Energy consumption influenced by occupant behavior: A study in residential buildings in Panama

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Abstract*– To propose a framework to assess the influence of occupants' behavior in the energy consumption within the residential sector in a case study in Panama, this work investigates the actual situation regarding building internal characteristics and energy consumption of two types of residential buildings to help built a database. An experimental study was carried out in Panama City, tropical climate, where four houses and three apartments were instrumented in terms of indoor and outdoor temperature and humidity, employing wireless data loggers. As a complement, to collect general households' data and energy consumption, i.e., electric bills, a survey constituted of 43 questions accompanied with small incentives was implemented. With a return response rate of 39.6%, it was possible to show that occupants' behavior and preferences were the critical causes of higher electrical consumption since ACs were frequently set at temperatures within the lower values of standard comfort limits.

Keywords—Energy consumption, occupant behavior, residential buildings, survey, tropical climate.

I. INTRODUCTION

Buildings use approximately 40% of global energy and are liable for almost a third of the worldwide greenhouse gas emissions. They also utilize about 60% of the world's electricity. In the last decade, stringent building regulations have led to significant improvements in the quality of many building envelopes' thermal characteristics [1].

Studies in the Netherlands have shown that energy regulations have been successful in reducing energy consumption in buildings. However, policies, aim to control the quality of construction and change the occupant's behavior are also necessary to achieve more significant energy reductions [2].

The current situation increases the pressure to take actions, such as those established recently in the climate conference in Paris (COP21) [3], which seeks to restrict the increase in greenhouse gas emissions, keeping the global average increase below 2 degrees Celsius and compliance with the Nationally Determined Contribution (NDC, for its acronym in English) and where Panama was one of the nearly 200 countries that signed in December 2015 to this Agreement against climate change, with the 2030 Agenda for Sustainable Development.

According to the National Efficiency Report on Energy Efficiency Monitoring of Panama, 2020, The Sustainable Development Goal 7 stands out, which is focused on energy and seeks: "to guarantee access to affordable, safe, sustainable and modern energy for all" as primordial [4].

In Panama, the residential sector represents more than 30% of the electricity demand [5].

Regarding buildings with similar constructive and operational characteristics (size, number of occupants, electrical appliances, orientation, windows, curtains, among others), a considerable variation in energy consumption among them is reported, which has led to consider that beyond new saving technologies and renewable energy applications that are used, an approach related to the occupant's behavior concerning energy consumption in buildings is necessary [6], [7].

According to simulation studies and monitoring, Wei et al. [8] have evaluated the actual literature on the occupant space-heating in residential buildings. At least 27 possible factors have been assessed as drivers for space-heating behavior, and only five of those 27 factors have been used to model space-heating behavior in building performance simulation (BPS): room type, occupancy, indoor relative humidity, outdoor climate, and time of day by typical operational schedules.

A. Factors affecting energy use

The lack of knowledge about the factors determining the final use of energy is one of the most critical barriers when looking to improve energy efficiency in buildings. In this area, the International Energy Agency (IEA) and the Energy in Buildings and Communities Program (EBC), in their Annex 53 project [9], identified six determinant factors of energy use in buildings: climate, building envelope, energy systems, and building services, interior design criteria, building operation and maintenance, and occupant behavior. The first five factors have developed with significant progress, while, concerning the last factor, there are current scientific flaws in the energy model related to the occupants' behavior in buildings. The energy consumption of a building varies considerably depending on each of these factors, which is why it is important to contextualize the specific environment to carry out adequate energy management, including, in any possible detail, the parameters of the site under study.

A distinction is made at the macro level, between the type and use of buildings (residential and offices), the residential sector presents different characteristics and greater complexity in the definition of occupation profiles, than those of office use [10]. According to experts from the IEA-EBC, and results

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of the international project Annex 66: Definition and simulation of the Behavior of Occupants in Buildings [11], the reasons for these differences are little known and largely have to do more with behavior than with the building design or installed systems.

Most studies on occupant behavior focused on office buildings. Residential buildings are characterized by a diversity of occupancy hours and activities, which can represent an increase in the complexity of monitoring and modelling the occupant behavior [10].

Occupant behavior in residential buildings includes three main categories: the occupancy, the operation of building service and energy systems, and opening windows, curtains, and blinds [12].

It is important to understand that people can know of government policies and information about the roles that they can play in energy saving, but sacrificing comfort levels to achieve energy savings is not a believable option, especially for younger people [13].

B. Occupant behavior related to energy consumption

In the context of these investigations, occupant behavior can be defined as the use of space, systems, and other services within the use that can influence energy consumption for air conditioning of the environment and production of hot water [14]. Furthermore, behavior can be specified as the observable actions or reactions of a person in response to external or internal stimuli or actions or reactions of a person to adapt to environmental conditions (indoor air quality) [12].

Energy consumption related to the behavior of occupants in buildings, actions such as adjusting the thermostat for comfort, turning lights on and off, opening and closing windows, opening and closing windows blinds, and movement between internal environments, is a vital issue for optimizing building design, diagnosing energy use, evaluating the performance of systems, and energy simulation due to its significant impact on the actual energy consumption and in the quality of the indoor environment [11]. Often, significant differences are reported between predictions and actual total energy use in buildings [15].

In research on occupant behavior, the methods used to collect data are essential, whether through measurements (sensors) or interviews or occupants' surveys [16]. Different technologies are used to detect occupancy in buildings [17] . Surveys are one of the most used methods as a tool to obtain information on data related to energy use.

In this matter, the authors in [18] conducted a literature review on the use of questionnaires in residential buildings. This collection of references (around 186) indicated that the questionnaires are mainly used for research on energy consumption and occupant behavior, where the use of different approaches causes the lack of a homogeneous methodology. Direct measurement is the least used method due to its high cost, a small sample size, and little representation. However, it has the advantage of informing the real energy consumption at the end-use or equipment level, it has high precision of the data collected, allowing the user to create awareness and identify changes in behavior that allow energy savings [19] .

Analyses of questionnaires (with multiple choice questions or Likert score scale) have been achieved in researches. In China, Chen et al. [20] found a negative correlation between occupant age and heating/cooling energy consumption, to explain this relationship, it is necessary to look at the thermal comfort perception and distinctive development history of this country. In contrast, investigations developed in countries such as Australia, Denmark, Brazil, and China [21], found that age has a positive correlation with residential energy consumption, while Steemers and Yun (2009) [22] found that the most significant parameter that determines energy use is the climate and the second most important is the use of heating and cooling systems and their control. Guerra Santín (2010) [23], established that occupant characteristics and behavior affect 4.2%, and building characteristics affect 42% of the variation in energy use for heating in the Netherlands.

Thus, this study investigates and starts a database to estimate the characteristics and consumption in the residential sector Panama City and analyze what variables can influence the electricity consumption in a tropical developing country. The main objective answers the question of how these types of changes are reflected in residential consumption and how people use energy inside their homes.

C. Energy regulation in Panama

The National Secretariat of Energy (SNE), the Ministry of Commerce and Industries and the Sectorial Technical Committees recognize the need to implement measures to improve energy efficiency at the national level, which is why several specific actions have been taken by Executive Decree 398 of 2013 and Law 69 of 2012 [24]. In them, it has been established the obligation to the businesses that distribute equipment such as air conditioners, refrigerators, lights, and other electrical appliances, which must comply with the energy efficiency indexes that indicate the technical specifications, providing energy efficiency labels visible to the consumer. Currently, there are fourteen approved Energy Efficiency Indexes.

Panama is one of the Latin American countries that has implemented a mandatory sustainable building code, called Sustainable Construction Guide (RES) for saving energy in buildings and measures for the rational and efficient use of energy, for the construction of new buildings in Panama City [25]. A prescriptive-simplified procedure has been designed with ease of implementation and dissemination at the local level, for its implementation.

One of the most important aspects of The National Energy Plan (PEN in Spanish) [5] is energy efficiency, which they identify as essential to achieve sustainable development. In this sense, efforts have been joined by both private companies and the public sector, in order to define and implement measures that lead us towards a more sustainable development model.

The energy demands are divided into four sectors according to the type of activity in which each client is engaged: residential, commercial, government, and industrial. Considering this classification, in 2017, the highest concentration of clients was in the residential sector, with 89.14% of the total. The province with clients´ highest concentration is Panama, with 59% of its clients [26]. Panama has a little diversified energy matrix, because almost 92% of the produced electric energy, still derived from petroleum, so the petroleum prize directly affects the electricity prizes [5].

According to The National Energy Secretariat, in 2018, the composition of the interconnected national system in installed capacity was 70.2% hydroelectric, 22.3% fuel, 5.3% wind, 2.1% solar, and 0.2% biogas. Wind and solar energy are not used in projects carried out in the city, only in rural projects or urban areas where it is difficult for electricity to reach.

Moreover, the energy production has changed, adding to the country, different ways of obtaining it more ecologically: 63.3% is from petroleum derivatives, 3.1% from coal, 5.0% from natural gas, 16.9% from hydropower, 1.0% from wind energy, 0.4% from solar energy, 0.20% other primary ones (biogas), 2.1% from bagasse and 4.2% from firewood [27].

According to the PEN 2015-2050, energy consumption is divided as follows: 45% transport, 21.8% industry, 15.9% residential, 16.1% commercial and public services, and 0.4% other.

The average temperature of Panama City has increased by 0.77 ºC between 1908 and 2012. Urban growth and the reduction of vegetation cover maybe some of the causes of this phenomenon, which is directly related to energy consumption [5]. Here, two seasons throughout the year are known as summer (or dry season), from January to April, and winter (or rainy season), from May to December, where September to October is the rainiest months of the year. The annual temperature is 27 ºC, and the relative humidity is about 87%. The lowest temperature is registered in the month of December with 25 ºC and the highest in the month of March with 28 ºC.

It is estimated that by 2050, 55% of residential consumption will be due to air conditioning and 48.6% in the commercial sector; 34.7% is estimated to be due to lighting [5].

II. METHODOLOGY

To address the purpose presented before, an experimental study was carried out in Panama City, considering the factor of the site, both cultural, socioeconomic, climatological, and others, so this research allows to lay the foundations for studies where the influence of the occupant behaviors in energy consumption in buildings for residential use.

A. Data Collection

Between October 2010 and January 2011, a survey was implemented to represent the general situation and identify existing and potential problems or limitations in residential energy use.

The questionnaires were randomly distributed to a group of university students. In October 2010, 1060 sets of the six-page questionnaire were distributed. As an incentive to cooperate in the survey and maximize the response rate, all respondents who completed the questionnaire joined a lottery to win nine prizes, each of a B/.10.00 prize.

The questionnaires were collected and analyzed in January 2011, of which only 420 were valid. Obtaining a response percentage of 39.6%, acceptable for this type of study [18] . The statistical Package for the Social Sciences (SPSS) and Microsoft Office Excel was used for tabulation and analysis. Regarding data on electricity consumption, respondents were asked to provide a copy of their electricity bill for the previous six or 12 months (according to the distribution company's billing standard). The collected information was compared with the data provided by The Office of the General Comptroller of the Republic [28] to check its representativeness. The questionnaire is divided into three parts, as shown in Table I.

B. Experimental Design

The experimental field study was carried out to measure the indoor and outdoor environmental conditions in three apartments and four houses. These were chosen from the 420 questionnaires (Fig. 1). Wireless data loggers were placed inside and outside the houses to measure temperature and relative humidity (Fig.2). Monitoring systems are frequently used to collect occupancy data, behavior drivers and effects of occupant actions [29]. In this case, the purpose of this part is to monitor the types of houses' external and internal conditions in order to find any possible relationship between them while the air conditioning is used and not used.

TABLE I
QUESTIONNAIRE CONTENT

Sections	Studied variables
General characteristics of the occupants and the dwelling	Housing type Rented or own home Family size Income Number of rooms Number of bathrooms Housing area Construction year Material Solar shading control Type of Windows and materials Methods to reduce heat gain Humidity problems in the home
Cooling and ventilation mechanisms	Type and frequency of air conditioning usage Type and frequency of fans usage Indoor comfort Water heaters Type of bulbs used
Use of gas and appliances	Gas use Use of household appliances Present and future actions to save energy

Fig. 1 Sample of apartments and houses chosen for the field study.

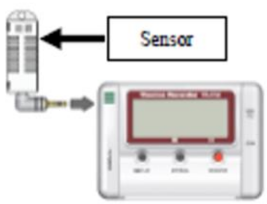


Fig. 2 A Thermo recorder model TR-72U.

Table II presents a summary of the selected dwellings' characteristics, where they are classified by year of construction, materials, number of rooms, floor area, numbers of floors, number of occupants, and location of the air conditioning units. The selected homes had air conditioning in their rooms.

The apartments chosen, labeled Apt 1, Apt 2, Apt 3, shared the same building materials: walls made of cement or clay blocks, tiled floors, and windows with framed shutters of aluminum; the apartments were built between 1980 and 2000. The number of rooms ranges from two to four, occupied by a few ones to four people. The surface of the apartments has air conditioners installed in the master bedroom, and one of them also has an air conditioning unit in the living room (Apt 3).

The selected houses, labeled House 1, House 2, House 3, House 4, vary slightly in construction materials. The walls are made of cement or clay blocks, tiled floors, and louvered windows with aluminum frames; the houses were built between 1980 and 2000. The number of rooms varies between 3 and 5, occupied by two to five people. The houses' floor area varies between 120 and 600 m^2, and all houses have air conditioners installed in the main bedroom.

TABLE II
CHARACTERISTICS OF THE SELECTED HOMES

Dwelling	Materials	N° of rooms	Floor area (m^2)	Level	Number of occupants	AC location
Apt 1	Cinder blocks and clay, concrete, slabs, aluminum-framed louvered windows, tile flooring	2	55	1	1	Main room
Apt 2		4	200	2	4	Main room
Apt 3		2	98	3	3	Living room and main room
House 1	Cement blocks, suspended ceiling, corrugated metal roof, shutter aluminum frame windows, tiled floor	3	120	1	4	Main room
House 2	Cinder blocks, wooden ceiling, tile ceiling, tile floor	4	272	1	5	Living room, dining room and main room
House 3	Cement and clay blocks, ceiling, corrugated metal roof, louvered windows tiled floor	5	150	2	2	Living room and main room
House 4	Cement and clay blocks, suspended ceiling corrugated metal roof, shuttered windows, tiled floor	4	600	2	4	Living room, dining room and main room

C. *Experimental Protocol*

Two data loggers were placed in each home to monitor indoor conditions: one in the living room and one in the main bedroom. As a safety measure, the devices were placed 1 to 1.20 meters above the floor and away from heat sources that could affect the result. Figure 3 shows the location of the data logger in a bedroom and a living room. The measurement period was from November 2010 and continued for eight months until May 2011.

To monitor outdoor conditions, meteorological data such as outdoor air temperature, relative humidity, wind speed, precipitation, and sunshine hours were obtained from the measurement station of the urban area of Panama City from August 2010 to August 2011.

On the other hand, homeowners showed willingness and interest in the measurement. They were asked to continue their normal activities and take precautions not to hit or move the devices. Since the devices have limited memory to record data, home visits were scheduled to download the information to a computer.

Fig. 3 Location of the data loggers in the bedroom and living room of the House 3.

III. Results analysis and discussion

From the 420 valid questionnaires, 26% of these were from people living in apartments, and 74% were houses. It was found that families are more likely to rent apartments than houses. While 44% of the apartments are rented, 56% is owned, while, in houses, 96% of them were owned.

The average number of inhabitants was 3 persons per apartment and 4 persons per house. According to the last census of Panama, in 2010, the average number of inhabitants per apartment is 2.8 people and 3.8 per house [28]. From the survey results, there were two rooms for apartments and three for houses; the number of bathrooms is similar in both houses and apartments; the average size per apartment is 93 m^2, and 197 m^2 per house. Most of the houses have been built with corrugated metal and apartments, concrete slab from floor to floor.

Panama is a country with a high level of humidity throughout the year, for this reason, some houses, and apartments, if not all, have different problems such as bad odors in different parts such as furniture, cabinets, even clothes, producing not only the deterioration of these but also diseases of the occupants.

In search of better thermal comfort, both in houses and apartments, at least one air conditioning unit (AC) is located in the rooms to obtain a better rest at night. The use of these varies depending on the season. In houses, they prefer to use it more frequently in summer. The opposite happened in apartments. Another way to improve thermal comfort, used with high frequency, are electric fans, where it was found that there are three units per dwelling.

Regarding lighting, the energy-saving bulb is preferred over incandescent, fluorescent, and halogen (Fig. 4). On the other hand, the use of other devices in common such as DVD/VCR/, fans, PC/Laptop/printers, refrigerators, and televisions is very noticeable.

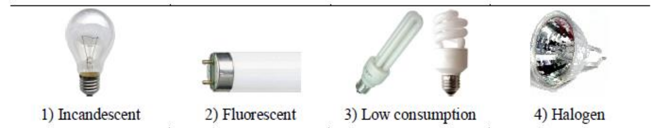


Fig. 4 Types of bulbs used as a reference.

A. *Electricity consumption based on the questionnaire*

Customers need to understand and be well informed about how much their daily activities affect their electricity consumption.

At the time of the study, two companies in Panama oversaw the distribution and collection of energy (ENSA and FENOSA). While ENSA has a six-month format, FENOSA has a 12-month format.

Six variables were considered to analyze electricity consumption per household, carrying out several linear regressions analyses to clarify and interpret the data. The variables were: type of dwelling, number of occupants, monthly income, number of rooms, size of the dwelling, and AC units.

In figure 5, the results obtained from the surveys of both types of dwellings are presented in terms of electricity consumption in kWh. In both cases, the highest consumption occurs in May, while February and November are the months where the lowest consumption was recorded. The increase and decrease may be due to the occupants' adjustments to assure comfort by climatic conditions recorded in those months.

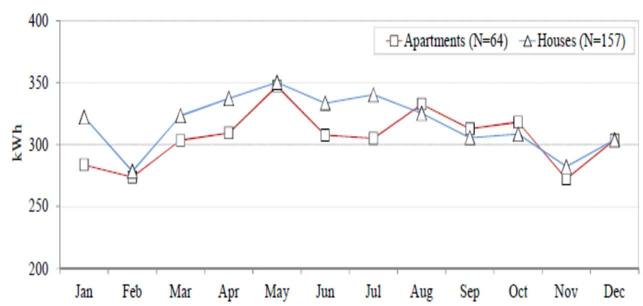


Fig. 5 Comparison of energy consumption per residential building type.

Through a linear regression, where the correlation coefficient was stronger in houses, results seemed to indicate that, in houses, the more people the lower the electricity consumption (Fig. 6), which was not expected but this strictly depends on the occupancy and energy use profiles. While apartments are not a determining factor when measuring electricity consumption, this is probably because the apartments' space is quite small compared to houses.

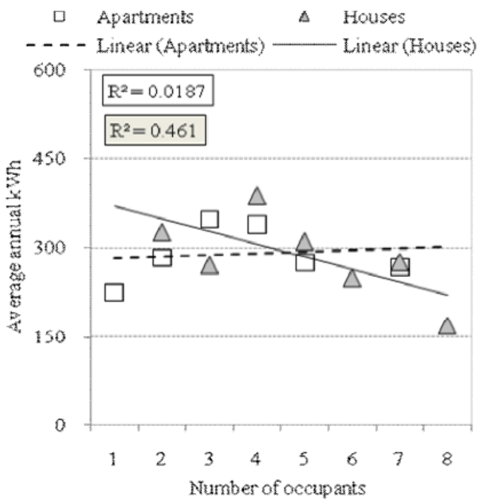


Fig. 6 Linear regression analysis: number of occupant's vs electricity consumption.

In apartments as in houses, the income vs. consumption ratio is directly proportional. The higher the salary, the higher the consumption (Fig. 7). Like the previous case, the more rooms there are in the house (floor area), the more consumption tends to rise, in addition to the fact that the rooms have individual air conditioning (Fig. 8).

The more air conditioners in use, the higher the energy consumption. Since these are installed in *most* of the cases in the rooms, it is consistent with the fact that the more rooms there are, the higher their consumption since there will be more AC units.

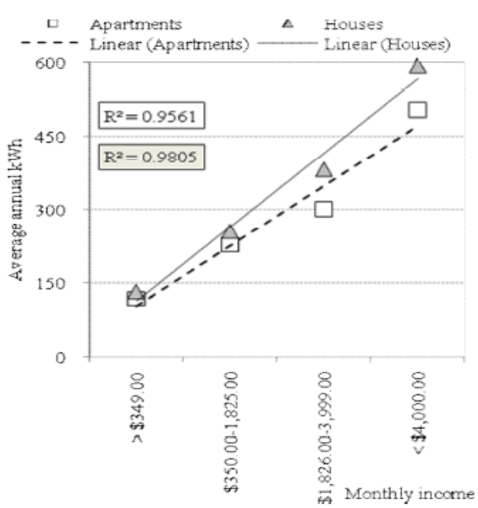


Fig. 7 Linear regression analysis: monthly income vs electricity consumption.

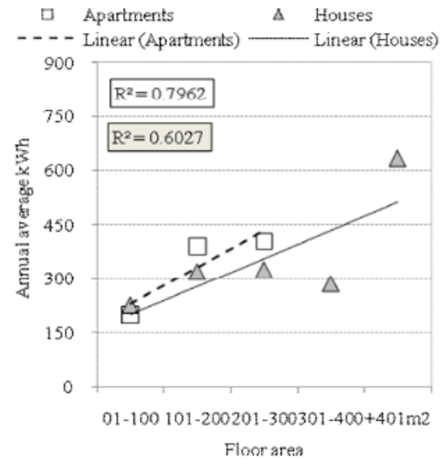


Fig. 8 Linear regression analysis: house floor area vs electricity consumption.

B. *Gas consumption based on the questionnaire*

The gas usage analysis was converted from pounds of gas to volume and energy units (Table 3). This conversion was necessary because there is no company in charge of measuring the amount used in the country. In Panama, there are only two types of water heaters: gas and electric. Only 18% of the houses and 34% of the apartments have water heaters. The electric heater is much more used in the former, while in the latter, the gas heater predominates.

Note here that some apartments currently bring a gas-fired heater with them, so the number of people who own a water heater is much higher in apartments than in houses.

When it comes to the type of stove, electric stoves' preference is almost zero compared to gas. This is large since the government subsidizes gas; therefore, its price is quite low and easy to obtain. The gas consumption capacity of apartments and houses cannot be measured because no technical equipment that says exactly how much is consumed per day.

TABLE III
CONVERSION OF GAS CYLINDERS TO VOLUME AND ENERGY

Capacity	Volume			Energy		
lb.	ft^{3*}	m^{3**}	L^{**}	BTU^{*}	kWh^{**}	GJ^{**}
25	163	5	4583	531	155	0.56
60	390	11	10998	1273	373	1.34
100	650	18	18330	2122	622	2.24

Source: *http://www.altenergy.com/technology/lpgproperties.htm
**http://www.iea.org/stats/unit.asp

An approximate monthly consumption was obtained in the different types of dwellings, based on this conversion. Apartments that buy a 25-lb cylinder use an estimated of 0.32 GJ per month, while houses that use the same cylinder use 0.45 GJ per month. Apartments that use 60 and 100-lb cylinder are somewhat rare since the new apartments tend to share the communal gas system, and houses that use these same gas cylinders spend approximately 0.25 to 0.61 GJ per month.

C. Indoor and outdoor climate behavior

During the analysis, it was observed that the outdoor climatic conditions (temperature, relative humidity, and absolute humidity) had influenced the indoor conditions, especially at night. In contrast, in the morning, the outdoor conditions do not significantly influence the indoor conditions.

It was found that indoor environmental conditions in Panama City homes can gain approximately 2.4°C compared to outdoor. The temperature gained is known as stored heat, released during the night, and early in the morning. The relationship between external and internal climate is strongest at night (7:00 p.m. to 9:00 p.m.).

An inverse relationship between temperature and humidity was found, since when the temperature rises (summer days). The humidity is reduced, and when the temperature drops (rainy season), the humidity rises. In the transition from rainy to the dry season (December-January), the rooms' temperature and living room increased. This indicates that the internal wind-chill during the summer season is warmer than around the building.

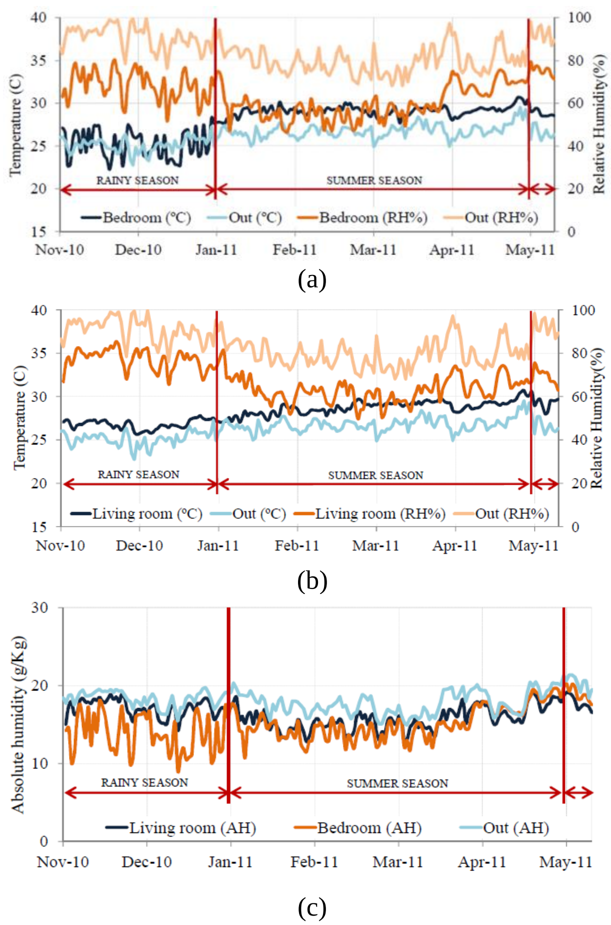


Fig. 9 Environmental measurements for Apt. 3 for 7 months: (a) temperature and relative humidity in the bedroom, (a) temperature and relative humidity in the living room, and (c) absolute humidity in the bedroom.

When the AC is not used in the room. An indoor temperature of 26.5 °C was registered, and the outdoor of 24.6 °C. In the bedrooms, AC is used during the night. When not in use, the internal temperature is around 27 °C, when in use, the temperature drops to 18.5 °C while outside is 23 °C (a difference of about 4.5°C). The cooldown time is approximately 9 hours, starting at 8:00 p.m. at 5:00 a.m. Figure 9 shows the variation of temperature and relative and absolute humidity for seven months in apartment 3.

Figure 10 is a breakdown of the monthly electricity consumption in apartment 3. There is a difference in electricity consumption between the rainy season and summer. During the summer, the temperature increases and, in the same way, the electricity consumption, registering in March as the month where it is consumed the most, thus where the temperature is highest, otherwise when the rainy season enters, while the temperature drops, consumption too. The lowest consumption was recorded in October. The same situation occurs in houses as with apartments. In the transition from rainy season to summer, there is an internal increase in the house's living room and outside. In the transition from summer to the rainy season (April-May), high temperatures begin to drop, and humidity rose.

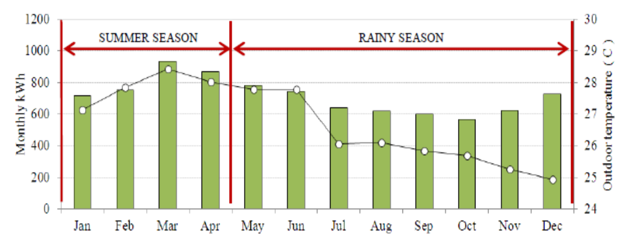


Fig. 10 Monthly electricity consumption in apartment 3 (bars) and outdoor temperature (line).

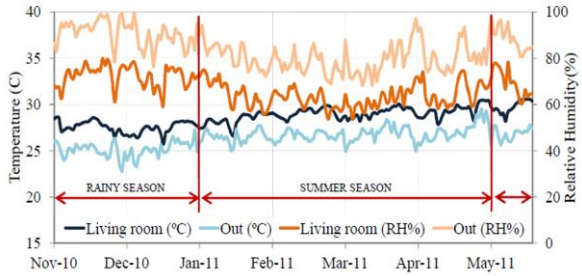
When AC was not used, an internal temperature was recorded close to 27.8 °C. When in use, the temperature drops to 16.6 °C while outside, the temperature is 21.5 °C, representing a difference of 4.9 °C. The cool-down period is approximately eight hours, starting from 12:00 to 8:00 a.m. Figure 11 shows the variation of temperature and relative and absolute humidity for seven months in house 3. Figure 12 is a breakdown of the monthly electricity consumption in house 3. The month with the highest energy consumption in April, while September, consumes the least amount.

D. Uses of time and lifestyles

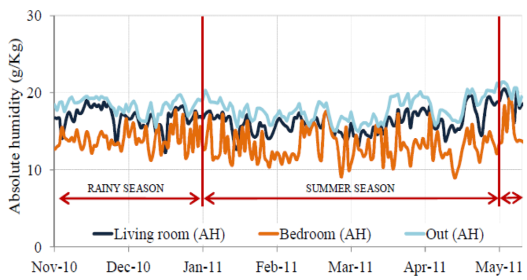
In more detail, the questionnaire allows us to infer that, in Panama, a person who lives alone tends to spend more time outside than inside the house, the opposite happens with families. Young people and adolescents are the most likely to spend the most time on video games and computers. Retirees tend to keep working and maintain an active lifestyle. The rooms have the longest occupation time and are a vital point in electricity consumption.

The preferences in choosing to set an AC temperature at night, well below the minimum limit of thermal comfort established in national regulations, cause the difference in energy consumption between both seasons.

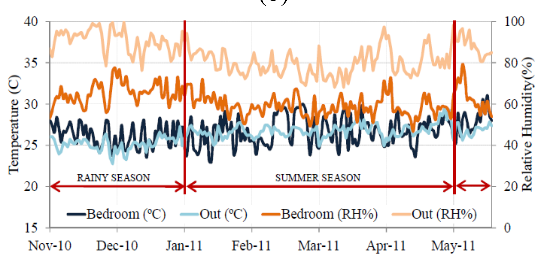
For both types of housing, the indoor climate conditions recorded during the AC power-up period are within an acceptable margin concerning the established comfort limits. Alternatively, this allows adequate comfort with turning on the fans and wearing light clothing during the said period, avoiding the use of AC. However, the occupants' recorded preferences in this study indicate an unnecessary overuse of the AC.



(a)



(b)



(c)

Fig. 11 Environmental measurements for house 3 for 7 months: (a) temperature and relative humidity in the bedroom, (a) temperature and relative humidity in the living room, and (c) absolute humidity in the bedroom.

Thus, the non-rational use of AC manages to show that, as has happened in other studies, the occupant's behavior and preferences have been and continue to be critical causes of electrical consumption higher than those expected in the building design phase.

Finally, it is evident from the above that there is the possibility of reducing the residential sector's energy footprint by implementation awareness campaigns that allow the transmission of strategies for the rational use of energy.

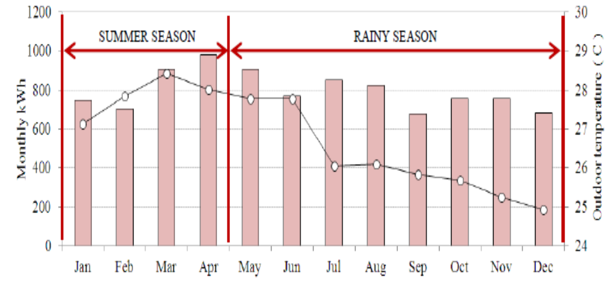


Fig. 12 Monthly electricity consumption in the house 3 (bars) and outdoor temperature (line).

IV. CONCLUSIONS

This work investigates the actual situation on the characteristics and consumption of residential energy in Panama, creating a database, and analyzing the variables that can influence the electricity consumption in a tropical country. The main objective focuses on how these types of changes are reflected in residential consumption and how energy is used within the residential sector. For the above, an experimental study was carried out in Panama City in two different buildings: four houses and three apartments over a year, where sensors were installed to measure internal and external environmental parameters. A survey was applied to 1060 students in a complementary manner, where 420 responses to the survey were selected.

The correct use of electricity consumption could bring positive repercussions for the consumer, not only in their economic potential but also in the durability of the electronic devices that are owned within the home. As is well known, Panama City has two climatic seasons: dry and rainy. During the dry season, a relatively high thermal sensation is perceived, both in houses and apartments, and it is in this season where it is recorded higher energy consumption. Here, ACs are used more frequently at night for a more pleasant rest, set at temperatures well below the national context's comfort limits. Thus, the non-rational use of AC manages to show that, as has happened in other studies, the occupants' behavior and preferences have been and continue to be critical causes of electrical consumption higher than those expected in the building design phase.

With these results, the foundations are laid for future research related to the study of energy use and the residential sector's occupant behaviors in the Province of Panama.

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