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The (Non-)Disclosure of Energy Efficiency: The Case of Cooling Technologies across Africa

Pille-Riin Aja, Louis-Gaëtan Giraudet, Sébastien Houde

February 7, 2024

Abstract

The adoption of air conditioning (AC) could grow exponentially across Africa under the joint effect of acute warming, sustained income growth and rapid urbanization. The implications for greenhouse gas emissions will crucially depend on the energy efficiency of the models adopted. Little is known, however, about how energy efficiency information is conveyed to consumers in these markets. To fill this gap, we gathered data on cooling appliances' characteristics from Africa's largest e-commerce platform, serving 13 countries—Algeria, Cameroon, Côte d'Ivoire, Egypt, Ghana, Kenya, Morocco, Nigeria, Senegal, South Africa, Tanzania, Tunisia, and Uganda. We find that less than 10% of the AC models available on the marketplace (N=1,229) have information disclosed about their energy performance. Information disclosure appears to be highly idiosyncratic with weak strategic motives. This overall lack of information about energy efficiency represents an important challenge for enforcing energy performance standards and steering demand toward energy-efficient cooling appliances.

1 Introduction

The impacts of climate change and the resources needed to adapt to them are unequally distributed across regions. In particular, Africa, already the hottest continent, is experiencing acute warming—a trend that is only expected to continue (Diedhiou et al., 2018; Nikulin et al., 2018). This vulnerability is exacerbated by low income levels across the continent, making it harder to adapt. The widespread diffusion of cooling technologies, such as fans and air conditioners (ACs), could be an effective way to address the adaptation challenge. These technologies are already mature, relatively inexpensive, and have a proven ability to mitigate a range of adverse effects related to heat stress; including mortality, morbidity, educational underachievement and productivity losses (Basu, 2009; Barreca et al., 2016).

The ownership rate of cooling devices is currently very low across Africa—less than 5%, compared to 88% among households in the United States, the country with the highest penetration rate (EIA, 2020). However, this could change rapidly thanks to fast income growth among African middle- and high-income households, known to be a first-order driver of AC adoption (Davis et al., 2021). Accordingly, the IEA (2022) projects that AC and fan ownership will more than double across Africa in the current decade.

A crucial question raised by this rapid market expansion is whether the implied energy demand will grow at the same rate or instead remain flat due to the adoption of highly energy-efficient technologies. One important condition for the latter is that energy efficiency information is conveyed transparently to consumers. This, in turn, depends on firms' information disclosure behavior, which we know very little about in this context.

In this paper, we intend to fill this gap and elicit the patterns of energy efficiency disclosure in several important markets for ACs in Africa. To do so, we use a novel database of product characteristics scraped over a 3-year period from Africa's leading e-commerce platform, serving 13 countries across the whole continent. We find that the information made available to consumers is very limited, with less than 10% of all products offered (N=1,229) having their energy consumption characteristics disclosed on the platform. We additionally find evidence that information disclosure

is correlated with the existence of a mandatory energy performance standard in a country and with product characteristics, such as brand and price category. The correlation is, however, weak. Altogether, these findings make it very unlikely that consumers will knowingly and deliberately adopt energy-efficient products—price constraints notwithstanding. More generally, we see this lack of systematic disclosure as an impediment to effectively enacting and enforcing energy efficiency regulations and incentives—minimum performance standards and subsidy programs in particular.

The remainder of the paper is organized as follows. In the next section, we describe the institutional setting of African markets for cooling appliances. In Section 3, we discuss our data collection and compute basic statistics depicting the market structure of cooling appliances. In Section 4, we analyze the decision to disclose energy information. We then conclude.

2 African Markets for Cooling Appliances

Between 300 million and 2 billion African residents are projected to experience 15-day extreme heat waves ($>42^{\circ}\text{C}$) by the end of the century (Marcotullio et al., 2021). With growing income and expanding energy access, mechanical cooling appliances—fans and air conditioning—are becoming increasingly accessible to households (Gertler et al., 2016). The current AC ownership rate on the continent is 0.08 units per household (compared to 0.7 units globally or 2.2 units in the U.S.) (IEA, 2022). The biggest markets are located in North and South Africa (CLASP, 2018). In Ghana, the African country with one of the highest rates of electricity access (World Bank, 2021), only 0.7% of households have ACs (Twerefou and Abeney, 2020).

Despite low ownership rates, the expansion of air-conditioning is putting African power grids under pressure (Falchetta and Mistry, 2021). In sub-Saharan Africa, half of electricity production capacity relies on polluting, low-efficiency backup generators (IFC, 2019). Unless significant changes occur in the grid and off-grid networks, increased energy demand from AC operation will be met by these polluting generators. It is therefore crucial to increase the energy efficiency of ACs.

Little is known about the energy efficiency of the ACs sold in African markets. In an international comparison featuring South Africa as the only African country, the IEA (2018) reports a narrow energy efficiency range there, centered around a relatively low average value. In addition, CLASP (2019, 2020), an active organization in the cooling field, reports evidence of active secondary markets where the dumping of used and low-efficiency appliances imported from other regions is common practice across the continent. Furthermore, comprehensive information about energy efficiency is scarce even in countries that have introduced energy regulations,¹ such as energy labels, minimum energy performance standards (MEPS), and/or bans on the import of used appliances (Agyarko et al., 2020). Several of these countries also participate in an IEA co-led initiative targeting the energy efficiency of different appliances including ACs (IEA, 2022).² The degree of enforcement of these measures however remains unclear, and consistent reporting of energy efficiency information is still lacking in most African countries.

The organization of the downstream market also makes it difficult to track energy efficiency information for the set of products for sale. As of today, African retail cooling markets consist of brick-and-mortar stores supplemented by informal markets. E-commerce still has a marginal market share. It is however growing rapidly, spurred by the increase in internet users—+33% between 2017 and 2021, now reaching 590 million³—and the spread of mobile phones offering broadband connection—+100% in five years, up to 28% of the population in 2020 (AFDB, 2022). This expansion is so fast that e-commerce could “leapfrog” bricks-and-mortar retail in many African countries, where the average number of stores is still below 15 per one million people Tempest (2020). This could be further accelerated by newly implemented policies. For instance, the African Union has committed to creating a single digital market by 2030 (African Union, 2020). The African

¹This includes Egypt, Ghana, Kenya, Morocco, South Africa and Tunisia (Shaffie et al., 2022; The Energy Commission, 2020; CLASP, 2019; IEA, 2020a,b; CLASP, 2020). These countries all feature in our database.

²Ghana and Nigeria joined the COP26 Product Efficiency Call to Action, Ghana and South Africa are members of the Super-Efficient Equipment and Appliance Deployment Initiative.

³Internet World Stats website of Miniwatts Marketing Group. Source: <https://www.internetworldstats.com/stats1.htm>

Development Bank Group’s 4IR Fund highlights e-commerce as an important element in improving digitalization in Africa (AFDB, 2022). ICA (2019) reports that \$7.8 billion-worth of investment was made in information and communication technology in 2018, a trend that continues to rise.

As e-commerce platforms are bound to play an increasingly important role in African households’ shopping decisions, it is crucial that they transparently disclose the technical characteristics of the products offered – energy-related information in particular. In turn, e-commerce platforms offer an ideal setting to track product characteristics, thus creating interesting opportunities for research at the intersection of economics and energy.

3 Data Collection

Very few African authorities maintain a public database of cold products (e.g., ACs, fans, or refrigerators),⁴ To overcome this limitation, we set out to build our own database. In the spirit of Cavallo and Rigobon’s Billion Prices Project (Cavallo and Rigobon, 2016) and Gerke and Tu (2015)’s International Database of Efficient Appliances (IDEA), we developed scraping algorithms to collect data on African e-commerce. Importantly, our data collection effort complements IDEA by documenting a yet uncovered region and surveying markets at a higher frequency (daily, instead of once every month or so) and over a longer period (four years and counting, instead of 2014). We focus on Jumia, Africa’s first and most visited e-commerce platform.⁵

3.1 Methodology

Our goal is to assemble a panel of daily prices and product characteristics for all major cold appliances offered on the Jumia platform. Our data collection effort started on June 28, 2019, and was carried out with a scheduled algorithm that extracted product information displayed to website visitors. The database spans 13 African countries where Jumia has a substantial presence – Algeria, Cameroon, Côte d’Ivoire, Egypt, Ghana, Kenya, Morocco, Nigeria, Senegal, South Africa, Tanzania, Tunisia, and Uganda. The information collected is in French or English.

Our targeted product categories are so-called cold appliances, which include ACs, comfort fans, refrigerators, refrigerator-freezers and freezers. We focus on several types of ACs, defined as appliances driven by an electric compressor that provide space cooling or heating (EU, 2017), such as double duct ACs, single duct ACs and ACs with additional functionalities like dehumidification and air-purification. For those appliances that provide both cooling and heating and have separate technical specifications for each functionality, we consider only those relevant to cooling. As for fans, defined as appliances that are designed to create air movement in the proximity of the human body for the purpose of personal cooling comfort (EU, 2017), we collect all device categories, including—but not limited to—floor standing, ceiling, and USB-powered fans. In the refrigerators and freezers section, defined as appliances with one or more compartments for preserving fresh or frozen foodstuffs that are cooled by an energy-consuming process (EU, 2019), we collect all models available on the platform.

Our scraping algorithm retrieves the following information from a product’s page: title, category, brand, average rating of the product submitted by the users of Jumia, number of ratings submitted, estimated delivery time to the customer, price, original price and discount percentage (if any), URL, and two description fields. Most importantly, the algorithm is specifically designed to identify and extract all energy-related information.

The panel is unbalanced due to various events that caused interruptions in data collection. The most frequent issues were changes in the website source code, which typically took us a few days

⁴Kenya is set to launch a public database of registered appliances (CLASP, 2019).

⁵According to Statista, Jumia was the most visited online marketplace in Africa in 2021 (<https://www.statista.com/chart/27527/africas-popular-e-commerce-platforms/>). Jumia, on its part, reported over 1.1 billion visits in 2021 (<https://group.jumia.com/>). The breadth of Jumia’s product coverage is similar to Amazon’s, who did not operate on the continent until very recently. Amazon plans to launch their platform in Nigeria and South Africa in 2023 (<https://www.theafricareport.com/234135/amazon-accelerates-in-africa-much-to-the-chagrin-of-local-players/>).

to incorporate in our algorithm. Moreover, data collection had to be discontinued altogether in Cameroon, Tanzania and South Africa, for different reasons.⁶

3.2 Recovering Energy-Related Information

Our primary goal is to retrieve energy efficiency information for all models of cooling appliances scraped on the Jumia platform. The most commonly used metrics for measuring AC energy efficiency are the energy efficiency ratio (EER) and the seasonal energy efficiency ratio (SEER). The former is the ratio between the cooling capacity of the appliance and its effective power input (Energy.gov). The latter factors in the effective annual energy consumption at the numerator (EESI). The EER is a convenient indicator to compare AC energy efficiency across countries. The SEER is, however, becoming more prevalent, for it more accurately captures climate-related differences in AC operation (Park et al., 2020).

Calculating these indicators requires detailed information about local seasonal conditions, appliance design, and energy consumption for all possible consumption modes (EU, 2017; Huang et al., 2018; EU, 2019). In this paper, we use the power input and annual energy consumption figures reported in the product description. We do not observe which local seasonal conditions or appliance design parameters were considered in their calculation.

Our algorithm is designed to identify EER and SEER ratings alongside other related attributes, usually in the product description field. We used regular expression patterns to locate and retrieve the relevant technical characteristics from those fields, which are presented on the website in raw text format. This task was complicated by inconsistent naming conventions, an ambiguous use of technical terms,⁷ mistakes and inconsistencies in text spacing, and illogical sentence construction. Since there is no straightforward way to bypass these obstacles, our identification process is not exempt from omissions. We nevertheless tried to minimize them by adding a step of manual browsing to identify undetected information.

For the purpose of our analysis, we refer to EER and SEER as *stated* if the ratios were directly communicated in the product description. Otherwise, if at least the cooling capacity and power consumption were reported separately, we could compute the ratios ourselves. We refer to these as *implicit*.⁸ We consider the stated ratios to be the most accurate proxy of energy efficiency. The computation of their implicit counterparts relies on rounded-off input values, resulting in measurement errors. Moreover, cooling capacity is documented in three different units: watt, BTU/h, and ton. The latter unit has a coarser measurement resolution, thus amplifying rounding errors.⁹ To account for these limitations, we construct two separate implicit ratios: (i) *Implicit EER (or SEER) computed using watt or BTU/h*, and (ii) *Implicit EER (or SEER) computed using ton*. Finally, when available, we use information about the maximum energy consumption to compute yet another ratio, which we refer to as *Implicit minimum EER*.¹⁰

4 The (Non-)Disclosure of Energy Information

In this section, we focus on the AC data collected in the first three years (i.e., through June 30, 2022) and analyze the EER/SEER metrics displayed on Jumia. Despite important efforts to systematically track and recover energy-related information, we find that neither the stated EERs

⁶Jumia ceased to serve Cameroon on November 18, 2019, and changed its business model from an e-commerce website to a marketplace platform on November 27, 2019, in Tanzania. The platform started serving South African in 2021 but stopped selling our products of interest by the end of that year. Our South African data thus only span the April 21–November 14, 2021 period.

⁷For example, the labeling of the power input and cooling capacity indicators are often unclear. Moreover, a significant number of ACs report horsepower as the unit of measurement for capacity. This is an indicator of compressor capacity only, which does not allow us to recover the cooling capacity or consumption of the AC.

⁸For the calculation of Implicit SEER, we used total seasonal power consumption instead of regular power consumption.

⁹To fix ideas, the measurement error is 32% if a 1.52 ton cooling capacity is rounded to 2 tons but only 0.6% if a 17,900 BTU/h capacity is rounded to 18,000 BTU/h.

¹⁰Conventional energy efficiency indicators are computed using nominal energy consumption values. A metric using the maximum energy consumption values as input can thus be considered a minimal EER.

nor the information needed to compute the SEERs are frequently disclosed. This motivates us to examine in a second stage whether the scarce information available follows a particular disclosure pattern.

4.1 Descriptive statistics

The following analysis will concentrate on the features of AC models, independent of the time component, so we transform the panel data into cross-sectional data. The modified database contains 14,134 AC models from 166 brands. Brand names could not be identified for only 87 observations (0.6% of the data set) in Côte d’Ivoire, Nigeria, Morocco, Kenya, Senegal, Ghana and Tanzania. The broadest product sets are found in Nigeria, Egypt, and Côte d’Ivoire and the smallest in Algeria, Kenya and Uganda.

Taken together, the five EER metrics (i.e., Stated EER, Stated SEER, Implicit EER, Implicit SEER or Implicit minimum EER) are available for 8.5% only of all AC models in our database, with substantial heterogeneity across countries. Stated EERs—both the most accurate and prevalent metric—are available 6% to 27% of the time in Senegal, Egypt, Uganda, Tanzania, Tunisia and Morocco, but less than 5% of the time in Côte d’Ivoire, Ghana and Nigeria. In Algeria and Cameroon, where the choice sets are the smallest, information is richer, with stated EERs available for about half of the products. There are no stated EER information available for ACs in Kenya and South Africa, so we exclude these two countries from the rest of the analysis and focus on the other 11 countries. Table 1 provides a detailed overview of these indicators. There is a strong correlation in the disclosure of various indicators: in countries where stated EERs is frequently available, so are the inputs needed to compute implicit EERs. In contrast, information is in most cases missing about the SEER and minimum EER.

The average AC energy efficiency level in the 11 African countries, where stated EERs were presented, is 3.2 W/W (table 2). To put these figures into perspective, EER values similarly fall within 2.9 and 3.6 W/W in Europe, East Asia and North America according to the IEA (2018). The African figures, however, follow a different distribution, both within and across countries. (see Min./Max. columns in table 2). In particular, the upper end of the distribution in Egypt and Senegal matches the performance of the world’s best technology (EER>6.0 W/W). Still, the maximum value remains well below this mark in most countries (between 3.0 and 4.0 W/W). Manufacturers, therefore, appear to refrain from offering the most efficient AC models in African markets. The technology frontier makes it unlikely that African households could leapfrog other countries by adopting the most efficient models at the onset of their electrification.

Table 1: Overview of available energy efficiency information for ACs on Jumia e-commerce platform.

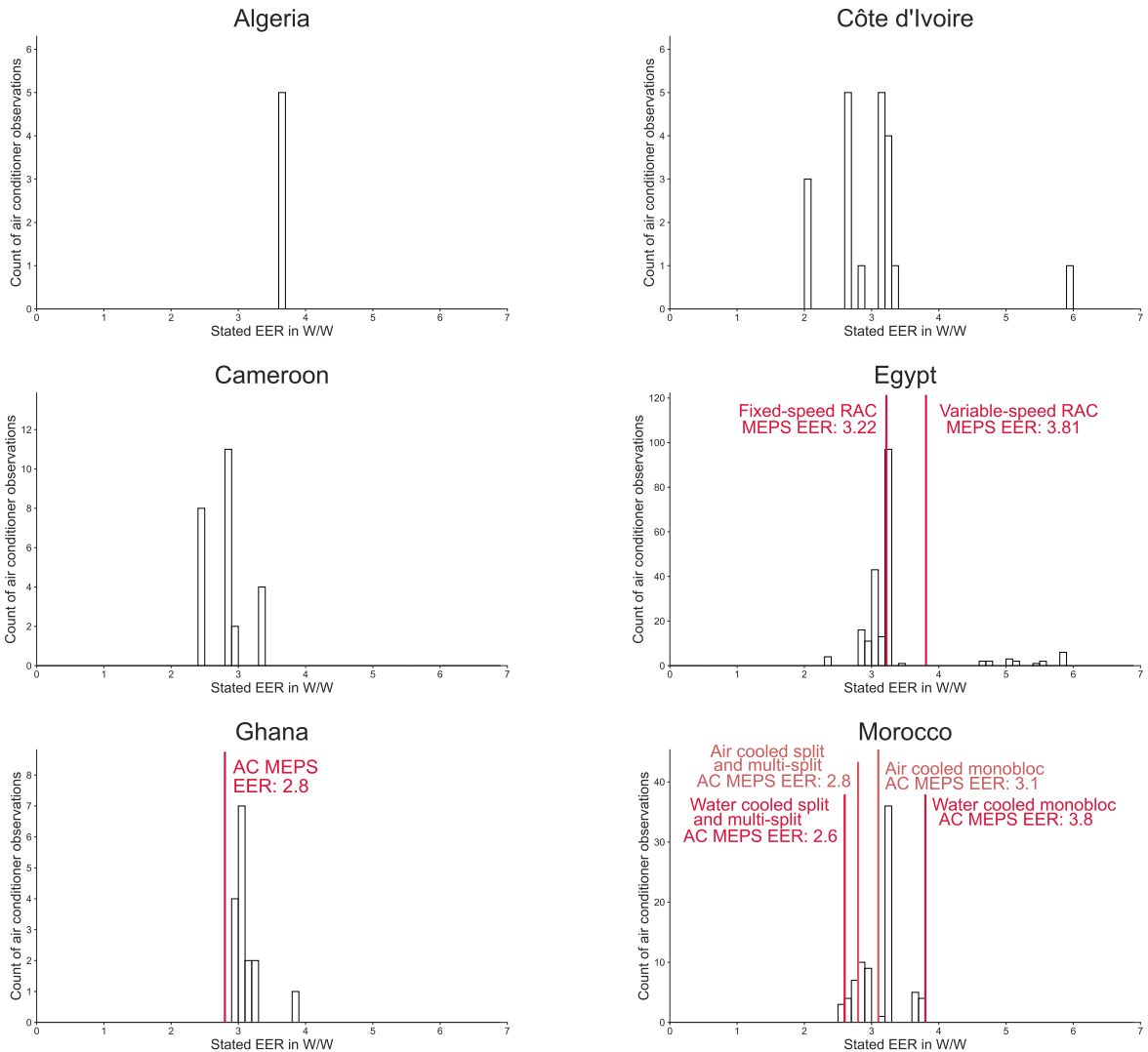
Country	# AC observations	# Brands	% Stated EER	% Stated SEER	% Implicit EER	% Implicit min. EER	% Implicit SEER	% Total EER
Algeria	9	3	55.6		11.1			66.7
Cameroon	44	10	56.8		18.2			75.0
Côte d’Ivoire	625	31	3.2	1.0	2.9	0.2		7.2
Egypt	2,628	35	7.7		1.0		0.3	9.1
Ghana	686	42	2.3		2.0			4.4
Kenya	30	12			3			3
Morocco	393	30	20.1		5.9			26.0
Nigeria	8,831	52	3.9		2.7			6.6
Senegal	436	42	6.4	0.2	7.1			13.8
South Africa	3	1						
Tanzania	57	11	26.3		7.0			33.3
Tunisia	343	26	17.5		9.0	1.2		27.7
Uganda	49	5	18.4	2.0	2.0			22.4
Total	14,134	166	5.7	0.1	2.9	0.1	0.1	8.5

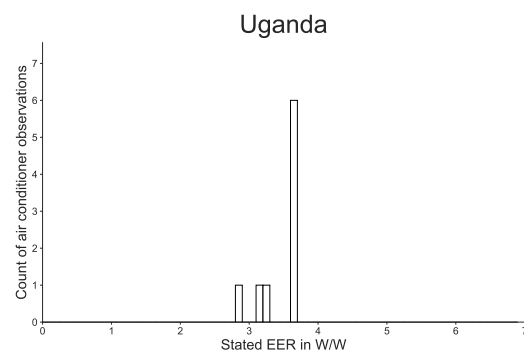
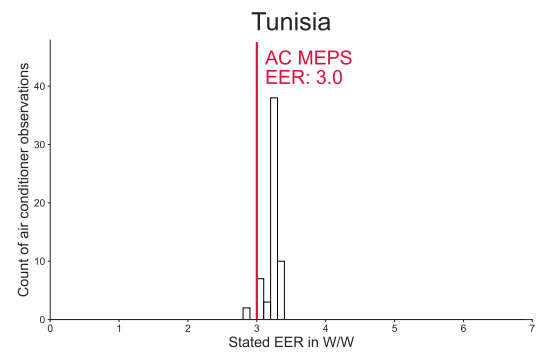
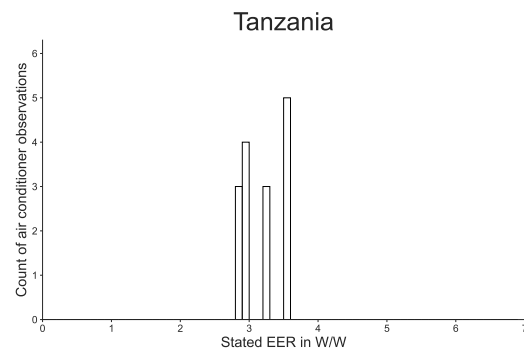
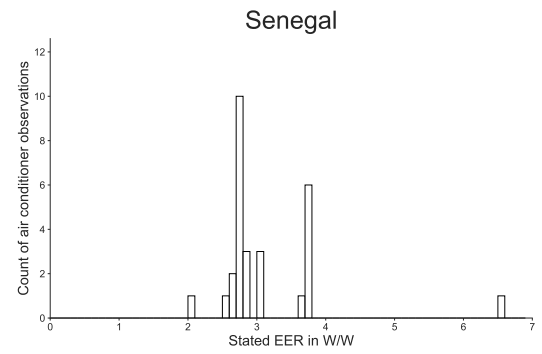
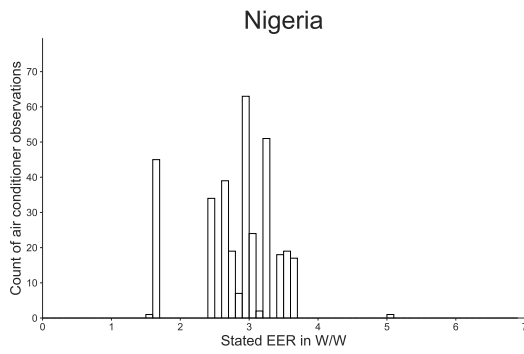
Data cover the period of 28 June 2019 to 30 June 2022. Stated EER: EER explicitly documented in the product description. Stated SEER: SEER explicitly documented in the product description. Implicit EER: EER computed from AC cooling capacity and energy consumption. Implicit min. EER: EER indicator computed from AC cooling capacity and maximum energy consumption. Implicit SEER: SEER indicator computed from AC cooling capacity and seasonal energy consumption.

Table 2: Descriptive statistics: Stated EER in W/W

	Count	Mean	Std dev.	Minimum	Maximum
Algeria	5	3.6	0.0	3.6	3.6
Cameroon	20	2.8	0.3	2.4	3.3
Côte d'Ivoire	15	3.2	0.8	2.0	5.9
Egypt	177	3.3	0.7	2.3	5.9
Ghana	9	3.2	0.3	2.9	3.9
Morocco	51	3.1	0.3	2.5	3.7
Nigeria	271	2.9	0.5	1.5	3.7
Senegal	25	3.2	0.8	2.0	6.5
Tanzania	8	3.2	0.3	2.8	3.6
Tunisia	47	3.2	0.1	2.8	3.4
Uganda	8	3.4	0.3	2.8	3.6

Figure 1: Distribution of Stated EER in W/W.





Note: MEPS usually vary with compressor type and other attributes. As for EER, we make no distinction between AC types and attributes, as we do not systematically observe such characteristics in our data.

During our sample period, six countries had mandatory minimum energy performance standards (MEPS) for ACs – Egypt, Ghana, Kenya, Morocco, South Africa and Tunisia (Shaffie et al., 2022; The Energy Commission, 2020; CLASP, 2019; IEA, 2020a,b; CLASP, 2020) – and two had voluntary MEPS – Nigeria and Uganda (CLASP, 2020). Figure 1 allows us to visualize the stated EER distribution for each country (except Kenya and South Africa, where we have no ACs with stated EER), together with MEPS when relevant. The mass of AC models that fall below the lowest MEPS in a given country provides a proxy for the degree of compliance with the regulation. Egypt stands out with more than half of the models (271, hence 60%) that are not compliant with the regulation. Non-compliance is much less pervasive in other countries. In Morocco and Tunisia, only one model (0.1% in both countries) is not compliant and in Ghana, all available models meet the minimum standard.

4.2 Disclosure of Energy Information

We now examine the decision to disclose energy efficiency information (namely EERs or SEERs) by manufacturers. In our context, manufacturers are responsible for this decision because the e-commerce platform discloses whatever information it receives from the manufacturers. As discussed above, we found that EER or SEER information is only available for 5.8% of the models offered (Table 1). Our goal is to investigate if the disclosure decision is strategic or correlated with specific product characteristics. For instance, if we find that EERs are only disclosed for products that systematically fit certain criteria, this could suggest strategic disclosure. We hypothesize that product quality, which we proxy by price levels, is correlated with the disclosure decision—expensive and high-quality products, yielding high markups, could be more likely to include energy efficiency information. The regulatory environment, particularly the presence of minimum performance standard regulations, could also be a driver of disclosure.

We consider the following linear probability model:

$$STATED_i = \beta MEPS_i + \gamma_j \cdot PRICECT_{ij} + \sigma_b \cdot BRAND_{ib} + \lambda_c \cdot COUNTRY_{ic} + \mu_m \cdot MONTH_{im} + \epsilon_i, \quad (1)$$

where the dependent variable is the disclosure dummy $STATED_i$, taking the value one if the stated EER/SEER of the AC model i is disclosed and zero otherwise. We regress this dummy against a parsimonious set of observable variables. The dummy $MEPS_i$ takes the value one when the country, on whose platform model i is displayed, has implemented a mandatory MEPS. The coefficient β estimates the effect of the existence of a MEPS on the probability of the AC having a disclosed EER/SEER. We use $PRICECT_{ij}$, a dummy for each price level j , to proxy for product quality. The coefficients γ_j estimate the effect of price level j on the probability of disclosure. The dummies $BRAND_{ib}$ refer to each brand b . The coefficients σ_b estimate the brand b 's effect on the probability of stated energy efficiency disclosure. The dummies $COUNTRY_{ic}$ and $MONTH_{im}$ refer to country and the AC's month of first appearance on a given country's Jumia website effects, respectively. Their coefficients λ_c and μ_m capture these variables' effect on the probability of energy efficiency disclosure.

Note that we exclude ACs with a maximum price above USD 2,000 and countries where no ACs have stated EER information (Kenya and South Africa).

As shown in Table 3, we find that the disclosure decision is negatively correlated with the descending price terciles, i.e., AC models in the top two highest price terciles are more likely to have their EER information disclosed relative to AC models in the lowest price tercile. This correlation holds across the different specifications. To account for time trends, we control for the month-of-sample the product was first offered on the platform. We also control for country fixed and brand fixed effects.

The coefficient of the regulation dummy is positive in the model with only the price terciles present. But the impact of regulation is not identified once we account for country fixed effect. This variable is likely to be correlated with other country-specific variables, which we do not account for. The specification with brand fixed effects generates several insights. First, the relatively

high adjusted R-squared value suggests brands explain a significant portion of the variance in the disclosure decision.¹¹ In Figure 2, we rank brand fixed effects. We observe substantial heterogeneity, as well as some patterns. Smaller brands (i.e., the ones with less models offered) are more likely to disclose, for instance, relative to larger brands. To illustrate this, we have indicated the number of AC models offered by each brand on the figure labels. The five brands that most frequently display energy efficiency information tend to be those with the smallest catalogues available on the retail platform.

Overall, our analysis of the disclosure decision points toward some strategic elements. Quality, energy regulations, and brand size are correlated with the disclosure decision. These elements, however, explain only part of the variation in the disclosure decision, which remains mostly idiosyncratic.

Table 3: Disclosure decision: linear probability model

	Decision to disclose EER or SEER		
	(1)	(2)	(3)
Country with mandatory MEPS	0.0284*** (0.0053)		
Price category 400-1000 USD	-0.0302*** (0.0098)	-0.0333*** (0.0094)	-0.0335*** (0.0091)
Price category <400 USD	-0.0708*** (0.0096)	-0.0458*** (0.0097)	-0.0353*** (0.0095)
Constant	0.0957*** (0.0095)	0.0867*** (0.0315)	0.0825** (0.0329)
Country	No	No	Yes
Brand	No	Yes	Yes
Month of first appearance	No	Yes	Yes
R squared	0.0169	0.1734	0.2154
Adj R squared	0.0167	0.1615	0.2035
Observations	14,101	14,101	14,101

***, **, * denote significance at the 1%, 5% and 10% level, respectively.

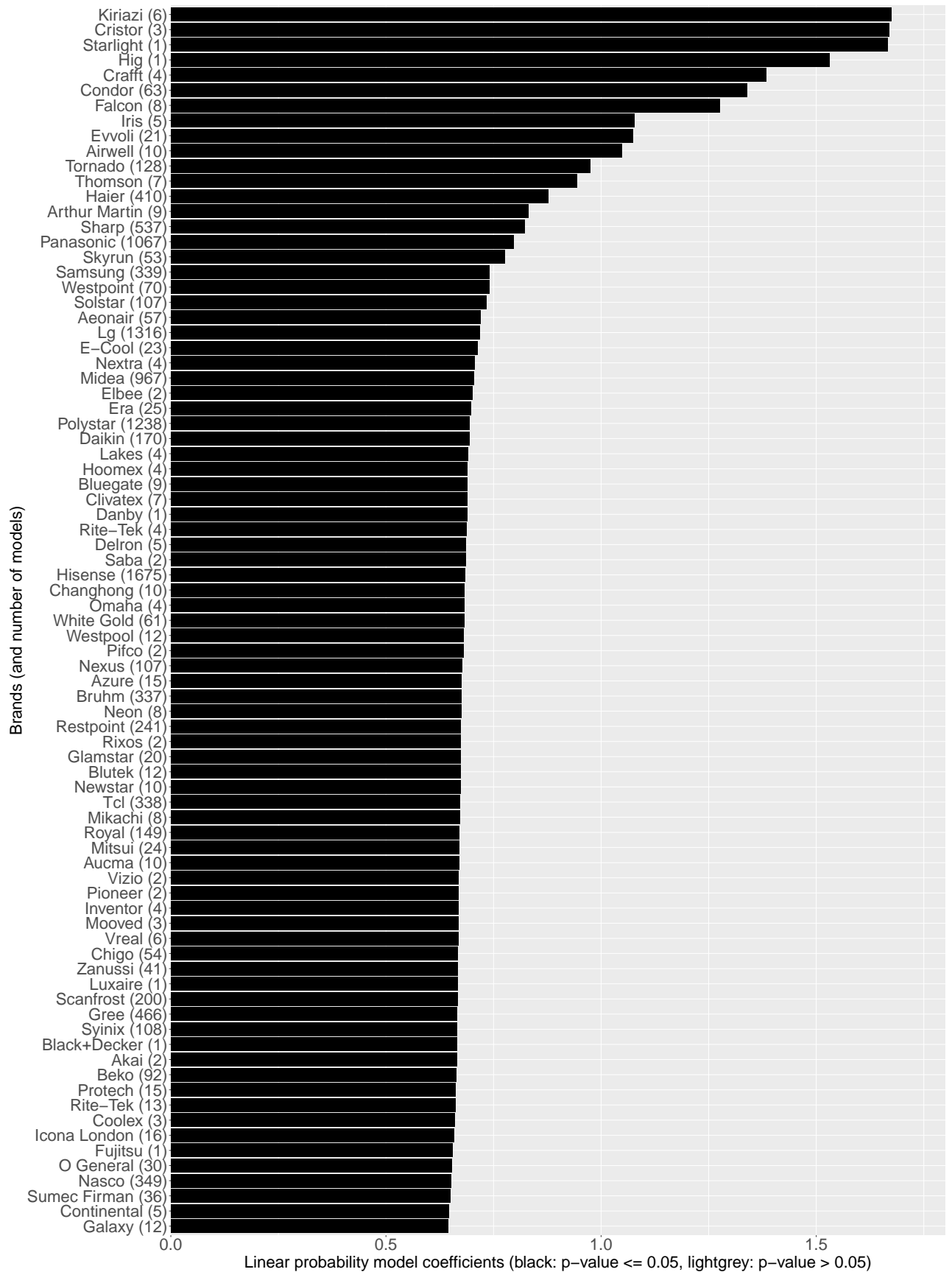
All regressions have robust standard errors.

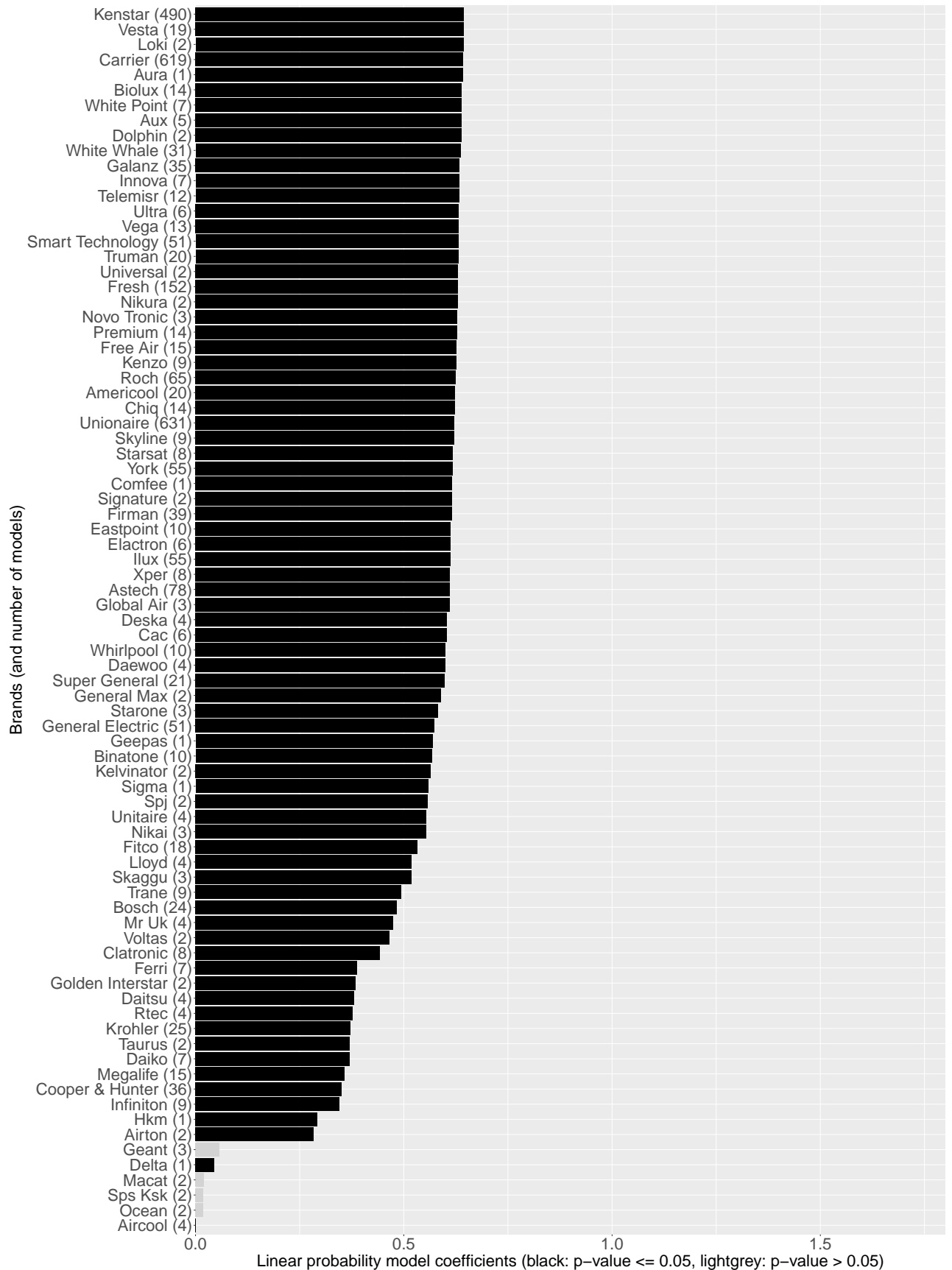
5 Conclusion

In an effort to document AC product lines in the African continent, we have assembled a database of product characteristics from online markets in 13 countries: Algeria, Cameroon, Côte d’Ivoire, Egypt, Ghana, Kenya, Morocco, Nigeria, Senegal, South Africa, Tanzania, Tunisia, and Uganda. Our analysis shows that less than 10% of ACs (N=1,229) available for sale on Jumia—Africa’s leading e-commerce platform—have their energy performance disclosed. While price levels, energy regulations, and brand size seem to explain some of the variation in energy efficiency disclosure, information disclosure is highly idiosyncratic.

¹¹We also considered a model where brand fixed effects were replaced by brand size and we found that the former regressor significantly improves the model’s ability to explain the variation in the efficiency disclosure decision than the latter. The brand fixed effects capture several dimensions related to a brand’s strategy, e.g. marketing strategy, in addition to the number of models offered.

Figure 2: Brand effects, indicating their propensity to disclose information





The disclosure of energy information in these markets is unlikely to occur without government intervention. Given the rapid expansion of the demand for cooling technologies across Africa in the upcoming years, it is crucial to implement policies quickly and enforce them effectively. Specifically, a combination of information provision and incentives could be instrumental in encouraging the adoption of highly energy-efficient appliances, thus helping African households adapt to climate change.

An important avenue for further research would be to enhance the database with product data gathered directly from manufacturers, thus allowing us to get a more complete overview of the energy efficiency of ACs in African online markets. The data collection could also be extended to further regions where AC markets are more established – India, Brazil, the United States and a key European countries such as France, Italy, Spain and Greece. This would generate insights into how energy efficiency standards could be coordinated at the international level.

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References

- Arona Diedhiou, Adeline Bichet, Richard Wartenburger, Sonia I. Seneviratne, David P. Rowell, Mouhamadou B. Sylla, Ismaila Diallo, Stella Todzo, N'datchoh E. Touré, Moctar Camara, Benjamin Ngounou Ngatchah, Ndjido A. Kane, Laure Tall, and François Affholder. Changes in climate extremes over West and Central Africa at 1.5 °C and 2 °C global warming. *Environmental Research Letters*, 13(6):065020, June 2018. ISSN 1748-9326. doi: 10.1088/1748-9326/aac3e5. URL <https://dx.doi.org/10.1088/1748-9326/aac3e5>.
- Grigory Nikulin, Chris Lennard, Alessandro Dosio, Erik Kjellström, Youmin Chen, Andreas Hänsler, Marco Kupiainen, René Laprise, Laura Mariotti, Cathrine Fox Maule, Erik van Meijgaard, Hans-Jürgen Panitz, John F. Scinocca, and Samuel Somot. The effects of 1.5 and 2 degrees of global warming on Africa in the CORDEX ensemble. *Environmental Research Letters*, 13(6):065003, May 2018. ISSN 1748-9326. doi: 10.1088/1748-9326/aab1b1. URL <https://dx.doi.org/10.1088/1748-9326/aab1b1>.
- Rupa Basu. High ambient temperature and mortality: a review of epidemiologic studies from 2001 to 2008. *Environmental Health: A Global Access Science Source*, 8:40, September 2009. ISSN 1476-069X. doi: 10.1186/1476-069X-8-40.
- Alan Barreca, Karen Clay, Olivier Deschenes, Michael Greenstone, and Joseph S. Shapiro. Adapting to Climate Change: The Remarkable Decline in the US Temperature-Mortality Relationship over the Twentieth Century. *Journal of Political Economy*, 124(1):105–159, February 2016. ISSN 0022-3808. doi: 10.1086/684582. URL <https://www.journals.uchicago.edu/doi/10.1086/684582>.
- U.S. EIA. U.S. Energy Information Administration - EIA - Independent Statistics and Analysis, 2020. URL [https://www.eia.gov/consumption/residential/data/2020/index.php?view=state&src=%E2%80%B9%20Consumption%20%20%20%20%20Residential%20Energy%20Consumption%20Survey%20\(RECS\)-f3](https://www.eia.gov/consumption/residential/data/2020/index.php?view=state&src=%E2%80%B9%20Consumption%20%20%20%20%20Residential%20Energy%20Consumption%20Survey%20(RECS)-f3).
- Lucas Davis, Paul Gertler, Stephen Jarvis, and Catherine Wolfram. Air conditioning and global inequality. *Global Environmental Change*, 69:102299, July 2021. ISSN 0959-3780. doi: 10.1016/j.gloenvcha.2021.102299. URL <https://www.sciencedirect.com/science/article/pii/S0959378021000789>.
- IEA. Africa Energy Outlook 2022. 2022.
- Peter J. Marcotullio, Carsten Keßler, and Balázs M. Fekete. The future urban heat-wave challenge in Africa: Exploratory analysis. *Global Environmental Change*, 66:102190, January 2021. ISSN 0959-3780. doi: 10.1016/j.gloenvcha.2020.102190. URL <https://www.sciencedirect.com/science/article/pii/S0959378020307731>.
- Paul J. Gertler, Orié Shelef, Catherine D. Wolfram, and Alan Fuchs. The Demand for Energy-Using Assets among the World’s Rising Middle Classes. *American Economic Review*, 106(6):1366–1401, June 2016. ISSN 0002-8282. doi: 10.1257/aer.20131455. URL <https://www.aeaweb.org/articles?id=10.1257/aer.20131455>.
- CLASP. Scoping Study of African Air Conditioner Markets. Technical report, 2018. URL <https://www.clasp.ngo/research/all/scoping-study-of-african-air-conditioner-markets/>.
- World Bank. Access to electricity (% of population) - Ghana - Data, 2021. URL <https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS?locations=GH>.
- Daniel Kwabena Twerefou and Jacob Opantu Abeney. Efficiency of household electricity consumption in Ghana. *Energy Policy*, 144:111661, September 2020. ISSN 0301-4215. doi: 10.1016/j.enpol.2020.111661. URL <https://www.sciencedirect.com/science/article/pii/S0301421520303918>.

- Giacomo Falchetta and Malcolm N. Mistry. The role of residential air circulation and cooling demand for electrification planning: Implications of climate change in sub-Saharan Africa. *Energy Economics*, 99:105307, July 2021. ISSN 0140-9883. doi: 10.1016/j.eneco.2021.105307. URL <https://www.sciencedirect.com/science/article/pii/S0140988321002127>.
- International Finance Corporation (World Bank Group) IFC. The Dirty Footprint of the Broken Grid. Technical report, 2019. URL https://www.ifc.org/wps/wcm/connect/Industry_EXT_Content/IFC_External_Corporate_Site/Financial+Institutions/Resources/Dirty-footprint-of-broken-grid.
- IEA. The Future of Cooling. 2018. URL <https://www.iea.org/reports/the-future-of-cooling>.
- CLASP. Kenya Room Air Conditioner Market Assessment and Policy Options Analysis. Technical report, 2019. URL <https://www.clasp.ngo/research/all/kenya-rac-market-assessment-and-policy-options-analysis-2019/>.
- CLASP. Environmentally Harmful Dumping of Inefficient and Obsolete Air Conditioners in Africa. Technical report, 2020. URL <https://www.clasp.ngo/research/all/environmentally-harmful-dumping-of-inefficient-and-obsolete-air-conditioners-in-africa/>.
- Ambereen Shaffie, Nihar Shah, Nihan Karali, Won Park, Moustafa Al-Sammany, Brian Holuj, and Leon Becker. Cooling Egypt: Cost and benefits of room air conditioner efficiency improvement in Egypt. Technical Report None, 1895348, ark:/13030/qt4qf5z8j2, October 2022. URL <https://www.osti.gov/servlets/purl/1895348/>.
- Ghana The Energy Commission. Ghana Appliance Energy Efficiency Standards and Labelling Programme, 2020. URL <http://www.energycom.gov.gh/efficiency/standards-and-labelling>. Publication Title: Ghana Appliance Energy Efficiency Standards and Labelling Programme.
- IEA. MEPS for Air Conditioners – Policies. Morocco, 2020a. URL <https://www.iea.org/policies/7683-meps-for-air-conditioners>. Publication Title: IEA.
- IEA. Law No. 2009-7 – Policies, 2020b. URL <https://www.iea.org/policies/2439-law-no-2009-7>. Publication Title: IEA.
- Kofi A. Agyarko, Richard Opoku, and Robert Van Buskirk. Removing barriers and promoting demand-side energy efficiency in households in Sub-Saharan Africa: A case study in Ghana. *Energy Policy*, 137:111149, February 2020. ISSN 0301-4215. doi: 10.1016/j.enpol.2019.111149. URL <https://www.sciencedirect.com/science/article/pii/S0301421519307360>.
- AFDB. Africa Digital Transformation Action Plan (2022 - 2026), 2022.
- Alistair Tempest. The Digital Economy and Ecommerce in Africa – Drivers of the African Free Trade Area? 2020.
- African Union. The Digital Transformation Strategy for Africa (2020-2030), 2020. URL <https://au.int/sites/default/files/documents/38507-doc-dts-english.pdf>.
- The Infrastructure Consortium for Africa ICA. ICT Financing Trends, 2019. URL <https://www.icafrica.org/en/topics-programmes/ict/ict-financing-trends/>. Publication Title: ICA.
- Alberto Cavallo and Roberto Rigobon. The Billion Prices Project: Using Online Prices for Measurement and Research. *Journal of Economic Perspectives*, 30(2):151–178, May 2016. ISSN 0895-3309. doi: 10.1257/jep.30.2.151. URL <https://pubs.aeaweb.org/doi/10.1257/jep.30.2.151>.
- Brian F Gerke and Thomas Tu. International Database of Efficient Appliances (IDEA): A Novel Tool for Efficiency Program Development and Evaluation. 2015.

- EU. Regulation (EU) 2017/1369 of the European Parliament and of the Council of 4 July 2017 setting a framework for energy labelling and repealing Directive 2010/30/EU (Text with EEA relevance.), July 2017. URL <https://eur-lex.europa.eu/eli/reg/2017/1369/oj>.
- EU. Commission Delegated Regulation (EU) 2019/2016 of 11 March 2019 supplementing Regulation (EU) 2017/1369 of the European Parliament and of the Council with regard to energy labelling of refrigerating appliances and repealing Commission Delegated Regulation (EU) No 1060/2010 (Text with EEA relevance.), March 2019. URL http://data.europa.eu/eli/reg_del/2019/2016/oj/eng.
- U.S. Department of Energy. Energy.gov. Room Air Conditioners. URL <https://www.energy.gov/energysaver/room-air-conditioners>. Publication Title: Energy.gov.
- EESI. Fact Sheet - Air Conditioner Efficiency Standards: SEER 13 vs. SEER 12 - White Papers - EESI. URL <https://www.eesi.org/papers/view/fact-sheet-air-conditioner-efficiency-standards-seer-13-vs.-seer-12#1>.
- Won Young Park, Nihar Shah, Jun Young Choi, Hee Jeong Kang, Dae Hoon Kim, and Amol Phadke. Lost in translation: Overcoming divergent seasonal performance metrics to strengthen air conditioner energy-efficiency policies. *Energy for Sustainable Development*, 55:56–68, April 2020. ISSN 0973-0826. doi: 10.1016/j.esd.2020.01.003. URL <https://www.sciencedirect.com/science/article/pii/S0973082619313560>.
- Baijia Huang, Peter Martin Skov Hansen, Jan Viegand, Philippe Riviere, Hassane Asloune, and Florian Dittmann. Air conditioners and comfort fans, Review of Regulation 206/2012 and 626/2011 Final report. Research Report, European Commission, DG Energy, May 2018. URL <https://hal-mines-paristech.archives-ouvertes.fr/hal-01796759>.