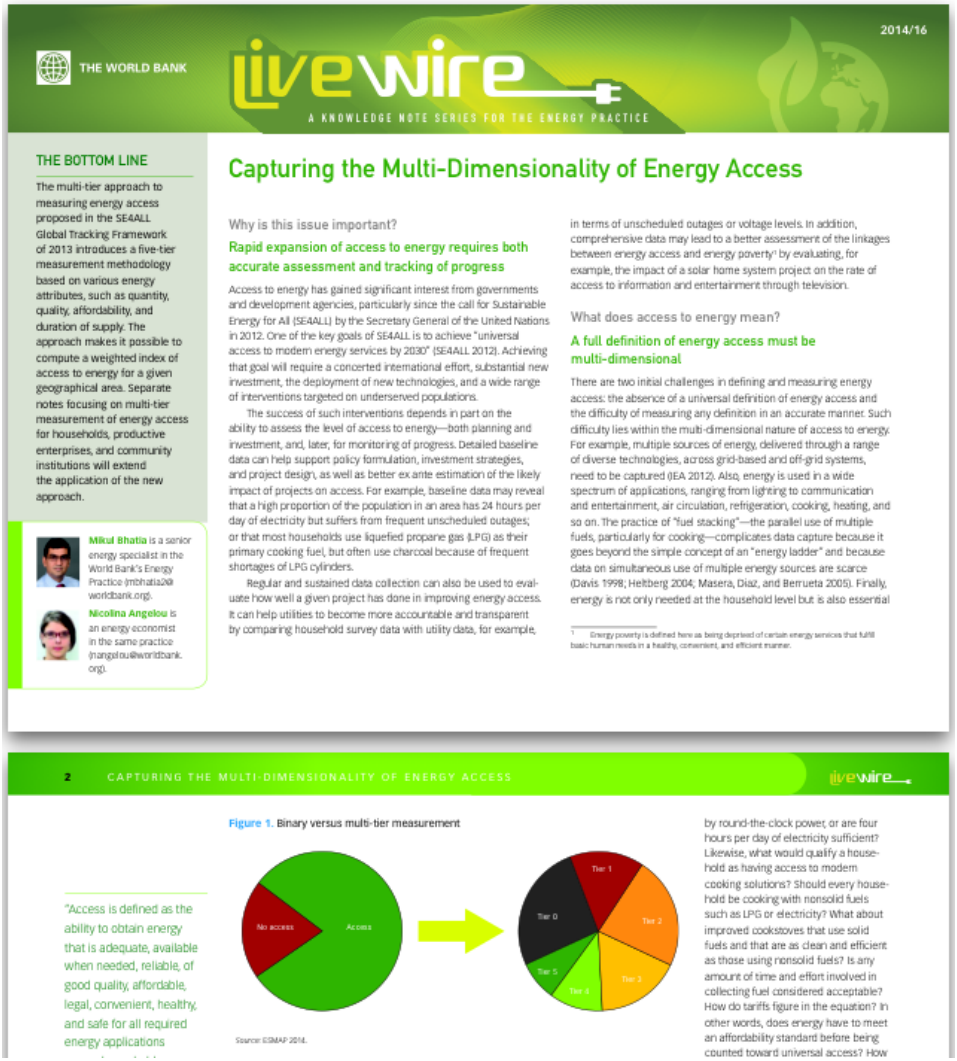
But what does 'access to modern energy services' mean?

Will the goal be achieved if every household had electric lighting? Are four hours per day of electricity supply sufficient or is access defined by round-the-clock power? Likewise, what would qualify a household as having access to modern cooking solutions? Should every household cook with liquefied petroleum gas (LPG) or electricity? What about improved cookstoves using solid fuels (such as charcoal or wood)?

Up until now, access to electricity has been measured as having a connection or by use of electric lighting, while access to modern cooking solutions has been measured based on the use of non-solid fuels. However, these binary metrics fail to capture the multifaceted nature of energy access, and may not reflect the impact that many interventions have on improving access.

To help address these shortcomings, ESMAP is developing a new approach to measuring energy access, using a multi-tier framework. This method was first proposed in the Global Tracking Framework report, the baseline report for the SE4ALL goals, released in May 2013. Under this approach, energy access is assessed through a combination of quantity of energy, as well as quality, duration, reliability, legality, affordability, convenience, and health and safety.

The objective of the new approach is to reflect all aspects of energy supply in the measurement of access. All common types



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A KNOWLEDGE NOTE SERIES FOR THE ENERGY PRACTICE

2014/16

THE BOTTOM LINE

The multi-tier approach to measuring energy access proposed in the SE4ALL Global Tracking Framework of 2013 introduces a five-tier measurement methodology based on various energy attributes, such as quantity, quality, affordability, and duration of supply. The approach makes it possible to compute a weighted index of access to energy for a given geographical area. Separate notes focusing on multi-tier measurement of energy access for households, productive enterprises, and community institutions will extend the application of the new approach.

Capturing the Multi-Dimensionality of Energy Access

Why is this issue important?

Rapid expansion of access to energy requires both accurate assessment and tracking of progress

Access to energy has gained significant interest from governments and development agencies, particularly since the call for Sustainable Energy for All (SE4ALL) by the Secretary General of the United Nations in 2012. One of the key goals of SE4ALL is to achieve "universal access to modern energy services by 2030" (SE4ALL 2012). Achieving that goal will require a concerted international effort, substantial new investment, the deployment of new technologies, and a wide range of interventions targeted on underserved populations.

The success of such interventions depends in part on the ability to assess the level of access to energy—both planning and investment, and, later, for monitoring of progress. Detailed baseline data can help support policy formulation, investment strategies, and project design, as well as better ex ante estimation of the likely impact of projects on access. For example, baseline data may reveal that a high proportion of the population in an area has 24 hours per day of electricity but suffers from frequent unscheduled outages; or that most households use liquefied propane gas (LPG) as their primary cooking fuel, but often use charcoal because of frequent shortages of LPG cylinders.

Regular and sustained data collection can also be used to evaluate how well a given project has done in improving energy access. It can help utilities to become more accountable and transparent by comparing household survey data with utility data, for example, in terms of unscheduled outages or voltage levels. In addition, comprehensive data may lead to a better assessment of the linkages between energy access and energy poverty[1] by evaluating, for example, the impact of a solar home system project on the rate of access to information and entertainment through television.

What does access to energy mean?

A full definition of energy access must be multi-dimensional

There are two initial challenges in defining and measuring energy access: the absence of a universal definition of energy access and the difficulty of measuring any definition in an accurate manner. Such difficulty lies within the multi-dimensional nature of access to energy. For example, multiple sources of energy, delivered through a range of diverse technologies, across grid-based and off-grid systems, need to be captured (IEA 2012). Also, energy is used in a wide spectrum of applications, ranging from lighting to communication and entertainment, air circulation, refrigeration, cooking, heating, and so on. The practice of "fuel stacking"—the parallel use of multiple fuels, particularly for cooking—complicates data capture because it goes beyond the simple concept of an "energy ladder" and because data on simultaneous use of multiple energy sources are scarce (Davis 1998; Heltberg 2004; Masera, Diaz, and Berrueta 2005). Finally, energy is not only needed at the household level but is also essential

1 Energy poverty is defined here as being deprived of certain energy services that fulfill basic human needs in a healthy, convenient, and efficient manner.

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2 CAPTURING THE MULTI-DIMENSIONALITY OF ENERGY ACCESS

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Figure 1. Binary versus multi-tier measurement

"Access is defined as the ability to obtain energy that is adequate, available when needed, reliable, of good quality, affordable, legal, convenient, healthy, and safe for all required energy applications

No access

Access

Tier 1

Tier 2

Tier 3

Tier 4

Tier 5

Tier 0

Source: ESMAP 2014.

by round-the-clock power, or are four hours per day of electricity sufficient? Likewise, what would qualify a household as having access to modern cooking solutions? Should every household be cooking with nonsolid fuels such as LPG or electricity? What about improved cookstoves that use solid fuels and that are as clean and efficient as those using nonsolid fuels? Is any amount of time and effort involved in collecting fuel considered acceptable? How do tariffs figure in the equation? In other words, does energy have to meet an affordability standard before being counted toward universal access? How

Thank you

For any further questions, please contact:

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Annexes

Multi-tier Framework –
Access To Household Cooking Solutions

			Level-0	Level-1	Level-2	Level-3	Level-4	Level-5
Attributes	1. Health (Indoor Air Quality)	PM2.5 (µg/m3)		<350	<250	<100	<35	<10
		CO (mg/m3)		<70	<50	<20	<7	<7
	2. Convenience • Fuel Collection Time (Hrs / week) • Stove Prepn Time (Min/meal) • Ease of Cooking				< 7 < 15	< 3 < 15 √		< 1 < 5 √
	3. Safety of Primary	IWA Safety Tiers			Tier-1	Tier-2	Tier-3	Tier-4
		OR, Past Accidents & Perceived Future Risk				None Yes		None None
	4. Affordability				<10% of HH Income		<5% of HH Income	
	5. Quality of Primary Variations in heat rate due to fuel quality that affects cooking						No Major Affect	No Affect
	6. Capacity of Primary Use of secondary due to number of burners or flame Size of primary						Minor	None
	7. Availability of Primary Use of secondary due to non-availability of primary						Minor	None

Tier-rating for the household is calculated by applying the lowest of the tier-ratings across all attributes.

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Multi-tier Framework –
Access To Energy For Productive Uses

			Tier-0	Tier-1	Tier-2	Tier-3	Tier-4	Tier-5
Attributes	1. Capacity	Electricity (Watts) (Wh)	<1W <2Wh	1-50W 2-200Wh	50-200W 200-1.2kWh	200W-2kW >1.2kWh	2-10kW -	>10kW -
		RM&T (% of needs)	<25%	25%-75%		75%-100%		100%
	2. Duration (% of needs)		<25%	25%-50%	50%-75%	75%-100%		100%+
	3. Reliability		Reliability issues with severe impact			Reliability issues with moderate impact		No issue or no impact
	4. Quality		Quality issues with severe impact			Quality issues with moderate impact		No issue or no impact
	5. Affordability		> 2 times grid tariff			≤ 2 times grid tariff		≤ grid tariff
	6. Legality /Formality		No			Yes		
	7. Convenience		No				Yes	
	8. Health & Safety		Non-BLEN without smoke extraction Likely to cause severe health damage/injury		Non-BLEN with smoke extraction or outside use Likely to cause moderate damage/injury		BLEN solutions Not likely to cause significant damage/injury	

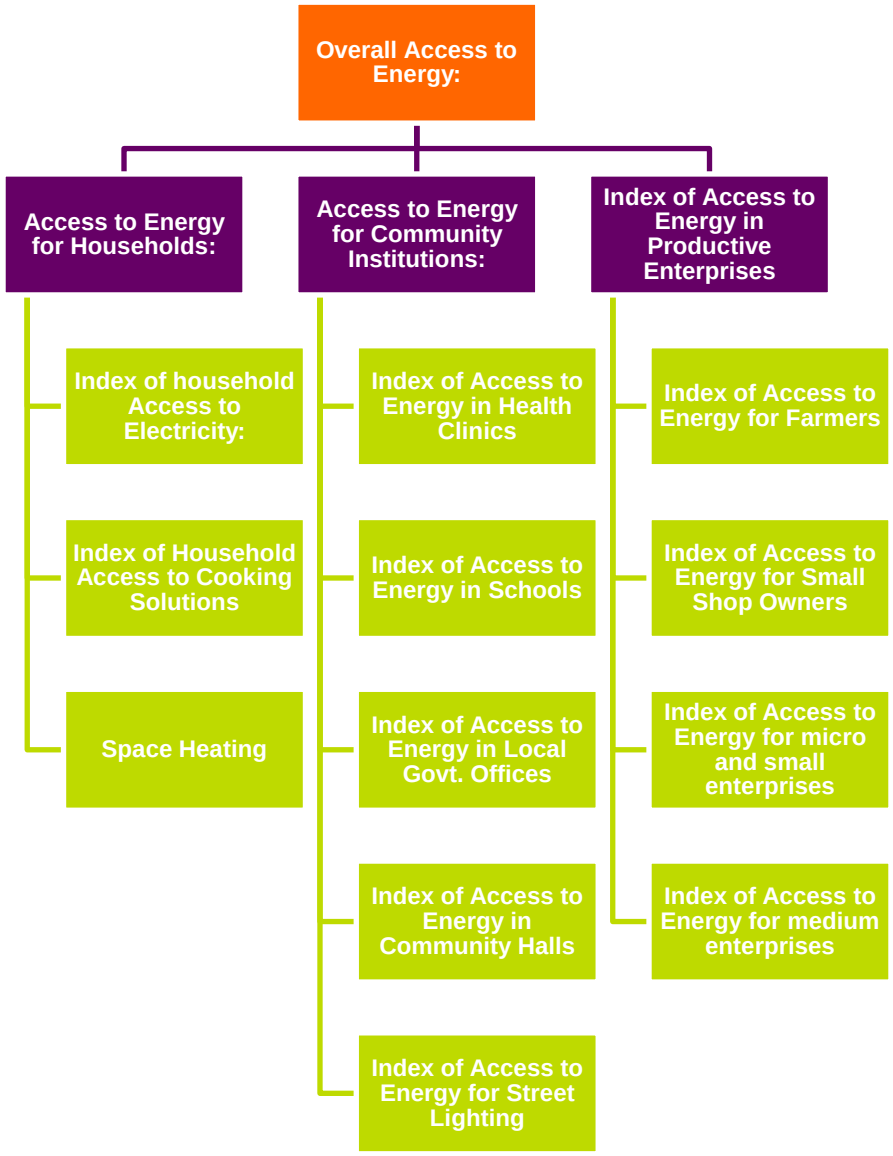
Tier-rating for the productive use is calculated by calculating Tier-ratings for all relevant applications and applying the lowest.

Multi-tier Framework - Access To Energy For Community Uses: Health Facilities; Education Facilities; Public & Community Buildings

			Tier-0	Tier-1	Tier-2	Tier-3	Tier-4	Tier-5
Attributes	1. Capacity	Electricity	No Electricity	Very Low Power	Low Power	Medium Power	High Power	
		Heating (if needed)	No heating (0%)	Capacity partially covers needs (1%-49%)		Capacity largely covers needs (50%-99%)		Capacity totally covers needs
	2. Duration	Electricity	No electricity/ heating (0%)	Less than ¼ of the time (1-24%)	Less than ½ of the time (25%-49%)	More than ½ of the time (50%-74%)	More than ¾ of the time (75%-99%)	All the time (100%)
		Heating (if needed)						
	3. Reliability	Electricity	Significant unscheduled interruptions				No significant unscheduled interruptions	
		Heating (if needed)						
	4. Quality	Electricity	Quality is not satisfactory			Quality is satisfactory		
		Heating (if needed)						
	5. Health & Safety	Electricity	Health & Safety is not satisfactory				Health & Safety is satisfactory	
		Heating (if needed)						

Tier-rating for the household's access to energy at each community institution is calculated by applying the lowest of the tier-ratings across all attributes.

How Is Energy Access Measured – Indices By Dimensions Of Energy Use



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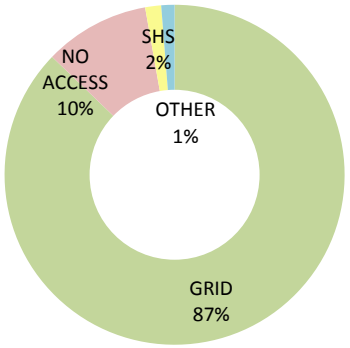
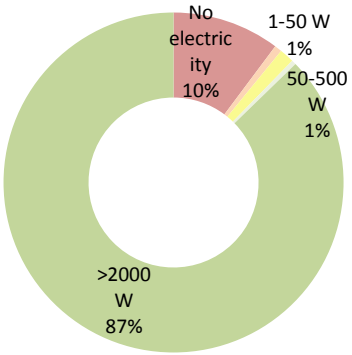
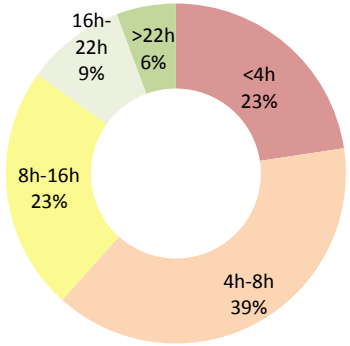
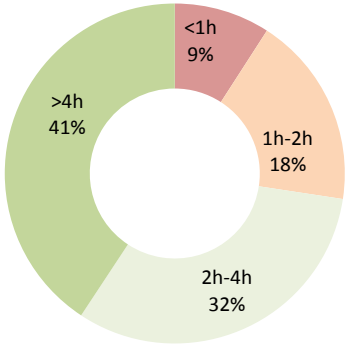
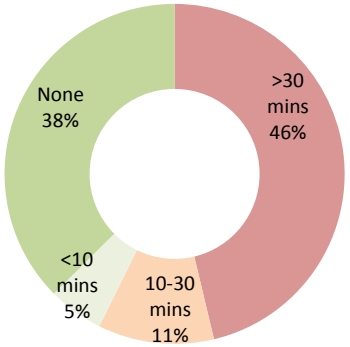
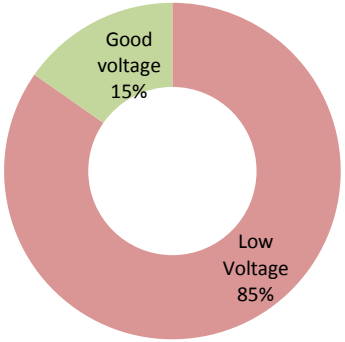
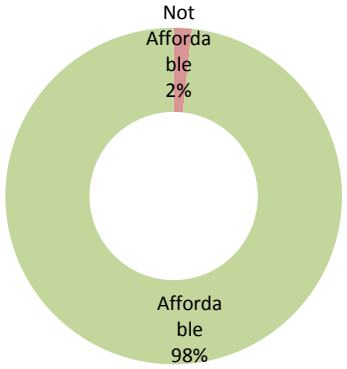
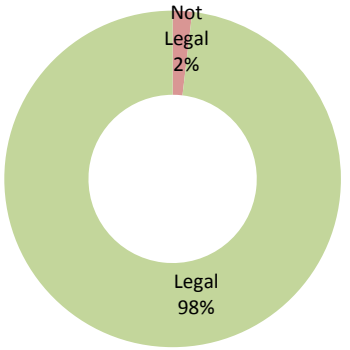
Piloting Of Multi-tier Framework – Status & Strategy

Survey Status	Country	Area	Dimensions
Completed	DRC	Kinshasa area	Household cooking, Household electricity
Completed	Uganda	National	Household Cooking
Completed	Ethiopia	Amhara Region	Household cooking, Household electricity
Completed	India	Bihar – 6 districts	Household cooking, Household electricity
Ongoing	Guinea	National	Household cooking, Household electricity, Productive uses, Community uses
Pipeline	Mali	National	Household cooking, Household electricity, Productive uses, Community uses
Pipeline candidate	Burundi		
Pipeline candidate	Liberia		
Pipeline candidate	Mozambique		
Pipeline candidate	Senegal		

Electricity - Attributes Summary Sheet

Electricity Source	Capacity	Duration	Duration
Source	**Wattage**	**Out of 24 Hours**	**Evening Supply**
			

Reliability	Quality	Affordability	Legality
Duration of Interruptions (mins)	**Low Voltage Problems**	**Cost of 30 kWh < 5% of Monthly Income**	**Based on Bill Payment**
			

Less than 8 hours per day for 62% of the household

Unscheduled interruptions are longer than 30 minutes for more than 57% of the household

Almost 85% of the household experienced low voltage

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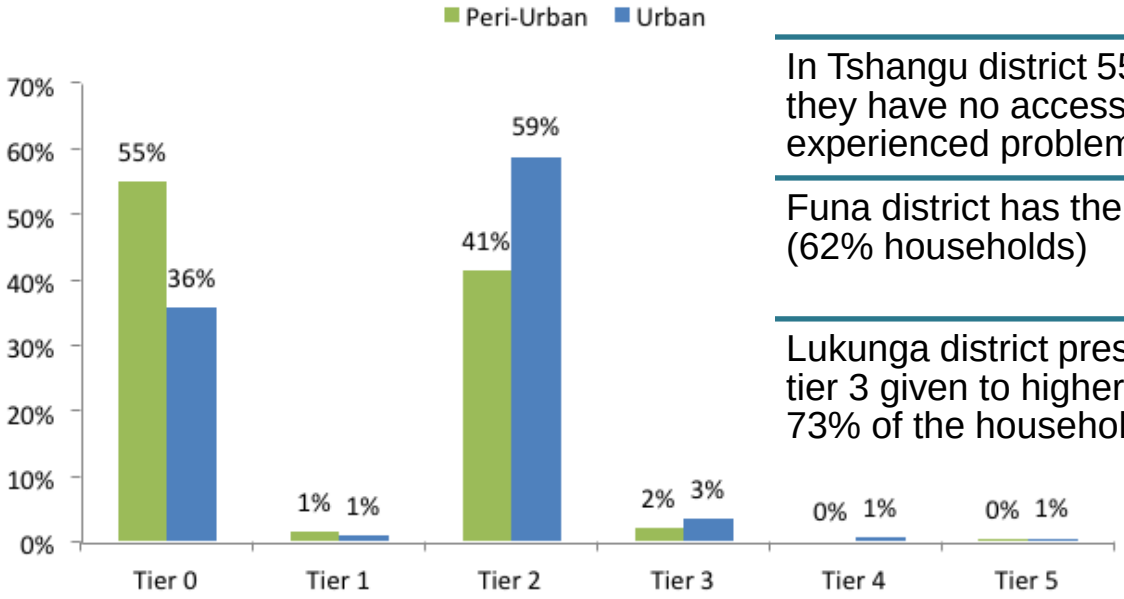
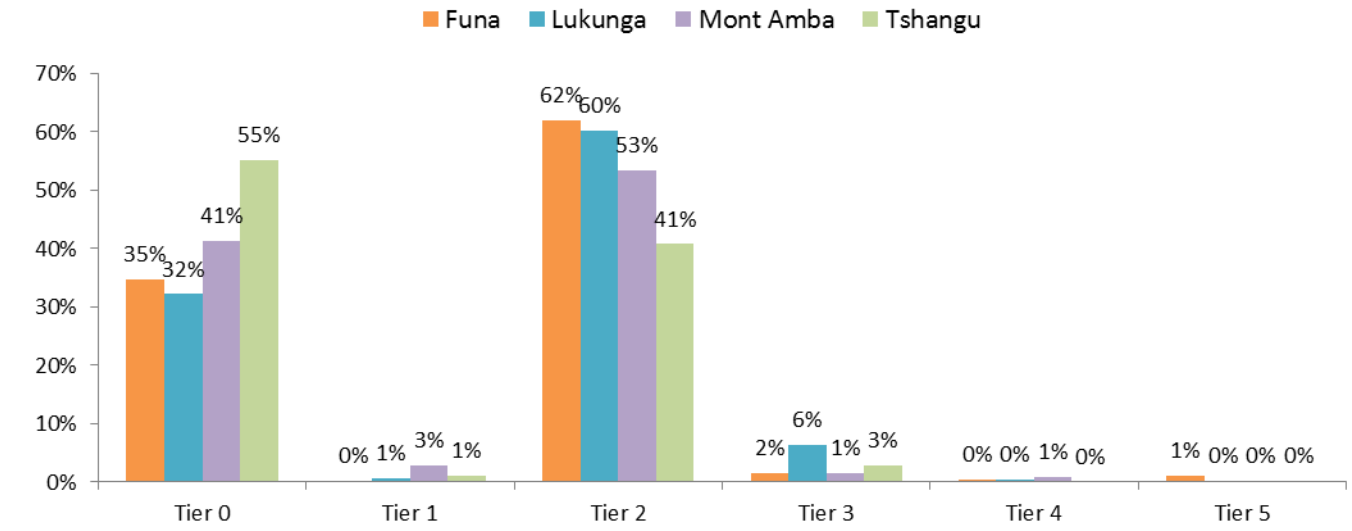
Electricity - Tiers Summary Sheet



In Tshangu district 55% of the households are in tier 0: they have no access to any form of electricity or experienced problems in duration of supply

Funa district has the higher rate of household in tier 2 (62% households)

Lukunga district presents the highest number of people in tier 3 given to higher rate of duration of interruption for 73% of the households



Area	Index
Urban	1.3
Peri-Urban	0.9
Funa	1.4
Lukunga	1.4
Mont Amba	1.2
Tshangu	0.9
Total	1.2

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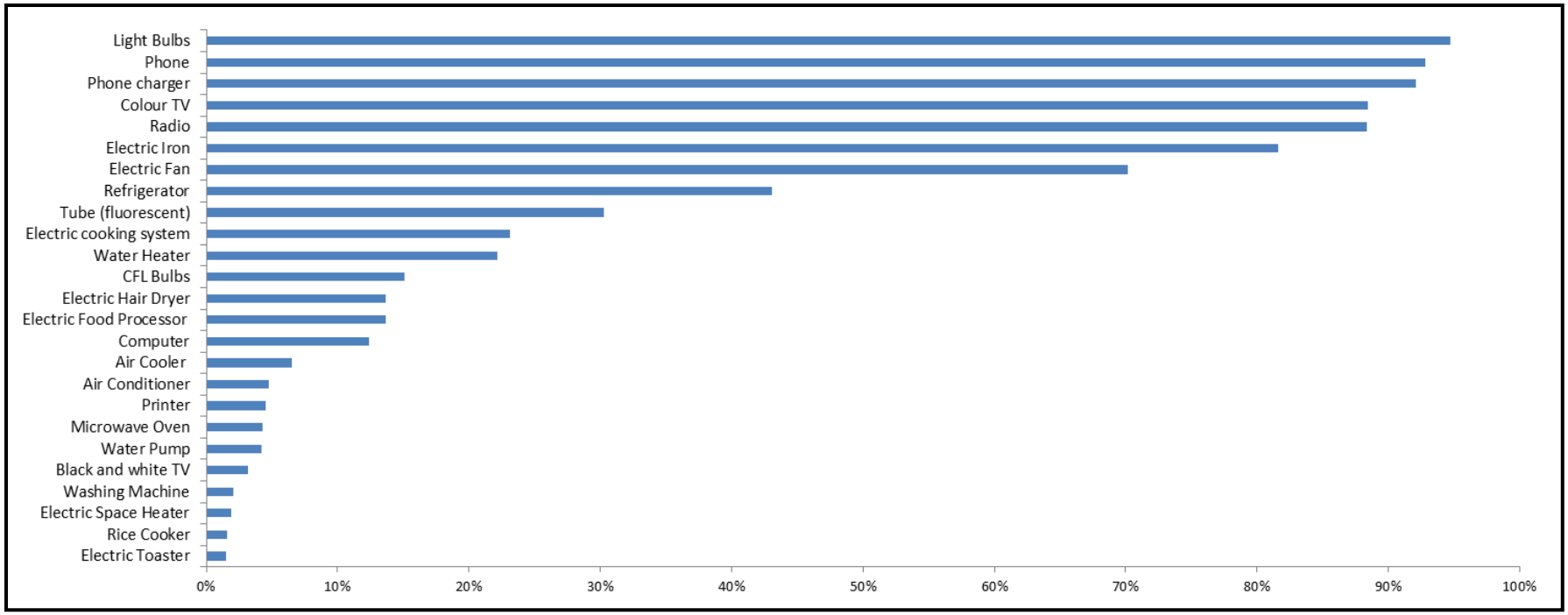
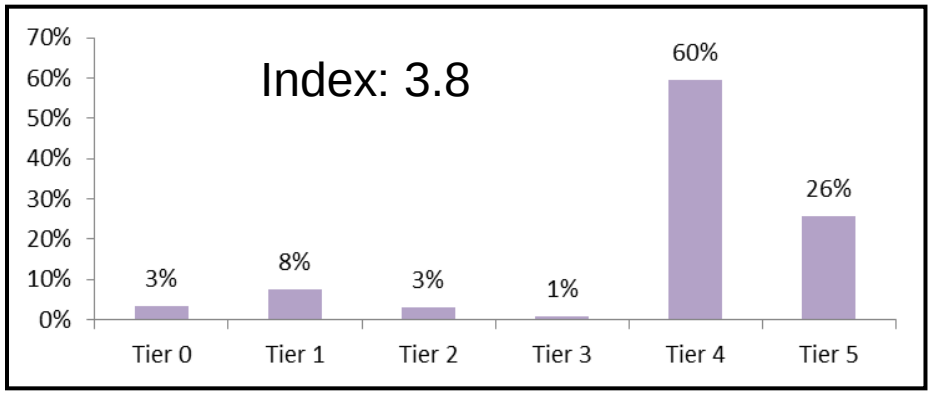
Electricity Services – Summary sheet





Observations:

Most household can afford to own energy appliances but they cannot use them properly due to poor electricity supply

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