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RESEARCH ARTICLE

ENERGY EFFICIENCY: AN ALTERNATIVE FOR REDUCING GREENHOUSE GAS EMISSIONS AND HOUSEHOLD ELECTRICITY BILLS IN TANKPÈ AND ZOPAH, IN THE MUNICIPALITY OF ABOMEY-CALAVI, BENIN

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Abstract

This study addresses the issue of excessive electricity consumption by energy-intensive appliances that flood the Beninese market and pollute the environment. It aims to demonstrate how, using information from energy labels, consumers can identify and purchase energy-efficient appliances, thereby saving money and protecting the environment from greenhouse gas emissions. To achieve this objective, the study employs a mixed-methods approach combining quantitative and qualitative methods. Using data collection tools such as a survey questionnaire and an interview guide, we targeted over 5.000 houses, with a sample of 60 households in each area. From the results, we can temporarily conclude that the spongy borders of Benin help the massive influx of energy-intensive second-hand equipment and new equipment smuggled from Nigeria, Europe, and Asia, the majority of which are of low energy efficiency. Despite the existence of energy performance standards in Benin, the country struggles to clean up its energy market, and many households have real difficulty reading and understanding energy labels. They are not adequately informed of the simple actions and behaviors they can adopt daily to reduce their electricity bills and improve their environment.

Introduction:-

The modern world is undergoing a major energy transition, compelling nations to shift paradigms and define new energy policies. Several factors drive this necessity. First, there are market tensions and rising prices for hydrocarbons. Second, there is the imperative of energy security, alongside climate change—an issue whose impacts concern both leaders and citizens alike. The situation is particularly concerning for countries like Benin, which rely on external sources for their energy supply. Meanwhile, the demand for electricity continues to rise, forcing the State and theBenin Electric Energy Company to commit to new investments. Available energy—often imported at great cost—is squandered by both households and public institutions through the use of energy-intensive lighting and equipment. Poor electricity consumption habits contribute to the waste of this scarce resource, which other

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nations are striving to conserve. To sustain or expand economic activity while consuming less energy, efforts must focus on three areas: energy sobriety (in both individual behaviour and organizational practices), energy efficiency, and the adoption of renewable energy sources.

This effort must be underpinned by a proactive, clear, and stable policy focused on energy management, with key objectives including:-

- easing the financial burden on households by lowering energy bills;
- reducing State expenditure on direct and/or indirect subsidies for energy products;
- reducing and eventually optimizing public investment in energy production.

Energy management has become a top priority for the current government, which has issued a decree to regulate the importation of LRC products (lamps, refrigerators, and freezers) into the country. Despite the authorities' efforts to clean up the market, it is evident that low-efficiency appliances—which fail to meet energy performance standards—continue to flood the Beninese market.

This situation raises a number of questions:-

- what factors explain the strong tendency among certain households to use energy-intensive appliances?
- are they sufficiently informed about the benefits of energy efficiency?

The aim of this research is to demonstrate that energy efficiency offers a way to reduce both greenhouse gas emissions and household electricity bills.

Specifically, the study seeks to:-

- identify the factors explaining the strong tendency among certain households to use energy-intensive appliances;
- assess the level of awareness regarding the benefits of energy efficiency among residents of Tankpè and Zopah.

The methodology adopted combines quantitative and qualitative approaches. Data collection tools included surveys and interview guides. A total of 120 households were selected, with 60 households chosen from each of the study areas: Tankpè and Zopah, in the municipality of Abomey-Calavi.

Study context:-

For nearly fifteen (15) years, Benin has been working to foster a culture of energy efficiency.Indeed, integrating an energy efficiency policy into the development process is now recognized—both nationally and internationally—as a means to meet demand and defer certain investments in new power plants or in the reinforcement of electricity transmission and distribution networks. Thanks to World Bank funding through the Energy Service Delivery Project (PFSE), the Modern Energy Access Development Project (DAEM), and the Millennium Challenge Account Benin II, some households have been sensitized to the rational use of electricity. Despite these efforts, it is evident that a number of barriers still hinder the adoption of the concept of energy efficiency by households.

The main barriers identified are as follows:-

- lack of awareness regarding the concept of energy efficiency among the majority of households in Benin;
- limited technical expertise in energy management, particularly within the private sector;
- fragmented institutional oversight of energy management;
- limited available funding and the absence of a role for the local banking sector in this area.

Data and Methods:-

For this article, we conducted two questionnaire-based surveys in two neighborhoods of the Abomey-Calavi municipality: Tankpè and Zopah. These two neighborhoods were selected for two key reasons. First, both localities are situated within the Abomey-Calavi municipality, which is known in Benin as a "dormitory town." The second reason is based on contrast: Tankpè is a somewhat precarious neighbourhood where residents have—relatively speaking—low purchasing power, whereas Zopah is a neighbourhood where residents possess high purchasing power, evidenced by the modern apartments and the residents' lifestyle. This contrast was intentional, designed to determine whether households' choices regarding electrical appliances depend on their purchasing power. Survey participants were selected at random from a total population estimated at sixty households per neighbourhood.

Conceptual framework:-

"Energy efficiency" is defined as the "ratio between the amount of useful energy delivered by a system and the amount of energy consumed to operate it." Ultimately, this notion relates to the concept of "energy service"—a function provided by a piece of equipment (such as a light bulb or a vehicle) powered by an energy input like electricity or fuel. It encompasses all technical and logistical measures implemented to optimize a system's energy performance (e.g., for a building or a facility) while maintaining or improving the service provided. The aim is to reduce energy dependence on fossil fuels (gas, coal, oil) and limit greenhouse gas emissions, which drive climate change. Energy efficiency offers significant economic and environmental benefits.

Key collective benefits include:-

- reduction of CO2 emissions and strengthened energy sovereignty;
- savings on energy and CO2-related costs within the context of carbon pricing;
- reduced maintenance and upkeep costs for efficient systems;
- stabilization of energy systems, ensuring uninterrupted production.

To reap these benefits, energy experts advocate for energy sobriety. Unlike energy efficiency, the concept of energy sobriety is less familiar to the general public. It is a policy concept introduced to encourage reduced energy consumption through changes in daily habits. It is not about carrying out renovations to improve a building's energy performance, but rather about adopting better energy-related habits.This national energy sobriety plan—which includes recommendations such as turning off lights when leaving a room—is guided by four key principles.

The first principle—"Energy 1.0"—focuses on the behaviours involved in energy sobriety. It requires us to be more attentive—and thus better informed—about how we use energy (whether consciously or unconsciously, and therefore voluntarily or involuntarily) so that we can change those habits. More than 200 actions or habits (also known as "eco-behaviours") have been identified that help reduce energy consumption: closing shutters and/or curtains, regularly defrosting the refrigerator, lowering the heating temperature (depending on the room and time of day), avoiding leaving electrical appliances on standby, and turning off lights—to name just a few simple examples from everyday life.

However, no matter how vigilant we are, managing our behaviour cannot compensate for energy loss in a poorly insulated home or one equipped with an old, inefficient boiler. We must therefore activate the second lever—"Energy 2.0"—which entails energy-efficient renovation. Public policy is specifically targeting this fundamental and highly relevant lever, given the state of the existing housing stock. This is where the Energy Savings Certificate (CEE) scheme proves its true value: it not only identifies specific energy renovation measures—typically over twenty are listed for a single home—but also estimates the average energy savings achievable over the measures' useful lifespan (accounting for efficiency loss due to wear and tear over time). These savings are expressed in a unit created specifically for this purpose: the "kWh Cumac" (discounted cumulative kWh), a hybrid unit bridging the energy and financial sectors. The ultimate goal is, of course, to create a financial incentive that encourages consumer-clients to proceed with renovation work. It is crucial to note, however, that while this incentive is a necessary condition, it is not a sufficient one on its own. The third lever—"Energy 3.0"—involves the implementation of "smart technologies." Essentially, the aim is to help clients take charge of their energy future by providing precise measurement tools that allow them to better understand—and thus better manage—their energy usage. This has led to the emergence of a wide range of "smart" devices, from "smart boxes" and smart thermostats to smart meters. These devices provide real-time consumption data to clients who are transitioning into "eco-consumers" (although, for the time being, electricity benefits most readily from this specific type of "energy intelligence"). This lever acts as an accelerator for optimizing energy performance; this can manifest as consumption comparisons with similar consumer groups, increased automation (now enabled by "smart boxes"), or a heightened focus on system performance following investments—as well as the continuous adjustment of behaviours based on seasonal changes or evolving family needs, to name just a few examples.

According to Boulanger (2007), public authorities—primarily in oil-importing countries—began to show interest in the rational use of energy and the improvement of energy efficiency at the time of the first oil crisis in 1973. He notes that while industrialized nations initially sought a solution to the crisis primarily through supply-side policies, an increasing number of voices began to emphasize the urgency and promise of a demand-oriented approach, citing the significant potential for energy and economic efficiency offered by available technologies and rational energy-use behaviours. Among these voices was that of Amory Lovins—who coined the term "negawatt" in 1988. In his influential 1976 article "Energy Strategy: The Road Not Taken?", Lovins demonstrated that there were two possible paths to resolving the energy problem: the "hard" path, involving increased production capacity based on oil, coal,

and uranium; and the "soft" path, based on conservation, rational use, efficiency, and renewable energy. Nearly 30 years after that seminal 1976 article, Lovins (2005, p. 1) reaffirmed his position: "Increasing end-use energy efficiency—that is, delivering more service per unit of energy consumed—is generally the most abundant, least expensive, most benign, quickest to implement, least visible, least understood, and most neglected way to provide energy services."

Situation assessment and problems to be addressed:-

Situation assessment:-

The rise in electricity consumption can be linked to the lamps and electrical appliances available on the Beninese market.

This market... ...is characterized by three sources of electrical appliance imports:-

- importers of used vehicles—primarily from Europe—fill them with household appliances, air conditioners, and other items that have poor energy performance;
- trade with Nigeria, a source of equipment with little to no technical documentation and poor energy performance; and
- imports of new equipment from Europe and Asia, most of which is not energy-efficient and includes air conditioners using Freon 22, a known greenhouse gas.

In the context of economic globalization, products that can no longer enter certain markets (such as those in industrialized nations regulated by energy performance standards) are inevitably diverted to markets in developing countries—like Benin—that are likely to accept them. The table opposite summarizes the strengths, weaknesses, opportunities, and threats identified during the assessment.

Table 1: General assessment (Strengths-Weaknesses, Opportunities-Threats) of energy efficiency promotion in Benin

STRENGTHS	WEAKNESSES
- Establishment of a testing laboratory for lamps and other energy-efficient equipment; - Financial, human, and material resources mobilized to promote energy efficiency; - Previous experience in promoting energy efficiency: the Energy Service Delivery Project (PFSE), the Modern Energy Access Development Project (DAEM), and the Millennium Challenge Account Benin II.	- High cost of energy-efficient products; - Imported new electrical appliances rarely bearing technical information regarding their energy consumption levels; - Lack of stores dedicated to energy-efficient appliances; - Absence of large-scale, ongoing initiatives addressing energy and environmental issues; - Presence of so-called "1-watt, 2-watt, or 5-watt" lamps that are actually energy-intensive; - Limited awareness of high-quality energy-efficient appliances; - Refrigerators and freezers frequently used for commercial purposes and often purchased second-hand rather than new; - Poor maintenance of refrigerators and freezers, often evidenced by rusted casings; dust and cobwebs are sometimes visible around the heating element; - Frequent overloading of refrigerators and air conditioners; whether for chilled water sachets or ice, products are stacked in a way that leaves little empty space; - Failure to cover costs associated with publicizing stakeholder communication activities aimed at the target audience—an expense not provided for in the implementation agreements between MCA Benin II and the stakeholders, yet one that creates internal financial difficulties; - Cessation of energy efficiency communication activities as soon as the underlying projects conclude.
STRENGTHS	**WEAKNESSES**

- Adoption of minimum performance standards by Benin; - Market regulation in line with new rules governing the importation of household appliances; - Availability of the necessary expertise among stakeholders to foster a sustainable energy-efficiency culture within the Beninese population; - Consumers purchasing electrical equipment based on recommendations; - Consumers increasingly inclined towards energy-efficient lamps.	- Consumer preference for imported second-hand products due to low purchasing power; - Importation of energy-intensive used equipment; - Importation of new equipment that does not meet energy efficiency standards; - Porous borders (customs issues); - Reluctance among women to address electricity-related issues, viewing them as the domain of men; - Poor organization among informal sector vendors; - Limited knowledge of energy efficiency among men, women, and children; - Tradespeople (electricians, refrigeration technicians) lack the necessary skills for the electrical installations required for energy efficiency; - Very low representation of women among electricians (3 women out of over 600 members of the Benin Building Electricians' Collective); - Absence of measures in Benin to encourage or incentivize energy efficiency.

This table reveals the predominance of weaknesses and threats, first internally and then externally. In summary, the key takeaways from the diagnosis are as follows:

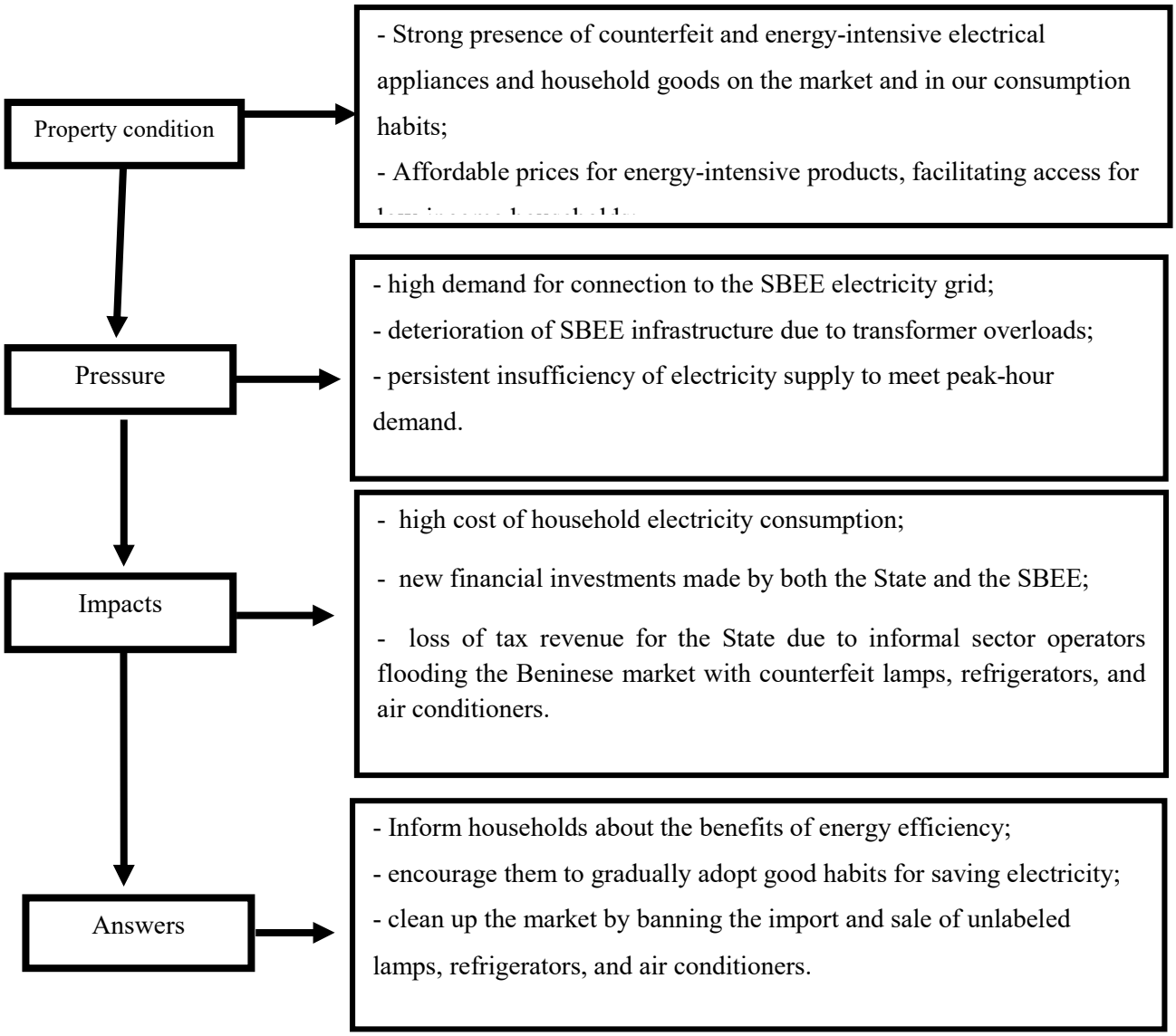

Figure 1: Summary of the diagnosis and proposed response
Source: Author, September 2026

This assessment highlights the issues that need to be addressed.

Issues to be addressed:-

The issues to be addressed fall into two categories:-

- the strong tendency among the Beninese population to use energy-intensive appliances;
- the adoption of poor practices or behaviours that do not promote energy efficiency at the household level.

Analysis of these issues indicates that communication can play a role in addressing the identified problems. In a context where energy-efficient appliances cost seven to eight times more than used products or new ones imported

without any regulation, how can households be convinced to choose electrical appliances that meet energy efficiency standards?

Objectives and hypotheses:-
Study objectives:-
For this study, we have formulated two objectives:-
- to identify the factors explaining the strong tendency of certain households to use energy-intensive appliances;
- to assess the level of knowledge regarding the benefits of energy efficiency among residents of Tankpè and Zopah.

Research hypotheses:-
Aligning the three issues with the specific objectives leads us to formulate the following hypotheses:-
- the strong tendency of households to use energy-intensive appliances is explained by their low purchasing power;
- the low level of knowledge among residents of Tankpè and Zopah explains the adoption of poor practices or behaviours that do not foster energy efficiency.

Results and Discussion:-

Research results from the surveyed households show that in the Tankpè area, 72% of respondents admit to buying second-hand household appliances due to their purchasing power. The use of such energy-intensive appliances leads not only to excessive electricity consumption but also to higher electricity bills. In contrast, in Zopah—where the majority of residents are relatively well-off—86.36% purchase new appliances from stores. 37.44% even take the energy label affixed to the appliance into account when making their choice. Consequently, there is a link between electricity consumption and the population's standard of living, as "the higher the per capita income, the lower the energy demand." Household poverty prevents people not only from purchasing energy-efficient appliances but also—and above all—from accessing modern energy distribution networks, where initial connection costs are often exorbitant relative to their income.

There is a significant lack of awareness or understanding among consumers regarding the energy implications of appliance use; this stems from the fact that, when seeking information, consumers rely on their past experiences with specific brands or models, as well as on advice from friends.The study also reveals that shoppers purchasing household appliances at Cotonou's Zongo Market unanimously acknowledge the absence of labels indicating energy performance ratings. This market is supplied by used-vehicle importers who, to maximize profitability, typically fill the imported vehicles with all manner of household appliances, air conditioners, and other items characterized by poor energy efficiency. Furthermore, the trade in electrical equipment between Benin and Nigeria, and between Benin and China, facilitates the influx of unlabeled appliances accompanied by technical manuals that fail to provide accurate information on energy characteristics. While equipment sourced from Nigeria is not always old or worn out, most of it is energy-inefficient. Business operators also import new electrical equipment from Europe and Asian countries, particularly China.

However, it has been observed that most of this equipment is not energy-efficient and fails to meet international standards regarding the use of greenhouse gases. For instance, some air conditioners imported from Asia use Freon-22, a known greenhouse gas. It is therefore important for households to be well-informed so they can make wise choices when purchasing energy-efficient appliances. The MCA-Benin II energy efficiency program has contributed to this goal, enabling savings of approximately 162 GWh between 2016 and 2020 and preventing the emission of nearly 113,000 tonnes of CO2 associated with light bulbs and individual air conditioning units (Victorien Justin Agué, 2022). The impact of the energy efficiency program during the period in question is estimated to be equivalent to deferring the need for a 45 MW power plant five years after the program's implementation. Regarding refrigerators, the program enabled the residential sector to save approximately 11.53 GWh between 2016 and 2020 and avoid the emission of over 8,000 tonnes of CO2; meanwhile, the commercial and institutional sectors saved approximately 13.2 GWh and avoided the emission of over 9,000 tonnes of CO2 during the same period. This is equivalent to deferring the need for a 4.48 MW thermal power plant five years after the program's implementation (Victorien Justin Agué). In light of the research findings, the initial hypothesis—that "households' strong tendency to use energy-intensive appliances is explained by their low purchasing power"—is confirmed. This hypothesis is validated because the study showed that 72% of low-income households in Tankpè are more inclined to purchase inexpensive, energy-intensive appliances. Meanwhile, 86.36% of residents in the Zopah area purchase new items from stores. We can infer from this that they possess the purchasing power to do so. As for the final hypothesis—"The low level of knowledge among residents of Tankpè and Zopah explains the poor practices or behaviors

adopted, which do little to foster energy efficiency"—it is not validated. The collected data show that Tankpè residents are unaware of the simple actions that ensure savings on both energy and money. Residents of Zopah, despite buying new appliances, do not always adopt the behaviors essential for the rational use of electricity.

If we wish to reduce greenhouse gas emissions and our electricity bills moving forward, we must begin adopting the following daily habits:-

- prioritize natural daylight whenever possible; the best way to save energy is simply not to use it;
- plug appliances into power strips that allow us to cut the power supply as soon as the devices are in standby mode;
- use energy-efficient light bulbs; they last much longer and consume less electricity.

Beyond this, specific actions are required depending on the types of appliances we own. Three essential tips should be followed:-

- do not leave appliances in standby mode;
- turn them off when not in use;
- purchase power strips with switches to make this easier.

Specific practices vary depending on the type of appliance. Take refrigerators and freezers, for example:-

- do not place food that is still hot into the refrigerator or freezer;
- $do not leave the refrigerator or freezer door open for too long;
- place these appliances away from any heat source;
- defrost the refrigerator or freezer every three (3) months, especially if it is an older model;
- regularly check the door seals; replace them if the seal is not airtight;
- ensure there is sufficient space behind the appliances for heat dissipation.

Regarding air conditioners, the following measures should be taken:-

- perform periodic maintenance by cleaning the condenser and evaporator fins;
- keep doors and windows closed while the air conditioner is running;
- set the target temperature between 24°C and 25°C and keep doors and windows closed.

It is also necessary to master the techniques for identifying energy-efficient electrical equipment. These fall into three categories:-

- technical specifications indicated on the equipment's nameplate or packaging;
- prior knowledge regarding the equipment's brand and model;
- the energy label (if present on the equipment).

Example 1: Technical specifications for lamps

Figure 1: Packaging of a 20W lampFigure 2: Packaging of a 15 W lamp

The higher the lamp's wattage, the more power it consumes and the higher the electricity bill. Households should therefore prioritize low-wattage lamps. As shown in Figures 1 and 2, the lamp's wattage (see the circled 20W and 15W) is indicated on the packaging. The final technical detail circled in Image 1 is the energy label, which shows the energy efficiency class. Luminous efficacy—expressed in lumens per watt—is the primary indicator used to identify an energy-efficient lamp. A lamp's efficiency class is an indicator that compares its consumption against a reference power level based on its luminous flux (measured in lumens). This allows for the following classifications:

A	B	C	D	E	F	G
(*)	<60%	<80%	<95%	<110%	<130%	>130%

Class A indicates that the equipment is energy-efficient, whereas classes B, C, D, E, F, and G indicate progressively higher levels of energy consumption for electrical equipment. The general scale ranges from A (dark green) for the most energy-efficient appliances to G (red) for those that consume the most. The general scale ranges from A+++ (dark green) for the appliances that consume the least energy to D (red) for the most energy-intensive ones.

Example 2: Technical specifications for refrigerators

Refrigerator data plate located inside

Technical specifications for refrigerators can be found on the rating plate, as shown in the image above.

Conclusion:-

Energy efficiency contributes to the fight against climate change, the reduction of energy consumption, and the preservation of energy resources. It is key to both curbing greenhouse gas emissions and delivering more services while consuming as little energy as possible. Managing energy demand is a major challenge for modern societies facing the threat of climate change. Field surveys conducted for this study revealed that many consumers are unaware that high bills are linked to the types of light bulbs and household appliances they use. They rightly attributed their high electricity costs to the perceived bad faith of the Benin Electric Energy Company. However, the steep cost of their electricity bills stems from the use of energy-intensive appliances; while these may be cheap to buy, they drain household finances. Energy-efficient appliances can be identified by their energy labels. Although they have a higher upfront cost, they are more durable and economical. Poverty drives many households to opt for energy-intensive appliances, which are prevalent on the Beninese market due to the porosity of customs borders.

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