

**ANALYSIS OF ENERGY CONSUMPTION AND ENERGY EFFICIENCY
IN INFORMAL SETTLEMENTS OF DEVELOPING COUNTRIES**

THE CHALLENGE OF ENERGY IN INFORMAL SETTLEMENTS. A REVIEW OF THE LITERATURE FOR LATIN AMERICA AND AFRICA

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EXECUTIVE SUMMARY

Current literature on energy access and efficient use in informal settlements of developing countries highlights that there are settlements in which the technical access (electric grid, LPG distribution system, gas network) is available, but the final potential users cannot afford it and/or the service is unreliable (frequent outages and low voltage for electricity; uncertain availability of gas bottles). In these cases the final user tends to make use of illegal connections - for electricity - and to use the energy sources being at lower steps of the energy ladder (such as kerosene, charcoal, wood and other biomass residues) for cooking.

More rare, and limited to a small percentage of dwellers, is the lack of technical access in big cities, while in small towns the situation is different because of the scarce availability of both electricity and LPG bottles.

Considering this scenario, limited access to modern energy services is a multi-faceted phenomenon that involves utilities, dwellers, and institutions/policy makers, and in this working paper we describe the mechanisms that trigger a sort of “vicious circle” that in many cases frustrates an harmonious cooperation among the above mentioned players. As highlighted by the literature, the main results of the vicious circle is that the inefficient use of energy leads to the paradox that low-income population pays essential energy services more than high income people.

Despite the factors influencing the vicious circle are found in different geographical and cultural contexts, here we report that energy access and energy use patterns show a different characterization in South America and Sub Saharan Africa (the two areas here examined). In fact, in Latin American big cities the technical access to modern energy sources and vectors is widely provided and the main problems regard the affordability and the reliability of the service. The picture is different in Sub Saharan Africa, where not only the technical access is provided to a lower share of the slum’s population, but the response to the lack of affordability and reliability of the energy services is strongly oriented towards illegal connections for electricity and towards the use – for cooking - of fuels located in the lower part of the energy ladder.

From the point of view of the utilities and policy makers, we show that the different characterisation is also related to a different political approach to these issues, and to a different level of social responsibility of the energy companies. By example, in Latin America strong energy access policies and best practices have been implemented by some energy companies that are actively innovating the relationships with dwellers and are working overcoming the main obstacles.

Finally, our literature survey confirms that few and out-dated information and data on energy use in informal settlements are currently available, suggesting the development of further activities and new surveys in order to fill the information gap..

CHAPTER 1 – GENERAL OUTLOOK

1.1 BACKGROUND

According to UN-Habitat¹, the term ‘slum’ describes a wide range of low-income settlements characterized by poor human living conditions. ‘Slum’, at its simplest, is ‘a heavily populated urban area characterized by substandard housing and squalor’. This definition encapsulates the essential characteristics of slums: high densities, low standards of housing (structure and services), and ‘squalor’.

Dwellings in such settlements vary from simple shacks to more permanent structures, and access to basic services and infrastructure tends to be limited or badly deteriorated.

Low income people are trapped in an informal and ‘illegal’ world, where waste is not collected, taxes are not paid and public services are scarcely or definitely not provided. Although slum dwellers may reside within the administrative boundary of a town or city, or even side-by-side to a high-income neighborhood, as shown in Figure 1, they formally do not exist and, commonly, local authorities such as city council are not present in the area, leaving room to “slumlord” or “mafia leaders”. Furthermore, as illegal or unrecognized residents, many slum dwellers have no property rights, nor security of tenure, and as consequence of their informality, they make whatever arrangements they can in an informal, unregulated and, in some respects, expensive parallel market.



Figure 1 – Two worlds facing

Low income dwellers are not able to access most of the formal institutions of society, and lacking a legal address, they are often unable to access social services and modern energy services, defined by the IEA² as “reliable and affordable access to clean cooking facilities, a first connection to electricity and then an increasing level of electricity consumption over time to reach the regional average”. Even when modern energy services - such as electricity and clean and safe cooking systems - are available, they cannot afford their use.

Today more than one billion people live in slums. This number, at the end of last decade, was growing by 500,000 a week³.

¹ UN-Habitat - The Challenge of Slums - Global report on human settlements 2003, Earthscan, 2003

² IEA, Energy for all – Financing access for the poor, 2011;

www.iea.org/publications/worldenergyoutlook/resources/energydevelopment/energyforallfinancingaccessforthepoor/

³ J. Aron, O. Kaiser, L. Liataud, A. Nowlan, Access to Energy for the Base of the Pyramid, Hystra/Ashoka, 2009 - https://www.ashoka.org/sites/ashoka/files/Ashoka-HYSTRA_Access_to_%20Energy_for_the_BOP.pdf

As the population moves from rural communities to increasingly crowded urban cities, their energy use patterns progressively change. Charcoal, kerosene and LPG replace wood and other lower quality biomass as the primary cooking fuels. The three stone fire is abandoned and charcoal braziers, kerosene stoves and LPG cookstoves become the main cooking devices. New energy devices are acquired. Examples include electric lights, refrigerators and televisions. The demographic shift to urban areas do not only triggers changes in the type and form of energy used but also implies a significantly higher demand for energy.

For slums' dwellers, access to modern, clean, and safe energy means working and studying after the sunset, improving indoor health and safety⁴, and the possibility to direct their scarce funds to more productive uses. It also allows keeping a shop open at night, or a child safely studying without candles..

Low income people suffer the economic consequences of insufficient power for productive income-generating activities⁵ and for other basic services such as health and education. It is straightforward noticing that economic growth goes hand in hand with increased access to modern energy services, especially in low and middle-income countries (see BOX 1- Impact of modern energy services access).

BOX 1 - Impact of modern energy services access on slum's dwellers⁶

Direct effects on well-being

- Improved access to lighting, heat, and refrigeration
- Savings in time and effort (due to reduced need to gather biomass and other fuels)
- Improved access to information (through radio, television and telecommunications)

Direct effects on health

- Improved indoor air quality through cleaner fuel
- Reduced fire hazard
- Improved quality of health services (through better lighting, equipment and refrigeration)
- Easier establishment of health centres
- Better Education

Direct effects on education

- Improved access to lighting, allowing more time to study
- Savings in time and effort, releasing time and energy to channel to education

Direct effects on economic opportunities for the poor

- Easier establishment and greater productivity of businesses that employ the poor
- Creation of employment in infrastructure service delivery
- Improved health and education and savings in time and effort, increasing individual productivity

Trickle Down effect of increased productivity

- Easier establishment and greater productivity of businesses in general (including through positive impact on the environment)

The global energy system – supply, transformation, delivery, and use – is one of the dominant contributors to climate change, representing around 60% of total greenhouse gas (GHG) emissions. Current patterns of energy production and consumption are widely considered by the scientific community as unsustainable, and are threatening the environment on both local and global scales.

Reducing the carbon intensity of energy – i.e., the amount of carbon emitted per unit of energy consumed – is a key objective in reaching long-term climate goals.

⁴ According to World Health Organization (WHO), indoor air pollution associated with biomass use is directly responsible for more deaths than malaria, almost as many as tuberculosis and almost half as many as HIV/AIDS. Only malnutrition, unprotected sex, and lack of clean water and sanitation are greater health threats

⁵ In slums many economic activities take place. There are enterprises that range from household-based enterprises to fully-fledged and operational workshops, and food-vending enterprises. They can be classified into two distinct categories: (1) service-based enterprises which include shop keeping (both wholesale and retail), vegetable and fish selling, tailoring shops, garages, electronic repair shops; and (2) production-based enterprises which include carpentry, welding workshops and metal smelting workshops. Energy needs and use in these enterprises is very different than in households, as it can be expected.

⁶ N. Scott, P. Dunn, S. Sugden, Barriers to Access to Modern Energy in Slums, Gamos Ltd, 2003 - <http://r4d.dfid.gov.uk/pdf/outputs/R8146.pdf>

Given that the world economy is expected to double in size over the next twenty years, mainly because of the economic growth of developing countries, the world's consumption of energy will also increase significantly if energy supply, conversion and use continue to be inefficient.

For their expansion, and in order to meet the needs of their inhabitants, cities in developing countries will require access to modern energy services in a way that is economically viable, sustainable, affordable and efficient, with a low impact on GHGs emissions⁷.

Summarizing, access to modern energy⁸ services is a critical issue, as they are more efficient than biomass. It has been estimated⁹ that the basic modern energy needs can be satisfied with 50-100 kWh per person per year of electricity for lighting, health, education, communication and community services and with 50-100 koe¹⁰ of modern fuel (or traditional fuel used in improved cook stoves) for cooking and heating water. This is the lowest possible threshold with very efficient appliances.

From the environmental point of view, 100 kWh per person per year of electricity, even if delivered through the current fossil fuel-dominated mix of generation technologies, would increase GHG emissions by only around 1.3 per cent above current levels⁹. The impact of this increased energy consumption can be reduced by means of energy efficiency and a transition to a stronger reliance on cleaner energy sources, including renewable energy sources and low-GHG emitting fossil fuel technologies.

This fact under-scores the importance of driving down costs of low-emissions technologies to enable accelerated deployment both on the supply side (including lower-emissions fossil fuel- based technologies) and the demand side, where energy-efficient end-use devices reduce the amount of energy consumed. Ensuring access to these technologies and developing new products and services geared to the needs of low-income communities is therefore critical.

1.2 ENERGY POVERTY AND “ENERGY LADDER”

According to UNDP¹¹ energy poverty is defined as the “*inability to cook with modern cooking fuels and the lack of a bare minimum of electric lighting to read or for other household and productive activities at sunset*”.

The most common concept illustrating energy poverty involves “energy ladders” for household services¹². The idea implies that the primary types of energy used by the poorest fraction of population in developing countries can be arranged on a “ladder” with the “simplest” or most “traditional” fuels and sources, such as animal power, candles, and wood, at the bottom and with the more “advanced” or “modern” fuels such as electricity LPG at the top (Figure 2). In fact, as families gain socio-economic status, in a first phase they abandon inefficient, polluting, and less costly technologies and move to transition fuels such as kerosene, coal, and charcoal in a second phase. Finally, in the third and last phase, households switch to fuels such as LPG and electricity. Higher ranked fuels are usually more efficient and costly, but require less input of labour and produce less pollution per unit of fuel. Furthermore, as reported by van der Kroon et Al., “the energy ladder also assumes that more expensive technologies are locally and internationally perceived to signify higher status. Families desire to move up the energy ladder not just to achieve greater fuel efficiency or less direct pollution exposure, but to demonstrate an increase in socio-economic status”, implying a strong correlation between income and fuel choice¹³. Under the point of view of efficiency, more efficient fuels or sources are placed higher on the ladder. For example, kerosene is 3 to 5 times more efficient than wood for cooking, and liquefied petroleum gas is 5 to 10 times more efficient than crop residues and dung.

⁷ Inefficient and unsustainable cooking practices can have serious implications for the environment, such as land degradation and local and regional air pollution. Charcoal, for example, is usually produced from forest resources. Unsustainable production of charcoal in response to urban demand, particularly in sub-Saharan Africa, places a strain on biomass resources. Charcoal production is often inefficient and can lead to localised deforestation and land degradation around urban centres.

⁸ “Affordable” in this context means that the cost to end users is compatible with their income levels and no higher than the cost of traditional fuels, in other words what they would be able and willing to pay for the increased quality of energy supply.

⁹ AGECC, Energy for a Sustainable Future, United Nations, 2010 -

<http://www.un.org/wcm/webdav/site/climatechange/shared/Documents/AGECC%20summary%20report%5B1%5D.pdf>

¹⁰ kilograms oil equivalent, corresponding to about 600-1200 kWh

¹¹ B. K. Sovacool, The political economy of energy poverty: A review of key challenges, Energy for Sustainable Development, Volume 16, Issue 3, September 2012, Pages 272–282

¹² A. K.N. Reddy and B.S. Reddy, Substitution of energy carriers for cooking in Bangalore, Energy, 19, 561-571, 1994.

¹³ B. van der Kroon, R. Brouwer, P. J.H. Beurkerling, The Energy ladder: theoretical myth or empirica truth? Ren. and Sust. Energy Reviews, 20, 504, 2013

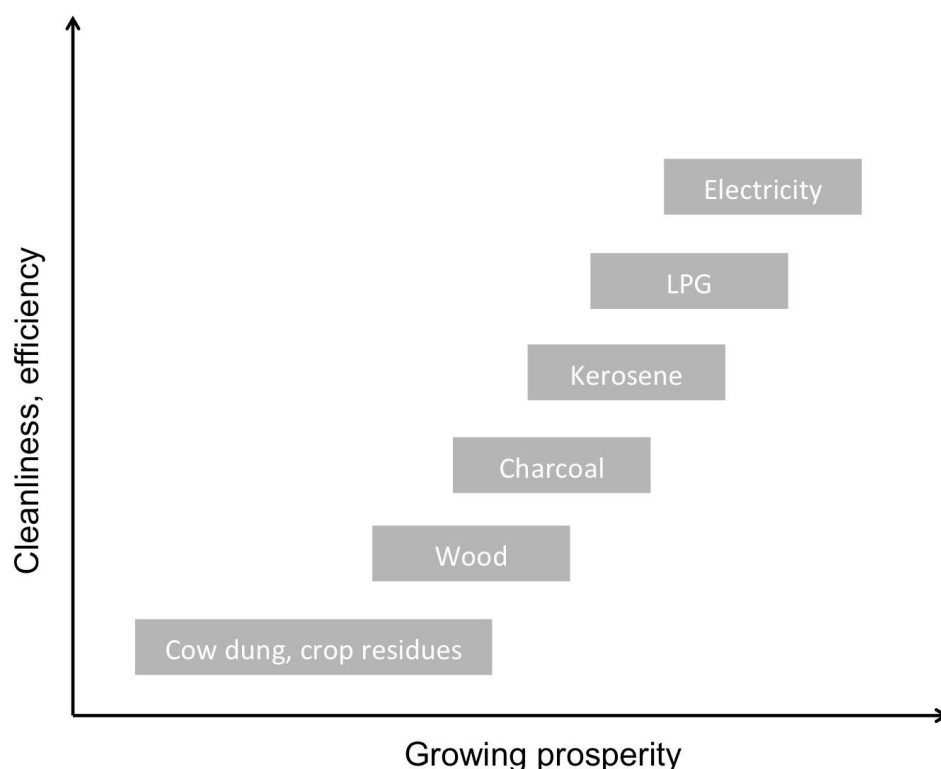


Fig. 2 – Example of energy ladder

For households energy poverty is usually measured by means of the fraction of the total income used for providing energy services (cooking, lighting, etc.); conventionally, energy poverty starts when this fraction is above 10%. In some slums of developing countries cities the fraction is far higher, such as in Nairobi¹⁴, where - on the average - households spend about 26% of their monthly income on energy with a maximum of 34% and a minimum of 15%.

Proportionally, people in the low-income bracket spend a higher fraction of their total income than high income ones (Table 1).

Table 1 – Energy expenditure as % of urban household in selected countries¹⁵

Income level	Energy expenditure as % of urban household income		
	Uganda	Ethiopia	Zimbabwe
Low income	15.00	10.00	7.70
High income	9.50	7.00	4.80

The amount of money spent for energy services generally increases with monthly income; however, the relative amount is highest when considering the lower income group.

Three factors, inter alia, explain why low income people spend more on energy:

1. Use of low-quality fuels that burn less efficiently when used, thus more is required to perform the same task;

¹⁴ UN-Habitat/GENUS, Expert Group Meeting - Promoting Energy Access for the urban poor in Africa: Approaches and Challenges in Slum Electrification, 2009 -

http://www.unhabitat.org/downloads/docs/8292_16690_GENUS%20AFRICA.EGM%20Final%20Report.pdf

¹⁵ S. Karekezi, L. Majoro, Improving modern energy services for Africa's urban poor, Energy Policy, Volume 30, Issues 11–12, September 2002, Pages 1015–1028

2. Fuel purchasing in small quantities at the end of a chain of small distributors resulting in higher retail prices;
3. Energy subsidies are largely captured by high-income groups, for example on electricity.

1.3 ENERGY USE IN SLUMS

Households generally use a combination of energy sources for cooking that can be categorised as:

1. traditional (such as dung, agricultural residues and fuelwood)
2. intermediate (such as charcoal and kerosene)
3. modern (such as LPG or biogas, and electricity).

Electricity is mainly used for lighting and small appliances, and represents a small share of total household consumption in energy terms.

Heavy dependence on biomass is concentrated in, but not confined to, rural areas. Indeed, almost half a billion people in urban areas also rely on these energy sources. Although urbanisation is associated with lower dependence, the use of fuels such as LPG in towns and cities is not always widespread. In sub-Saharan Africa, by example, well over half of all urban households rely on wood, charcoal or wood waste to meet their cooking needs.

As income increases, households do not simply substitute one fuel with another, but add fuels in a process of “fuel stacking”. Modern forms of energy are usually applied sparingly at first and for particular services (such as electricity for radio and television, or LPG for making tea and coffee) rather than completely supplanting an existing form of energy that already supplies a service adequately.

The most energy-consuming activities in the household – namely cooking and heating – are the last to switch. Use of multiple fuels provides a sense of energy security, since a complete dependence on a single fuel or technology makes households vulnerable to price variations and unreliable services. Some reluctance to discontinue cooking with fuelwood may be also due to taste preferences and the familiarity of cooking with traditional methods. By example, in several countries many wealthy households retain a wood stove for baking traditional breads. As incomes increase and fuel options widen, the fuel mix may change, but wood is rarely entirely excluded.

In the poorest households, where access to electricity lacks (either for lack of connection or because not affordable), kerosene is used for lighting; kerosene or charcoal are used for cooking. Reused car batteries are the main source of electricity for TV sets and radios; dry cells are prominently used in electronic gadgets (e.g. radio) and hand held spotlights

Studies^{12,16} carried out in Nairobi’s slums showed that:

- Kerosene for lighting and cooking (90% of households), charcoal for cooking and dry cells were the base energy/fuel type in all households, using a significant proportion of the residents’ monthly income and posing a risk to safety and health that most of the residents are unaware of.
- Fuel substitution is a common wish for all residents, but high costs of connections for electricity and LPG, plus the costs of appliances is a major hindrance to connectivity and accessibility.
- The irregular nature of incomes for a proportion of residents (casuals, unemployed) is a hindrance. Most residents resort to charcoal and kerosene, which can be purchased in smaller quantities in close proximity of the households, and are often available at all times.

In addition, the use of kerosene for lighting and cooking is cause of many accidents, mainly because is a highly flammable liquid and because it is not rare that it is accidentally drunk by children, being usually stored in water bottles.

¹⁶ S. Karekezi, J. Kimani, O. Onguru, Energy access among the urban poor in Kenya, *Energy for Sustainable Development*, Volume 12, Issue 4, December 2008, Pages 38–48

1.4 ACCESS TO ELECTRICITY

With limited budgets for welfare programs and the growing problem of illegal slum inhabitants in urban centres, governments are often not inclined to provide a favourable environment for slum electrification¹⁷. Especially in Africa, governments do not recognize slum neighbourhoods as part of the legal municipality and hence do not provide public service to improve these areas.

Historically, because of the situation that they encounter in the slums, electric utilities have experienced or expected low or negative returns from expanding service to low income customers, given their relatively low consumption levels and the high costs of electrifying these mostly informal areas.

In general, meeting the fast growth of slums electricity demand tends to be complicated by the following issues:

1. **NATURE OF THE SETTLEMENT** – The settlement often is too far away from the grid; the streets tend to be narrow and are rarely straight, making vehicular access, necessary to install and maintain power cables, either impossible or dangerous.
2. **HIGH COST OF SERVICES** - The high (compared to the income) upfront costs for the grid connection as well as the need for regular periodic payments does not match with irregular income. Many slum-dwellers work informally and occasionally. This means that their income, regardless of size, is often occasional in nature.
3. **ILLEGAL STATUS OF SLUM DWELLERS** - Due to their illegal status, slum dwellers are often unable to provide the required documentation for electricity connection, such as proof of permanent location. In addition, slum-dwellers are typically squatters. That is, there is no official connection between slum-dwellers residences and themselves, and consequently, utility companies would find it extremely difficult to bill a slum-dweller successfully. Without mail service in the slums, companies would be obliged to set up their own collection service at great expense.
4. **LOW ELECTRICITY CONSUMPTION** – Due to the very few appliances that most slum residents can afford to buy and use, the amount of energy consumed is very low, making their connection economically unattractive for the electricity companies.
5. **ILLEGAL CONNECTIONS AND THEFT** – Due to the limited ability of households to pay or to their ineligibility to be connected, a high level of illegal connections and theft occurs.
6. **LACK OF EDUCATION AND AWARENESS** - Slum dwellers are often unaware of the health and financial benefits of legal and cleaner energy access.
7. **LACK OF TRUST BETWEEN COMMUNITIES AND SERVICE PROVIDERS** - Slum dwellers and energy service providers often perceive each other with suspicion. Utilities doubt slum dwellers' willingness and ability to pay for services, and slum dwellers view utilities as quick to disconnect service. This prevents the establishment of a relationship between urban poor communities and energy service providers, and their capacity to negotiate for services.

The reader should be aware that the occurrence of the above mentioned issues depend on the geography and on the different and complex cultural context that characterize the slums. By example, as we will see in the following, these aspects do not equally occur in Africa and Latin America, where relationships between slum dwellers, utilities, and policy makers are significantly different.

1.4.1 The “vicious circle” of slums electrification

Slums electrification faces a sort of standstill deriving, paradoxically, from a converging interest of the two parties involved in the slums' electrification process: the electricity company and the slum's dweller. The converging objective is the access to electricity. The company wants to expand its customers to increase its revenues, provided that the customer pays the bill; the dweller wants the electricity, and is generally willing to pay, as confirmed by all the cases in which pays to a private, generally illegal, local provider more than he would pay if legally connected by the electricity company. The problem is that each of the two parties is generally forced to act in such a way to prevent that the two interests actually converge.

- *The electricity company challenge*

¹⁷ Especially in Sub-Saharan Africa and Asia; a different approach is followed in many countries of South America

The challenges of grid connections in slums are many. As with any business that serves low-income people, slum grid connections face low purchasing power and complexity of collecting payment, complicated by the fact that residents often have no property title, which is a common pre-requisite for installing a regular connection or enforcing a bill.

Significant deterrents to slum electrification are posed by situations where the distribution company is not achieving full cost recovery in its tariffs, because the selling price is kept low mandatorily by the government, thus investors are reluctant to support additional investments for widening electrification (every kWh sold legally increases the losses), and where there is inadequate supply to serve new load.

Electric utility companies experience both technical and non-technical losses. Technical losses are those associated with the production and delivery of electricity. Usually electricity is being delivered through substandard connections to slum residents, and a percentage of the electricity leaving power plants is lost in transmission and distribution. This loss pushes the power plants to capacity, as they struggle to provide an unnecessary amount of electricity.

Non-technical electricity losses are those resulting from theft. In fact, part of slums residents resort to stealing energy from the grid and, because of this, they tend to consume much more electricity in comparison with that they could pay in a regularized connection, being unrestrained by the cost of electricity. This behaviour enforces the electric utility's unwillingness to provide slum neighbourhoods with electricity infrastructures. A further consequence of illegal connections is the reduced reliability of the service (due to frequent blackouts triggered by unplanned excessive load on the grid and on the generation plant) in the whole neighbourhood, which also include regularly connected customers.

Another barrier to connect the slum dwellers in the lowest income bracket derives from the fact that because of their living conditions and budgetary limitations, households are characterized by very poor internal wiring, no ground fault protection or circuit breakers, and/or very long and often undersized wires or cables connecting them to the electricity grid or to a neighbour who is connected. In these cases risks for electrocution and/or fires are high, further dragging families and communities down the economic ladder. As a consequence, utilities may also risk costly damage to their facilities and/or outcries from the public about their poor and risky service.

- The slums' dwellers challenge

For slum dwellers access to electricity is a crucial topic for the improvement of their quality of life. The aspects that are most important to them are primarily the quality and reliability of the service they receive and the ancillary benefits of taking the first step towards "citizenship" by establishing proof of an address and a payment history, improved safety in the home, and security in the streets.

The fact that electricity is often 'tapped off' illegally in urban poor areas or that a fee is paid to a intermediate person to obtain the illegal connection is an evidence of the desire of the low income people to have access to the benefits that electricity provides, such as illumination, radio and television, and the ability to use machines and appliances that create jobs and incomes.

On the other hand, because of a lacking quality of service also provided to regular customers, who experience frequent outages and low voltage, the electricity theft is in many cases considered by slum dwellers as a justified reaction to the perceived inefficiency of the service. In all the cases in which the grid reaches the settlement, the two most common barriers to access to electricity among the poor are the connection fee and the inability to pay regularly.

These two barriers are overcome in two ways: one is simply the electricity theft; the other is to buy electricity from informal service providers (ISPs). ISPs, being themselves slum residents, are more flexible with delayed payments and have strong persuasion means to collect payments.

ISPs can operate in two versions: semi-legal and theft. The semi-legal ISP is someone who has legal access to the electric grid and connects people who do not have access to the grid and then charges them a premium for their consumption. In the "theft" version, Illegal ISP's steal energy from the grid and then sell it at a premium. The fees charged for electricity consumption are usually not based on actual consumption but rather are set fees based on the number of appliances in a person's home and other factors, such as the number of people living in the household.

The existence of ISP's represents an extra stress on the grid, as the connections from the ISP's to final consumers are inefficient, causing unnecessary technical losses. The flat fees disincentive the customers from

conserving energy, as they can have the appliances on 24 hours a day or 1 hour per day and be charged the same price.

1.4.2 Breaking the vicious circle

As shown, the barriers in providing access to electricity are technical, economical and behavioural, all interwoven in such a way that it seems very difficult to find a viable solution. As a consequence of this, a single solution to escape from the vicious circle is not easily available; instead a set of different and appropriately balanced actions must to be implemented. Actions that, in order to be successful, should involve a number of key stakeholders: electricity distribution utilities, national and local government authorities and regulators, slum communities and their leaders, NGOs and community based organizations (CBOs) operating in the community. Illegal service provider may be considered as “shadow” stakeholders.

The main issues to be faced to escape from the vicious circle, besides the illegal status of slum dwellers, are: subsidies, payment system, energy efficiency of appliances, cooperatives and Distributed Generation.

1.4.2.1 Subsidies

Consumption subsidies may be provided to all those with private household connections. Connection subsidies, by contrast, are available only to unconnected households, which are households that are not currently utility customers.

Untargeted subsidies occur when there is a general under-pricing of utility services, such as when certain costs are not passed on to customers. By contrast, targeted subsidies benefit only a subgroup of utility customers.

Within the category of targeted subsidies, a distinction should be made between those that rely on *implicit* targeting and those that rely on *explicit* targeting. Explicit targeting represents a conscious attempt to reduce the cost of service or the cost of connection for customers with particular characteristics (for example, poor households, households in informal settlements, or households that consume small amount of electricity).

On the other side, the most basic form of implicit targeting arises from charging one flat connection fee or one flat monthly service fee to all households for electricity service. Some households are inevitably more expensive to connect because they are farther from the network, or they are more expensive to serve because they consume more electricity with respect to the other households. Flat fees subsidize those costumers that are expensive-to-serve, at the expenses of those who are inexpensive to serve.

In the case of connection fees, it would be possible to avoid implicit targeting of subsidies—each customer could be charged the exact cost of his connection—but making this calculation for each new customer imposes a significant administrative burden on the utility. In practice, many utilities prefer to use a flat connection fee, which will overcharge some new customers and undercharge others.

Implicit targeting does not arise only from flat fees. Low collection rates (with no disconnection for non-payment) and tolerance of illegal connections are two other practices that lead to implicit targeting of subsidies, because, in practice, customers who pay for the service they receive, at the same time subsidize those who do not pay.

Targeting subsidies to the poor has three potential benefits:

1. Targeting has the potential to lower the subsidy budget or the cost of providing the subsidy. If only some households receive the subsidy, the amount of revenue the utility needs to obtain through cross-subsidies or from some external source to fund the subsidies it provides is reduced.
2. Targeting means a greater potential impact on poor households for a given subsidy budget, because such targeting should allow a larger proportion of the total subsidy budget to benefit the poor.
3. Subsidies that are targeted to fewer households have the potential to cause fewer distortions in consumption decisions than untargeted or poorly targeted subsidies (but are still more distorting than no subsidies at all).

Targeting does have its costs, however. First, targeting programs may receive weak political support and thus may be eliminated. In the case of utility subsidies, there would likely be a stronger support for a broad-based subsidy that protects all customers from potential tariff increases rather than protecting only to low-income households by means of a narrowly targeted subsidy.. Second, administrative costs are associated with targeting, both for the agencies in charge of the targeted program and for the households receiving the targeted benefit. It is administratively more difficult to limit who receives a benefit than to provide the benefit to all.

Government-funded subsidies can be delivered in a variety of ways. Governments may transfer the subsidies

directly as a cash payment to the beneficiary household. Alternatively, the government may make cash payment to the utility against proof that a subsidy was provided to a specific consumer.

1.4.2.2 The payment system

The payment method is a crucial issue in electricity access. As a result of the differences in the conditions encountered in slums and in government policies in different regions, a wide range of methods can be found throughout the world, ranging from very simple, low cost approaches to ones involving highly sophisticated anti-theft technologies.

The simplest programs generally attempt to keep service costs low (and in line with expected revenues from legal consumption) by eliminating the need for individual electricity meters.

Since actual individual household consumption cannot be precisely known in these cases, a “fixed invoice” (set periodic payment) is usually adopted in place of billing based on actual consumption. The fixed invoice is usually based on an estimate of likely consumption and/or the average bill for a customer with similar number and type of appliances paying the applicable residential tariff. The use of limitations on current supplied is often justified by suppliers because of illegal commercial activities that have moved into an area to take advantage of free power⁹³.

However, very few incidences of sustained successful slum electrification have been found using such simple approaches, and they tend to be unpopular for the very reason that they keep households from establishing micro-businesses in their homes.

Other low cost first steps involve providing individual meters to each structure. It is essential that meters be situated so that they are visible from the street and preferably are enclosed in some sort of tamper proof enclosure.

South American distribution companies and regulators have pioneered some of the most elaborate service approaches with combinations of anti-theft technology, real time monitoring to identify consumption anomalies due to theft and high levels of assistance in affordability (mainly elimination of connection fees and energy efficiency assistance). It is worth mentioning the case of AMPLA (Rio de Janeiro), that developed an anti-theft technology by displacing electronic meters on the pole arm that allow automated remote reading and can stop any irregularity by remote disconnection.

More recent are the prepayment electricity meters, which operate in the same manner as prepaid cellular telephones. As consumers purchase in advance only what they can afford at the moment, there is no risk to the distribution company of them falling into arrears and likewise no need to maintain service crews ready to disconnect customers for non-payment.

In the prepayment scenario, customers purchase a certain amount of power through local prepaid card retailers. Prepayment systems are technologically somewhat different from conventional systems in that there is normally an intermediary vendor who sells electricity units as needed. The vending system can be relatively simple (with a vending machine or a merchant set up to sell the units to the consumer) or it can be set up to vend kWh via cell phones or even the Internet. Prepayment systems for low-income consumers tend to be on the simpler side, but they are evolving, particularly where cell phone service is practically universal, such as is found in most urban areas.

However, the application to electricity of the pre-paid method used for cell-phones has two drawbacks. The first derives from the fact that in case of electricity, there is the disadvantage of intermittent access. As cell phone users are frequently "out of minutes," electric utility clients might not have power for several days during the week, rendering the overall benefits of the electricity less meaningful and encouraging users to steal energy in the interim. The second drawback is that, the people selling the prepaid cards can become similar to the ISP's in overcharging and forcing bribes out of consumers, thus creating or re-creating the problems associated with ISP's.

Africa leads the world in adoption of prepayment systems as they seem well suited to conditions there. Many distribution companies, like Eskom, have moved to advanced electricity prepayment systems to reduce their costs for billing and collections and disconnections associated with non-payment.

Surveys indicate that customers in general like prepayment, and most companies report significant reductions of non-technical losses as a result of implementing the system¹⁸.

Another initiative towards the reduction of electricity costs has been implemented in Brasil and Chile, where people can exchange recyclable waste for a reduction in the electricity bill. In Brasil, Coelce (Companhia Energética do Ceará), launched in 2007 the initiative ‘Ecoelce’, a program that allows the exchange of recycled solid residues (paper, glass, iron, plastic, and car batteries, for example) for a bonus in the electricity bill.

The recyclable garbage is taken to the collection sites (mobile or stationary), where is automatically translated into scores that are directly transferred to an electronic card as credit, which is used to calculate the discount on the client's energy bill. The collection sites are fully automatic, the interaction is very intuitive and, more relevantly under the point of the security of the user, does not involve the exchange of money.

Nowadays, there are about 30 collection points in Fortaleza, and more than 100 in the whole state of Ceará, distributed in more than 29 municipalities. Only in Fortaleza, the program accounts for over 18,500 tons of trash properly disposed, over 425,000 consumers registered, and 950,000 US\$ of bonuses granted in the electricity bill. The initiative has been replicated in 2010 by Chilectra in Santiago and by Ampla in Rio de Janeiro.

1.4.2.3 Improving energy efficiency

In addressing the demand of slum communities for electricity at an affordable price a possible answer may be supporting the use of energy efficient equipment together with education initiatives on efficient use of energy and appliances. In fact, one should bear in mind that doubling the efficiency of use is equivalent to halving the cost for the consumer. The consumption areas to be first addressed are¹⁸:

- Lighting – the use of fluorescent, LEDs, long life bulbs increases efficiency. (However, this method implies high costs).
- Refrigeration – a vast majority of the refrigerator market in developing regions is based on second-hand, highly inefficient devices.. The use of the latest generation, high efficiency, refrigerators and freezers would significantly reduce electricity consumption.
- Introducing education in efficient energy use.
- Television and Radio – encouraging the use of modern energy efficient models.

Although desirable in principle, it may be difficult at first glance to introduce energy efficient equipment because of higher initial cost and local availability.

In general, in areas where slum inhabitants have large illegal consumption (e.g. on the order of 250 to 350 kWh per month or more¹⁹), higher investments in energy efficiency and “high-tech” anti-theft technology are more likely to be warranted (and necessary). Data on average consumption and household appliances in slums help to determine the likely benefit from energy efficiency efforts and the likely urgency that motivates slum consumers to try to steal electricity.

Energy efficiency assistance aims to achieve two goals: reduce consumption that is above the low income tariff level and thereby reduce the number of kWh to be purchased. In such cases, where energy efficiency assistance is a component of slum electrification, the proportion of the budget that must be dedicated to electricity purchase can fall by as much as 40% as a result¹⁶.

A successful approach to energy efficiency assistance was set up by Codensa³, the Colombian electrical utility (and subsidiary of Endesa, Enel group). Moved by the fact that an increase of its customer base in Bogotá is not permitted due to government restrictions on market share, Codensa realized that the poor were not spending on electricity because they could not afford to buy electrical appliances. In response, Codensa settled-up a complementary business to offer household credit so customers can purchase electrical appliances and pay back over time with amounts included in their electricity bill. Prevented from increasing the number of customers, Codensa was able to increase revenue per customer. Codensa now covers 31% of the market for electronic appliances in Bogotá.

Faced with a cap on market share, Codensa successfully grew revenue and provided a unique service to a low-income customer base. Codensa turned an intimate knowledge of payment history into a profitable business line providing household credit.

Another energy efficiency assistance was set up in Brazil by COELBA¹⁹ (Companhia de Electricidade do Estado da Bahia), after it was found that households were accustomed to high levels of energy consumption due to use of low efficiency refrigerators and light bulbs, faulty electrical installations, and other inefficiencies. As a

¹⁸ A socioeconomic survey of electricity consumption patterns, carried out in 1999 by the Companhia de Electricidade do Estado da Bahia (COELBA) in Brazil, found that old refrigerators accounted for 70% of residential electricity consumption, inefficient lighting accounted for 20.6%, and televisions accounted for 8.4% (source: ESMAP, Innovative Approaches to Energy Access for the Urban Poor: Summaries of Best Practices from Case Studies in Four Countries, 2012 - http://www.esmap.org/sites/esmap.org/files/FINAL_EA-Case%20Studies.pdf)

¹⁹ ESMAP, Innovative Approaches to Energy Access for the Urban Poor: Summaries of Best Practices from Case Studies in Four Countries, 2012 - http://www.esmap.org/sites/esmap.org/files/FINAL_EA-Case%20Studies.pdf

result, energy consumption was consistently above the customers' ability to pay. COELBA then started a refrigerator exchange program. Individual households that received new refrigerators through the subsidized program saw a reduction of consumption of 43% per month. Reduction in household energy costs has contributed to important behavioural changes, including increased spending on food, health, education, and clothing, resulting in improvements in the quality of family life.

1.4.2.4 Cooperatives

The co-operative (co-op) electrification model is one in which a group of people takes out a loan to build proper electric infrastructure and then provides electricity to the surrounding community. Co-ops are usually non-profit; they pay the utility a fee for use of grid-based electricity, and then channel any other profits into expanding the neighbourhood grid as the neighbourhood grows. Co-ops may charge higher fees for electricity than the national electric utility does, but the extra cost contributes to sustainable community infrastructure. In slums, being connected to the grid does not as easily ensure a steady electric supply. In order to ensure reliability in the long-term, slum co-ops would have to incorporate local sources of power into the community's portion of the citywide grid. This could be an opportunity for further enterprise and job creation in the neighbourhood, as well as introduction of more environmentally friendly sources into the community grid.

Energy entrepreneurs within the community could form a co-op and acquire the necessary loan through a microfinance institution.

Overall, the co-op structure has potential in the permanent slum environment because of the sense of community there. It would be a way to formalize the ISP's role and expand it in a more equitable way. It could also discourage theft; members of the community would be discouraged to steal electricity from the owners of the co-op, as neighbours. The stability of the community structure is vital to electric co-ops' success, and therefore, other strategies may be more effective in less permanent slums.

1.4.2.5 Distributed Generation (DG)

Devices such as solar lanterns provide energy for lighting and are affordable to people in the very low income bracket. Solar lantern enterprises demonstrate high potential for profitability, and are receiving social venture capital. Growth goals are ambitious and entrepreneurs expect significant scale over the coming years.

Solar home systems (SHS) provide electricity for households and home-based entrepreneurs with a stand-alone solar photovoltaic panel wired into lamps and a plug. SHS enterprises have demonstrated profitability, but are vulnerable to the expectation of free help from governments and the swings in input prices that have characterized the solar PV market.

In both cases loans or microcredit schemes should be settled-up; slums residents would pay for the capital cost only, being zero the energy cost.

Distributed Generation (either fossil fuel based or hybrid, renewable and fossil) is a model that could have a positive impact on slum communities because of its involvement of a variety of local actors. Through both DG and co-ops, people in the community would have a sense of ownership of the electric supply, rather than being subjected to the regional or municipal electric utility. This would not only be empowering but would also encourage job creation and training within the neighbourhood, while discouraging theft from the DG network or regional grid.

Distributed generation is often talked about as a solution for rural electrification needs, but it is generally assumed that in urban areas, traditional service is more economically feasible, but it is not always so.

While slum areas are not by any means remote or dispersed, they are expensive to reach on account of their density, their legally ambiguous status, and endemic thievery. Moreover, per capita electricity demand is, at least for the present, quite small, as is per-capita income, and some of the specific uses for urban electricity are similar to those in rural areas.

Distributed generation has many advantages over traditional generation for slums. To begin with, the initial investment required to construct a distributed generation plant is relatively small.

Since no development project is ever assured of success, the size of the initial investment ought to be an important consideration in any slum policy. Distributed generation plants, in addition to having relatively low initial costs, are physically reusable. If a distributed generation plant meets with little success in one slum, it is

possible to move the physical equipment to a different slum without loss to the value of the equipment, though of course installation and siting costs will be lost⁷¹.

In addition, distributed generation projects are not subject to electricity thievery, as all projects involving additional power cables certainly would be. For distributed generation projects, thievery will not be a large problem for the simple reason that the amount of power cables will be small, and visibly connected from the source to residences.

Distributed generation does introduce a new element of theft, however, in that the distributed generation equipment itself could be stolen. There are several possible strategies for pre-empting equipment theft. To begin with, all generators should be mounted to metal frames, themselves securely mounted to buildings. This will make attempted theft apparent and visible.

A more promising solution, perhaps, is placing generators that benefit entire communities in public places. Because members of the community will value these generators, they are likely to react quickly and negatively if anyone attempts to steal them.

Another compelling advantage distributed generation has over traditional service is that it can directly empower residents of the slums, who are usually marginalized in their societies at large. Because it occurs on a small scale, metering, bill collection, and even basic maintenance can be performed, with proper instruction, by actors who are themselves beneficiaries of the service.

1.5 ENERGY FOR COOKING

For many households, switching away from traditional biomass is not feasible in the short period. Improving the way biomass is supplied and used for cooking is, therefore, an important way of reducing its harmful effects. This can be achieved either through two approaches: transformation of biomass into less polluting forms or through improved stoves.

Less polluting forms of biomass are charcoal and agricultural residue briquettes, which have a higher energy content than fuelwood and so reduce the amount of fuel needed and the amount of smoke.

Even less polluting than briquettes are modern biomass fuels such as ethanol gel, plant oils and biogas.

Improved stoves are simple and relatively cheap devices, such as “rocket stoves” for fuelwood and Jiko type stoves, are capable to burn respectively fuelwood or charcoal more efficiently than the traditional devices.

In slums, however, fuelwood is used at a very limited extent, being kerosene and charcoal the preferred fuels.

Especially kerosene, being also used for lighting, is the most popular fuel used for cooking whenever LPG (Liquefied Petroleum Gas) is not affordable, also because in many countries pro-poor incentive strategies have been exclusively focused on kerosene¹⁴. LPG and, where available, natural gas distributed through a network are at the top of the energy ladder for cooking, but they have the highest upfront cost.

The overall effect on greenhouse-gas emissions of switching from biomass to LPG is very difficult to quantify because it depends on several different factors, including the fuels involved, the types of stoves used and whether biomass is being replaced by new planting. Although the overall impact on emissions of switching to modern fuels can be either positive or negative, improved stoves and greater conversion efficiency would result in unambiguous emissions reductions from all fuels.

LPG is increasingly seen as an option with significant potential for enhancing access to modern energy services among the poor. However, incompatible LPG cylinders allow oil companies to lock-in customers and charge higher prices¹⁴. If customers could retain the same cylinder and have the flexibility to change LPG suppliers, the cost of LPG would be expected to decrease.

One of the key barriers to wider use of LPG among the poor is the high upfront cost of cylinder acquisition. Moreover, the lack of an efficient distribution system prevents access to using LPG.

In terms of safety, there are several concerns linked to the use of LPG. There have been cases of LPG cylinders exploding and causing serious damage to both property and human life. This is mainly caused by misuse of cylinders (i.e., not adhering to the safety standards for use of LPG) and faulty cylinders and valves supplied by the oil companies.

There have also been cases of sale of half-filled cylinders by unscrupulous dealers in the market¹⁴. This practice in the low-income areas has greatly affected the credibility of the LPG option.

While in Sub Saharan Africa policies aiming to substitute biomass fuels or kerosene with LPG are not common, in many South American countries such policies have been commonly implemented and, whenever available, extended to natural gas.

In Brazil, for example, 98% of households (including 93% of rural households) already in 2006 had access to LPG – a situation that can be attributed to government policy that has promoted the development of an LPG delivery infrastructure in all regions, including rural regions, and subsidies to LPG users²⁰.

In Argentina, Provivienda, the gas company of Buenos Aires, built a community trust fund and a diverse collection of partners to bring piped cooking gas to poor communities². Benefits of grid connections are significant. Provivienda's gas lines increased real income by 7%, decreased respiratory illness by 30%, and created community organization and understanding that can be used to tackle other problems. Customers paid five to seven times less for piped natural gas than they had paid for LPG.

Despite abundant natural gas resources, poorer communities in Colombia continually used polluting forms of energy for cooking and heating requirements. The barrier to cleaner energy access was the relatively high initial cost of the connection and of the natural gas stove.

In 2006, the largest natural gas holding and distribution company in Colombia, Promigas, promoted an initiative that would subsidize the initial cost of a gas stove and connection over a period of six years.

The project sought to subsidize the connection cost for natural gas access; local municipalities helped to identify eligible recipient households, the poorest households. Outreach and awareness programs were used to educate the community on the benefits of consistently using natural gas. Before the project, 40% of households suffered respiratory illnesses. After installing the new stoves, respiratory illness fell by 75% due to decreased exposure to indoor air pollutants from the burning of fuels²⁰.

Apart from the individual health impacts, environmental health impacts were a concern. As a direct result of using natural gas to replace firewood, an estimated 34 hectares of forest and swamp land has been preserved.

In slums located in cities where natural gas is not available, a local scale option is possible, capable to cover part of the energy needs for cooking of the community: biogas from community toilets. Biomass from toilets goes to a digester, producing biogas and a biological fertilizer as by-product. Hundreds of such projects have been implemented in India¹⁸ and a few in Sub Saharan Africa.

It is an approach that at the same time addresses the issue of energy poverty and lack of sanitation.

CHAPTER 2 – FOCUS ON LATIN AMERICA

2.1 URBANIZATION AND INFORMAL SETTLEMENTS

The Latin American and the Caribbean region (LAC) is one of the most urbanized in the world, although it is also one of the least populated in relation to its territory. Almost 80% of the population lives in cities, a proportion even higher than the group of most developed countries. Population growth and urbanization, processes that were accelerating in the past, have decelerated. Currently, the evolution of urban populations tends to be limited to natural growth only.

The number of cities in the region has increased 6 fold in 50 years. Half the urban population now lives in cities with less than 500,000 inhabitants and 14% in megacities (more than 222 million in the former, and 65 million in the latter)²¹.

Progress regarding access to water, sanitation and other services has increased the attractiveness of intermediate-size cities, which helps more balanced urban systems in these countries.

Mass migration from the countryside to the urban areas has lost its growth-feeding importance in most countries. Migration has now become a more complex phenomenon and occurs mainly between cities, in some cases crossing international borders. Also relevant are population movements within cities, between the city centre and its periphery, but also between Intermediate cities.

Urban expansion has caused many cities to spill over their administrative boundaries and physically absorbing other urban centres in a conurbation process. The result has been the emergence of large urban territories, sometimes formalized in a single metropolitan area consisting of multiple municipalities and intense activity across all areas.

On the other hand, urban sprawl continues to increase, despite the demographic deceleration. Cities are growing in a less compact way and they are expanding physically at a rate that exceeds the increase in their population.

²⁰ IEA, World Energy Outlook 2006, Energy for Cooking in Developing Countries, Pages 419–445 - <http://www.iea.org/publications/freepublications/publication/cooking.pdf>

²¹ UN-Habitat, State of the Latin American and Caribbean cities. Towards a new urban transition, 2012.

The percentage of the population living in cities in Latin America is expected to rise reaching 86% by 2030²² and more than 90% by 2050²³.

Inequality and poverty can be expressed in terms of the prevalence of urban slums in the region. In general, the proportion of people living in slums has fallen, but the actual population in these areas is 111 million, a higher figure than twenty years ago²⁰.

Figure 3 shows that slum incidence remains relatively high: 23% urban residents in the region live in *tugurios*, *favelas* or *campamentos*, as the precarious settlements are locally known. The LAC region is quite heterogeneous in terms of human development indicators and slum incidence. Approximately one-third of the total urban population in Peru and Guatemala lives in slums, compared with roughly one-quarter in Argentina and Brazil. Elsewhere in the region, slum incidence is low in Colombia, with less than 15% of the urban population living in them; the lowest proportion is found in Chile. The trends of the past two decades suggest that the slum population in Latin America and the Caribbean will continue to grow by half a million people every year, reaching 120 million by 2020²⁴.

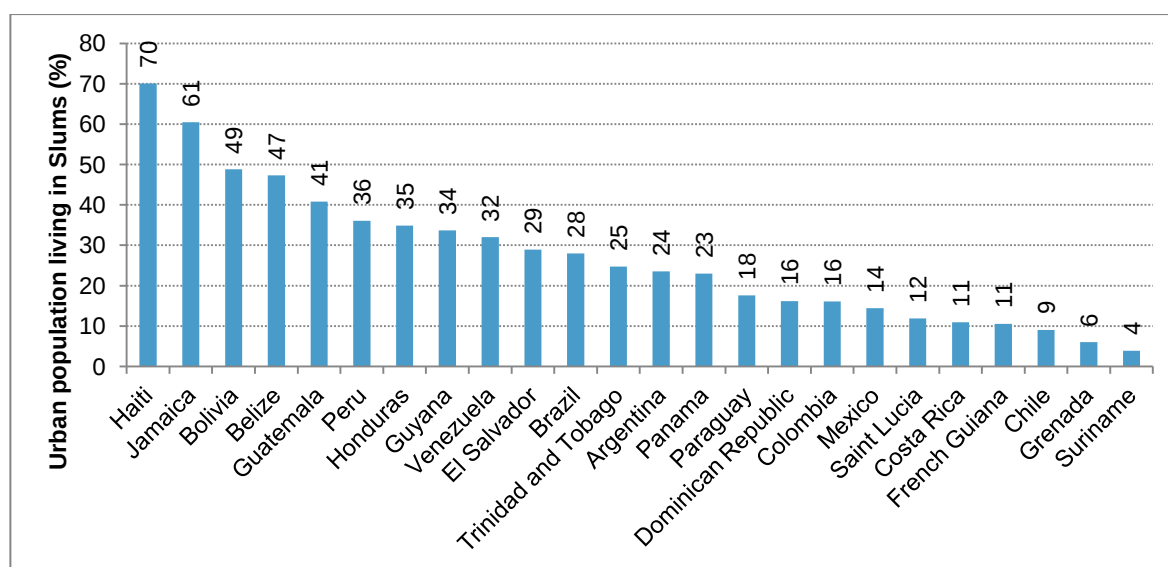


Fig. 3 – Percentage of urban population living in slums in the Latin America and Caribbean Region (Source: EF elaboration based on UN-Habitat Urban-Info Data – Data are from 2005 excluding Haiti, Bolivia, Guatemala, Peru, Brazil, Argentina, Dominican Republic, Colombia, Mexico, provided for 2007)..

2.2 ENERGY AND ELECTRICITY ACCESS

In Latin America government policy has promoted penetration of clean cooking fuels such as natural gas and LPG. This includes the development of an LPG delivery infrastructure in all regions, including rural regions, and subsidies to LPG users. The rest of population relies on wood, kerosene, candles, expensive disposable batteries and other rudimentary, and often more costly, forms of energy²⁵.

As example, in Table 2 is reported a comparison between Colombia and Peru in terms of type of fuel used in the households for cooking at urban and slum scale.

²² Latin American green city index, Assessing the environmental performance of Latin America's major cities. A research project conducted by the Economist Intelligence Unit, sponsored by Siemens

http://www.siemens.com/entry/cc/features/greencityindex_international/all/en/pdf/report_latam_en.pdf

²³ UN Habitat, State of the World's Cities 2010/2011. Bridging The Urban Divide.

²⁴ The challenge of slums. Global report on human settlements 2003. United Nations Human Settlements Programme.

²⁵ Access to Energy in Low-income Communities in the Latin America and Caribbean Region: Lessons Learned and Recommendations. Arc Finance, the Basel Agency for Sustainable Energy (BASE) and Poch Ambiental, 2013.

Table 2 - Energy source used for cooking (per cent households)²²

Energy source	Urban		Non slum		Slum	
	Colombia (2005)	Peru (2004)	Colombia (2005)	Peru (2004)	Colombia (2005)	Peru (2004)
Electricity	8.3	1.3	8.5	1.7	7.0	0.6
LPG, natural gas	85.6	73.1	87.1	83.2	79.2	55.5
Kerosene, other liquid fuel	1.0	11.6	0.5	8.3	3.1	17.4
Coal, lignite	0.2	1.8	0.1	0.8	0.4	3.6
Firewood, straw, dung, charcoal, other	2.5	9.5	1.3	3.2	7.8	20.5
Don't cook	2.4	2.6	2.4	2.8	2.4	2.3
Total	100.0	100.0	100.0	100.0	100.0	100.0

Among the South American countries, Peru has the second (after Bolivia) lowest rates of electricity access. A detailed picture of electricity access for LAC countries is reported in Table 3. It should be noted that there is a difference between the average figures and those related to informal settlement, where, as average, electricity connection is available for the 84.7% of dwellers²³.

Table 3 – Percentage of population with access to electricity access in LAC (2012 – EF elaboration based on WB data)

Country	Electricity access (%)	Country	Electricity access (%)
Argentina	96,28%	Honduras	85,57%
Bolivia	88,19%	Mexico	99,2
Brazil	99,49%	Nicaragua	72,52%
Chile	99,6	Panama	89,12%
Colombia	96,99%	Paraguay	98,45%
Costa Rica	99,0	Peru	90,77%
Ecuador	94,00%	Uruguay	99,1
El Salvador	91,96%	Venezuela	99,66%
Guatemala	84,66%	Average	93.39%

Data show that between 1970 and 2006 per capita yearly average energy consumption has quadrupled (from 427 to 1,688 kWh)²⁰.

In Peru the monthly per capita average electricity consumption is about 30 kWh in rural areas and 100 kWh in urban areas²⁶.

²⁶ Addressing the Electricity Access Gap. Background Paper for the World Bank Group Energy Sector Strategy. June 2010.

Data on electricity access, however, in Latin America countries can be misleading if not complemented with the reliability of the supply. In 2005, the average number of outages per subscriber was 12.5, while duration of outages per subscriber was 16.5 hours²⁷.

2.3 OVERVIEW OF SELECTED CITIES

2.3.1 Bogotá

Bogotá is the capital of Colombia and the country's most populous city, with 7.3 million people. Estimating the number of people living in poverty and in slums in Bogotá is difficult and varies depending on the different localities of the metropolitan area; a maximum figure of 44% was found in the literature²⁸.

In Bogotá 99.4% of households has access to electricity and 79.8% is connected to natural gas²⁹.

For cooking, however, different kind of fuels are adopted, mainly gas in cylinder, natural gas from the network, kerosene, and, rarely, electricity.

Illegal connections and morphologic difficulties represents the main barriers to a continue energy access.

Service quality in Colombia, as measured by service interruptions, is much higher than the average for Latin America and the Caribbean. In 2005, the average number of interruptions per subscriber was 185.7, far above the regional average of 13 outages. The duration of outages per subscriber was 66 hours, also far above the regional average of 14 hours²⁹

2.3.2 Buenos Aires

In 2010, although the metropolitan area is home to some 13.3 million people, the Autonomous City of Buenos Aires is considerably smaller, with 3.1 million inhabitants, and about 30% of the population lives in informal settlements.

Almost the total of Buenos Aires households has electricity access. The average availability of natural gas within the Greater Buenos Aires is around 80% of households, but in the poorest areas this figure drops to 55%.

The most popular fuel is LPG. However, given the inability to pay for the cylinders, abandoned woods, cardboard and other garbage materials are often burned for cooking. During winter, the situation turns critical, when indoor heating must be provided. Acknowledgement by the authorities of this issue is very scarce. Since the start of the so-called "Welfare Cylinder" (*"Garrafa Social"*) initiative, little improvement has been achieved on facilitating permanent energy access to the poor, under economic viability's conditions, specifically to those living under extremely poor conditions³⁰.

Table 4 shows that in informal settlements in Buenos Aires the main use of energy is for cooking, which accounts for nearly 43% of household consumption, followed by water heating (18,3%), food conservation (refrigerator), which accounts for 15.7% and space heating (12.6%). Other devices (mainly irons, washing machines, sound systems and TV sets) consume 5.5% of the total, while lighting consumes 4.5%.

The use of Electricity for heating purposes (water and space heating) is relatively high. In Argentina this is not normally the case in the household sector, not even in high-income households. The situation presented here is a consequence of the fact that in these settlements, many dwellings are illegally connected to the electricity grid, or do not pay the electricity bill. The distribution company cannot, then, discontinue the service without causing serious conflicts with the dwellers. Nevertheless only a 15% of the surveyed homes declared directly or indirectly to be illegally connected to the grid.

Table 4 - Households final energy consumption by energy source and use (%)³²

²⁷ World Bank, Benchmarking Analysis of the Electricity Distribution Sector in the Latin American and Caribbean Region <https://openknowledge.worldbank.org/handle/10986/12675?show=full>

²⁸ N. Rueda-García, Facultad de Arquitectura y Diseño Universidad de Los Andes. The case of Bogotá D.C., Colombia.

²⁹ DANE (Departamento Administrativo Nacional de Estadística), Censo general 2005 (2010).

³⁰ Urban and Periurban Energy Access – UPEA II Buenos Aires Case Study. Final Assessment Revised Draft Report. Energy Economics Institute, Fundación Bariloche – IDEE/FB, Argentina, Global Network on Energy for Sustainable Development – GNESD, Facilitated by UNEP. San Carlos de Bariloche, Argentina, April 2008 (<http://www.gnesd.org/upload/gnesd/pdfs/upea%20technical%20reports/fb%20final.pdf>).

Uses/sources	LPG	Natural gas	Kerosene	Charcoal	Biomass residue	Electricity	Total
Lighting						4.5	4.5
Cooking	33.2	1.0	0.6	7.6	0.3	0.1	42.8
Water heating	6.7	2.0	1.1	2.0		6.4	18.3
Space heating	1.0	0.6	0.6	6.6		3.8	12.6
Food conservation				0.0		15.6	15.6
Ventilation						0.6	0.6
Other devices						5.5	5.5
Total	40.9	3.6	2.3	16.2	0.3	36.6	100.0

Illegal connections and the lack of willingness to pay represent the main barriers to a continue energy access. Data on interruption frequency and duration In Buenos Aires were not found, however in Argentina they are considerably below the averages for the LAC region. In 2002, the average number of interruptions per subscriber was 5.15, while duration of interruptions per subscriber was 5.25 hours²⁹.

2.3.3 Caracas

At present about 3.5 million people live in the metropolitan area of Caracas and more than 1/3 in informal settlements³¹.

About 280,000 low-income households are located in a poverty belt of slums and shanty-towns surrounding Caracas³².

A survey into Venezuelan low-income households carried out in 2002 by the National Institute for Statistics established that³³:

- More than 90% have kitchens with gas burners
- 87.5% have a least one TV
- 78.5% have refrigerators
- 44.3% have washing machines
- 21.0% have mobile phones
- 12.2% have vehicles, mostly damaged and very old
- 11.4% have access to cable or satellite TV
- 8.5% have installed air conditioning equipment.

There are three sources of energy supply for domestic use in Venezuela: electricity, natural gas and LPG, and kerosene. In practice, however, electricity and LPG are the main energy supply options for Caracas' low-income households. Even if Caracas is provided with a gas distribution network, low-income households are located on the top of the hills surrounding the city or in narrow valleys, both of which are difficult and expensive areas for laying down gas piping. Moreover, kerosene consumption for energy purposes has nearly disappeared because this fuel has been un-subsidised since 1996.

Average consumption of electricity is 220 kWh/month for low-income families³³.

The average number of Voltage outages and their durations are over the averages for the LAC region.

2.3.4 Lima

³¹ A. A. Ayala Aleman. A Theoretical Framework of the integration process of barrios in Caracas, Venezuela, 2005.

³² Alleviating Urban Energy Poverty in Latin America. REPORT April 2006. World Energy Council, 2006. ISBN: 0-94612-121-4.

³³ i.e. 2640 kWh/year. It is worth to note that, according to the Autorità per l'energia elettrica e il gas, the average Italian household electricity consumption is 2,700 kWh/year, i.e. almost the same, but with a certainly higher standard of life. The main reason of this apparent contradiction lies in the very low efficiency of electric devices in Caracas.

The capital of Peru, Lima, is home to 8.4 million people in the metropolitan area, about a third of the country's population.

At present, 1/3 of the population lives in informal settlements³⁴.

A large fraction of Lima households have electricity access (94.5% in 2007³⁵)

For cooking, different kinds of fuels are used e.g. LPG in cylinder, kerosene and biomass (wood) as reported in Table 5.

Table 5 - Type of fuels adopted (in %) in urban households in 2012³⁶

Fuel used	%
LPG or natural gas only	54.3
LPG or natural gas and other fuels	31.6
Wood	4.3
Charcoal	0.9
Kerosene	0.2
More than one fuel	5.0
No cooking	3.7
Total	100.0

Illegal connections and morphologic difficulties represents the main barriers to a continue energy access.

In Peru, in 2005, the average number of interruptions per subscriber was 14.5, while duration of interruptions per subscriber was 18.3 hours²⁷.

2.3.5 Rio de Janeiro

In 2010, with 12.6 million residents, Rio de Janeiro is the second most populous metropolitan area in Brazil. At present, about 22% of the population lives in informal settlements.

Almost all the households in Rio has electricity access. For cooking, the main fuel adopted is LPG in cylinder³⁷.

An analysis of the energy uses in *favelas* is reported in Table 6.

Table 6 - Distribution of energy consumptions (survey on 10 *favelas* in Rio)³⁸

Appliance	Electricity consumption (%)
Fan	22
Refrigerator	18
Lighting	18
Shower	12

³⁴ G. Riofrio, UNDERSTANDING SLUMS: Case Studies for the Global Report on Human Settlements 2003 - The case of Lima, Peru.

³⁵ L. Criqui, Pragmatic planning: extending water and electricity networks in irregular settlements of Lima, Peru. *Planum, the journal of Urbanism*, n°26, vol 1/2013.

³⁶ INEI, Instituto Nacional de Estadística y Informática.

³⁷ Universidade COPPE/UFRJ, Acesso a energia elétrica de populações urbanas de baixa renda: O caso das favelas do Rio de Janeiro, 2012.

³⁸ C. Cohen, D. Alcantara, L. Furtado e F. Pilo, "Análise do consumo de energia elétrica através do perfil de uso e posse de equipamentos em comunidades de baixo poder aquisitivo do Rio de Janeiro", 2010.

Air conditioning	11
Freezer	5
Iron	4
Other	5
Television	2
Sound reproduction	2
Washing machine	1
Total	100

Interruption frequency and duration are very close to the averages values of the LAC region. In 2005, the average number of interruptions per subscriber was 12.5, while duration of interruptions per subscriber was 16.5 hours⁴⁰.

2.3.6 Santiago de Chile

Santiago is Chile's administrative and financial capital, and the country's most populous city, with 6.8 million residents in the metropolitan area³⁹.

Currently more than 20% of the population live in informal settlements⁴⁰ and almost all the households have access to electricity, but a large part of them are illegally connected, as show by a survey⁴¹ carried out in one of the informal settlements of the city, where 42.1% of the households was sharing the meter with a neighbour, 26% were stealing electricity from a nearby distribution grid, 1,7% didnot have any access at all and only 30,2% had his own regular meter.

In 2002, the average number of interruptions per subscriber was 9.8, while the total duration of interruptions per subscriber was 11.5 hours in 2005²⁷.

2.4 MAJOR ENERGY CHALLENGES IN LATIN AMERICAN CITIES

Previous sections underline that the barriers to energy access are not technical: the access is available to almost everybody and everywhere in South American cities, but most slum dwellers cannot afford its cost.

The other issue that heavily affects the energy access issue is the poor efficiency of appliances and, thus, the relatively high electricity consumption.

Illegal connections and of thefts mainly derive by the fact that most slum dwellers cannot afford regular payment of the electricity bill, even if the connection fee is subsidised. On the other side, paradoxically, the electricity theft and the lack of capital for buying energy efficient appliances, force slum residents to consume (and waste) a large amount of energy, triggering the vicious circle: "high consumption – inability to pay – theft".

Furthermore, despite electricity access is above 90% in almost all the slums, voltage outages, also due to illegal connections make the electricity availability uncertain. Many safety and security problems derive from this situation.

Other negative effects are suffered by the electricity utilities, whose revenues are heavily challenged by the thefts with the consequence of lack of the financial resources necessary to maintain, repair, expand and upgrade the electric grid.

³⁹ City administration across the metropolitan area is divided into 52 "communes", each with its own mayor. An "Intendant", appointed directly by Chile's president, heads up the metropolitan regional government, which is responsible for harmonizing multiple local and national policies on the environment and other municipal issues.

⁴⁰ <http://kbetanco.jimdo.com/slums/>

⁴¹ Un techo para Chile, Encuesta de Campamentos RM 2010, Centro de Investigación Social (CIS).

Similarly, for thermal uses the natural gas network connection or the LPG cylinder cost is generally not affordable for most slum dwellers, and other types of fuel are used, ranked lower in the energy ladder, with threat to their health.

About thermal uses of energy, in some parts of South America space heating is required, but generally (if the southernmost part of Argentina and Chile is excluded) the number of heating degree-days, i.e. the need for heating is generally moderate, corresponding, in the average, to those that we can find in coastal south-centre Italy. This means that reasonably comfortable conditions could be achieved with very little energy input if the construction is appropriately insulated, even with one of the many low cost techniques available. It is mainly a problem of awareness and knowledge.

On the other hand, most of the slum population in Latin America lives tropical, mostly hot and mostly humid climates, where air conditioning, especially in buildings not appropriately constructed, becomes a must, and results in a significant electricity consumption share in medium and high income households.

CHAPTER 3 – FOCUS ON AFRICA

3.1 URBANIZATION AND INFORMAL SETTLEMENTS

In 2008, Africa still had only 39.1% of its total population living in cities, making it the least urbanized region in the world. African urban populations are also highly unevenly distributed over the continent's sub-regions, ranging from a 22.7% urbanization rate in East Africa to 57.3% in the Southern Africa region. Among individual African countries the contrasts in urbanization rates are even greater, from as low as 10.1 and 12.8% in Burundi and Uganda to Gabon's 84.7% and Djibouti's 87%. Africa's highest 2007 national urbanization rate of 93.1% was at the island Réunion⁴⁹.

This is changing: Africa's cities are growing fast. In 2005, Africa had 43 cities with more than one million inhabitants and it is projected that by 2015 this number will grow to 59 cities.

Despite African cities are generating about 55% of the continent's total GDP, a massive 43% of its urban populations live below the poverty line. In several Sub-Saharan nations that share even exceeds 50% and Africa's urban slum populations continue to grow. In some of the fast-growing African cities almost all of the current urban spatial growth is the result of slum and informal settlements proliferation.

Contrary to common perception, most urban growth in Africa now takes place in secondary and tertiary settlements (the towns with less than 500,000 inhabitants) rather than in the largest cities. This is an even more noteworthy phenomenon given that the bulk of Africa's urban transition, though yet to come, is only a generation away. By 2030 the majority of Africans will be urban residents, and the majority of them are predicted to live in slums and informal settlements unless radical corrective measures are taken (Fig. 4).

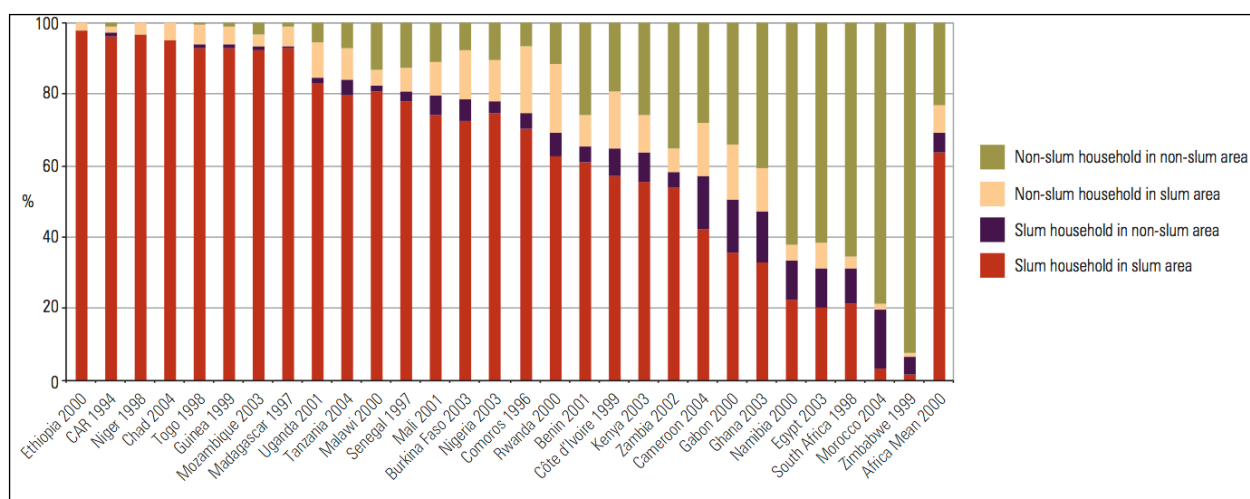


Fig. 4 – Distribution of slum and non slum household⁴²

⁴² UN-Habitat, The State of African Cities 2008. <http://www.unhabitat.org/pmss/listItemDetails.aspx?publicationID=2574>

3.2 ELECTRICITY ACCESS

In Africa, access to modern energy for household cooking is very limited, with unsustainably large and growing population directly relying on biomass, especially in sub-Saharan Africa, where access to electricity is around 30% but with significant disparity between urban (89%) and rural (46%) areas⁴³. Access rates in the Northern African countries, instead, are closer to those of developed countries, with 97% in Morocco, 99% in Algeria and 100% in Tunisia, Egypt and Libya. Eastern Africa is a particular concern, as shown in Table 7, which shows also that in many African countries, especially those in sub-Saharan region, low electrification rates are compounded by very low levels of electricity consumption implying very limited use of this energy service.

Table 7 - Snapshot of electricity access and consumption in some African countries (Source: World Bank)

Country	Population with electricity access in 2012(%)	Electricity consumption per capita in 2011(kWh)
Angola	34.6	248
Benin	27.9	91
Cameroon	49.0	255
Congo, Democratic Republic of	37.1	171
Cote d'Ivoire	58.9	212
Eritrea	32.5	49
Ethiopia	23.0	51
Kenya	23.0	155
Mozambique	15.0	447
Nigeria	48.0	148
Senegal	56.5	186
South Africa	82.7	4603
Sudan	29.0	114
Tanzania	14.8	92
Togo	27.9	111

Data on electricity access, however, in African countries can be misleading if not complemented with the reliability of the supply. In Sub Saharan Africa the cumulative electrical interruptions amounted to more than 90 days/year⁵¹.

3.3 INSIGHT ON SELECTED CITIES

3.3.1 Nairobi

⁴³ United Nations Economic Commission for Africa (UNECA), Enhancing energy security in Eastern Africa, Draft background report. [www.uneca.org/sites/default/.../8 - full report - energy-17thice.pdf](http://www.uneca.org/sites/default/.../8_-_full_report_-_energy-17thice.pdf)

At present about 50% of the population lives in informal settlements⁴⁴.

Households, commerce and industry in Nairobi use a combination of fuels. In 2010, 75% of Nairobi households had electricity access⁵². For cooking, however, different kind of fuels e.g. kerosene, LPG, charcoal etc. are used and these have different contribution for non-slum and slum households (Table 8).

Table 8 - Households energy use in Nairobi (2003)⁵³

Type of fuel	Urban (%)	Non-slum household (%)	Slum household (%)
Electricity	1.8	2.4	1.0
LPG, natural gas	19.8	28.3	7.5
Biogas	0.6	0.6	0.6
Kerosene	68.3	61.6	78.0
Coal, lignite	0.3	0.1	0.6
Charcoal	7.4	5.4	10.3
Firewood, straw	0.1	0.1	0.1
Other	1.7	1.6	1.8

Nairobi suffers from 11,000 high voltage fluctuations and voltage outages every month.

3.3.2 Addis Ababa

According to the literature,, about 18.3% of the population lives in informal settlements⁵².

Addis Ababa uses a considerable amount of kerosene fuel followed by firewood for domestic purposes, as shown in Table 9. In 2010, about 97% of households of Addis Ababa had electricity access ⁵².

Table 9 - Households energy use in Addis Ababa (2005)⁴⁵.

Type of fuel	Urban (%)	Non-slum household (%)	Slum household (%)
Electricity	1.3	1.7	1.0
LPG, natural gas	2.2	2.8	1.7
Biogas	0.5	1.0	0.1
Kerosene	69.8	74.6	66.4
Charcoal	9.7	6.7	11.8
Firewood, straw	12.3	7.3	15.9

⁴⁴ African green city index, Assessing the environmental performance of Africa's major cities
A research project conducted by the Economist Intelligence Unit, sponsored by Siemens
http://www.siemens.com/entry/cc/features/greencityindex_international/all/en/pdf/report_africa_en.pdf

⁴⁵ UN-Habitat, State of the African cities, 2008

Dung	0.3	0.2	0.3
Do not cook	3.1	5.0	1.7
Other	0.8	0.6	1.0

Frequent outages are a major problem, as well as the low position in the energy ladder.

3.3.3 Dar es Salaam

At present, about 68% of the population lives in informal settlements and over half of them live on an average income of \$1 a day⁴⁶.

In 2010, about 60% of Dar es Salaam households had electricity access⁵².

According to a survey carried out in 2008⁵⁴, it has been estimated that 94% of Dar es Salaam's households use charcoal, either alone or mixed with other fuels, and about 78% use charcoal as their first choice energy source. Only 6% do not use charcoal. Kerosene is Dar es Salaam's second major energy source for cooking (13% households), followed by electricity (5%) and gas (4%). Reasons given by various households for not using electricity include: increased tariffs and the unreliability of electricity due to rationing of power during dry seasons. The low adoption of gas for cooking is attributed to low awareness (users still feel that gas can be risky, even though gas cookers have improved and explosions are infrequent), and the fact that the prices of appliances that use gas are high for low-income households. Most households (71%) combine more than one type of fuel such as charcoal, firewood, kerosene, electricity and gas.

3.3.4 Dakar

About 42% of Dakar's population lives below poverty line.

Currently slum covers 35% of Dakar's land area. These slums are located around the edges of the city or inside the city centre⁴⁷.

Dakar uses a considerable amount of LPG/natural gas for domestic purposes (92%) as shown in Table 10.

Table 10 - Households energy use in Dakar (2005)⁵³

Type of fuel	Urban (%)	Non-slum household (%)	Slum household (%)
Electricity	0.6	0.7	n.a.
LPG, natural gas	92.1	92.7	88.1
Charcoal	4.7	4.3	7.2
Firewood, straw	0.3	0.1	1.0
Other	2.4	2.1	3.8

In 2009, the electricity access rate in urban area of Dakar was about 96%⁵⁵.

⁴⁶ Pan-African START Secretariat, Urban Poverty & Climate Change in Dar es Salaam, Tanzania: A Case Study-Final report, International START Secretariat Tanzania Meteorological Agency Ardhi University, Tanzania. March 10, 201. <http://start.org/download/2011/dar-case-study.pdf>

⁴⁷ Touria Dafrallah, Access to electricity in Dakar: Role and Barriers to Renewable Energy Technology diffusion, ENDA Energy Environment, Development, IRENA Workshop Renewables for Growing Cities in Africa: Naples, September 2, 2012. http://www.irena.org/DocumentDownloads/events/NaplesSeptember2012/Touria_Dafrallah.pdf

In Dakar, the land tenancy issues and illegal settlements entail illegal power connections.

3.3.5 Lagos

Lagos is the economic and social heart of Nigeria and of the West African sub-saharian region, and is the headquarter of transnational corporations and national conglomerates. It has 22 industrial estates (65% of the country's total), and 60% of the nation's value-added manufacturing; it accounts for 32% of national GDP (2004) and 65% of Nigeria's value-added tax.

Informal settlements in Lagos have grown gradually during last decades and in 2006 about 66% of the population lived in them⁵².

Lagos uses a considerable amount of Kerosene (79.9%) followed by firewood (8.1%) and LPG (6.1%) for household uses⁴⁸.

Currently, almost all households (99.6%) have the electricity access⁵¹.

Demand for electricity far outstrips supply, and the city is faced with frequent voltage outages (the hours of electrical service provided during a day ranges from 5 to 13 hours in different parts of the city⁴⁹). Many homes and businesses have their own generators.

4. COMPARISON BETWEEN AFRICAN AND LATIN AMERICAN CITIES

Compared to Latin America, in Sub Saharan Africa the problem of the energy access to modern energy sources is far more critical (with only exception of Dakar, among the cities considered).

Kerosene is generally the most used fuel for cooking (with all the safety and cost problems deriving), followed by biomass (with the health problems deriving). The major part of slum dwellers lays in the lower part of the energy ladder.

Also electricity access statistics are far away from those of Latin America, and the technical and non-technical barriers are combined: not only the problem of illegal connections and theft is present, but also the grid often does not reach the neighbourhood. Exceptions to this general rule are Dakar and Lagos, where the energy access is estimated above 95%.

Largely more significant than in Latin America is the problem outages, reaching very high values in number and duration in all cities, especially in Lagos.

Thus, African cities are only at the beginning of the path leading to modern energy use among the poor, exacerbated by the fact that the percentage and the absolute number of slum dwellers is far higher than in Latin America.

Because of the scarce diffusion of LPG as cooking energy source, a special challenge has to be faced in Africa about the use of more efficient cooking devices, not only more efficient electric devices.

Thermal comfort conditions are generally very poor in the slum's dwellings, where the hot climate is exacerbated by inappropriate construction materials (like iron sheets used for roofing) and the lack of ventilation. Growing the availability of affordable electricity, it can be expected growing consumption at least for the use of fans, or of low cost and inefficient air conditioners. The issue of the electric appliances efficiency is not yet an issue because of their very limited diffusion due to the poverty of slum dwellers, but even a slight improvement of their conditions, as experienced in Latin America, will make this issue critical and needing to be faced as early as possible.

The problems faced today by African cities, regarding energy access, were faced (and unfortunately not solved) in earlier times by Latin American cities. The former could learn many lessons from the latter, to avoid the same errors.

Comparative Table - Major energy challenges

Energy use	Latin America	Africa
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⁴⁸ Ewah Otu Eleri, Okechukwu Ugwu & Precious Onuvae, Expanding access to pro-poor energy services in Nigeria, International Centre for Energy, Environment & Development, 2012. <http://www.icednigeria.org/workspace/uploads/final-pro-poor-energy-access-paper-26-nov.pdf>

⁴⁹ UN-Habitat. "Cities and Citizens Series: Urban Inequities in Three (3) Cities-Addis Ababa, Casablanca and Lagos" Research Report, 2008. http://www.unhabitat.org/downloads/docs/9175_77451_cities_and_citizensseries_addis_casablanca_lagos.pdf

Energy use data	- Data on energy use to be verified; - Growing settlements	- Lack of data on energy use - Growing settlements
Cooking	- Data on fuels to be verified	- Low position in the energy ladder
Electricity	- Service generally available but not economically affordable; - Voltage outages; - Expected growing electricity consumption for domestic hot water and appliances	- Badly managed policy of electricity access for the poor; - High cost of service; - Illegal connections; - Voltage outages
Thermal comfort	- Very low thermal comfort - Expected growing electricity consumption at least for fans	- Very low thermal comfort - Expected growing electricity consumption at least for the use of fans

APPENDIX A. Note on data sources and year of reference.

The reader may consider the data on slum population and energy use in the informal sector provided in this paper outdated. Regarding this point, as previously mentioned in the introductory sections, it is worth noticing that data collection in (and about) informal settlements is a well recognized challenge, and, according to our knowledge, we would like to inform the reader that have reported the most updated sources in our availability.

Main data sources are cited in the literature and in the footnotes, the most relevant are the World Bank, IEA, and UN-Habitat.

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