Characterization of the current electric energy needs in subsidized residential users

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Characterization of the current electric energy needs in subsidized residential users

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Abstract. In this paper it is considered the characterization and behaviour of the residential energy demand of users located in socioeconomic sectors of the Department of Atlántico, also, the participation of communities to declare the typical energy consumption at the residential level. The results are based on direct measurement sources which allows the development of energy efficiency projects, renewable energies that respond to the needs of the communities and seek to encourage the proliferation of renewable energy projects by adequately sizing the installed capacities of the resources, with the possibility of establishing grid connection as well as systems for energy management in residential users.

1. Introduction

In the different world debates on sustainable development and environmental care, influential aspects are highlighted such as the generation and consumption of energy in countries due to the accessibility, quality, technological level and state of the infrastructure in a nation with regard to power, has direct effects on the quality of the inhabitants and the productive processes of the same [1].

As a result, different countries have studied the trend and relationship of variables such as the development of a nation and the generation and distribution of energy, an example of which is Turkey, where studies show that an effect of the use of renewable energy helps to supply the demand for electricity, which has increased annually by 6% and 8% in recent years and also includes the need for a sustainable energy policy to meet the demand and use of Renewable Sources (RS) [2]. Another country that targets the use of RS is the Republic of Azerbaijan, a nation whose economy is significantly based on oil production, demonstrating that the transition to renewable energy and sustainable energy development diversifies its economy through a green economy by addressing the environmental and social concerns of that country.

Vidadili, Suleymanov, Bulut, y Mahmudlu [3], Japan, for its part, is studying the inclusion of RF in the generation of energy through the cultural development of a country. Shortall y Kharrazi (2017), some African countries, promotes the financing of renewable energies considering that it is a crucial challenge of the sustainable development objectives of this continent, Nigeria, analyzes the barriers to sustainable energy development, where it is highlighted in costs and prices, legal and regulatory and market performance, where it was identified that government policies have an impact on overcoming these barriers [4]. In general, the development of studies for the inclusion of RF in a country's power generation has been of global relevance [6].

On the other hand, the trends in economic models that examine the behavior of energy demand are structured in two large blocks, the demand management model or "demand-driven," which emphasizes the concepts of supply and demand. The operating principle of this model applied to the electricity sector encourages demand to schedule its consumption during the day to reduce its energy costs. On the other hand, the supply-driven model is based on the control of generation prices and the search for alternatives to cut them, through the participation of renewable and non-conventional resources.

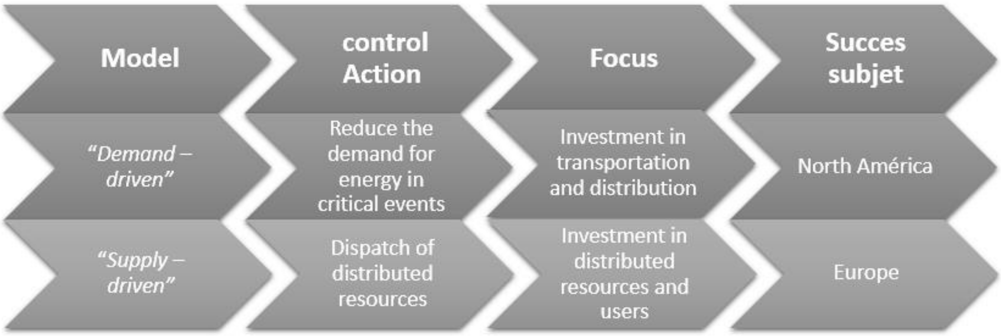

Figure 1. Models of operation and control of an electrical network in general.

The demand management model is based on controlling demand through the application of efficient energy management techniques to obtain appropriate and rational use of available resources, which has led to the inclusion of intelligent devices in the electricity network. As an initial measure in the 1970s, the "virtual utilities" proposed as computing and consumption management techniques are shown, which are capable of generating control overloads and focus on reducing maximum levels during critical hours. To solve the problems of high consumption that began with the proliferation of electronic technology, communications, the presence of household appliances and equipment in residential and administrative buildings (FEDIT & Electrónica, Tecnologías de la información y Telecomunicaciones, 2011).

The successful inclusion of the model is attributed by many researchers to the maturity of the capacity to respond to demand behavior [8]. At the same time, the inclusion of technologies based on original concepts and the Internet of Things (IOT) has made it possible to guarantee the control of consumption by end users.

According to Giordano and others [9], the energy policies of the United States of America encourage investments that improve the grid operation scheme to a value of 476 billion US dollars before 2030, where 24% will be directed to energy transmission, and substations, 71% to distribution and the rest of the funds will be allocated to users. The North American electricity system is focused on supply reliability, so more than eight million smart meters will be installed by network operators in the United States (Giordano et al., 2011; Physical Measurement Laboratory, Office of the National Coordinator for Smart Grid Interoperability, & Information Technology Laboratory, 2012). Among the projects aimed at demand management are the objectives of the EPRI project (Electrical Energy Research Institute), which considers the inclusion of the concept of a virtual plant for remote user dispatches on the North American electricity grid [11].

On the other hand, supply-driven models consider the use of renewable energies as one of the fields of action [9], [12]. This model encourages the development of research into non-conventional sources, with emphasis on research into the control of microgrids, distributed energy resources, evaluation of energy potentials and high penetration participation from renewable energies. The monitoring of energy storage technologies is contemplated with the objective of reducing the intermittency of non-conventional sources to guarantee reliability, new technologies are considered on an individual basis, and intelligent devices are contemplated to allow connection to the network of users [9], [13].

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However, they do not focus on solutions that strengthen the power grid, and it is possible that the high penetration of new technologies in automation will generate a new approach as mentioned in [14].

Additionally, the scheme considers projects in the areas of smart metering, grid automation in energy transport, integrated systems, application to end users and development of energy storage technologies.

Some researchers believe that within ten years, the penetration of new technology will be underway due to the increase in current automation trends at the residential and industrial levels, which will allow the rapid deployment of technology related to the management and uses of electricity.

It is essential that structured incentives be put in place to replace current business opposition and to boost user programmers. These technologies will create the potential to radically change the electrical system in a supply-centered order to a highly reliable "perfect" demand-driven scheme (p. 160). As presented above, there are different trends and models for operating an electricity system. However, they agree that the inclusion of new intelligent tools and technologies will favor the integration of small-scale generation and user management.

This is evidenced by the outstanding work and developments in the areas of market models [15], [16], cogeneration technologies [17], renewable energies [18], smart metering [19], energy storage [20] and a set of topics related to power quality [21].

Advances in China, North Korea, India, and Japan are considering schemes focused on tracking demand growth. This model requires substantial investments in the grid and control to transfer high power capacities through a robust interconnected system, which is integrated with the energy policies established to complement the implementation of the model:

- China: China's electricity system is less developed compared to European and North American operations. However, China's economic growth has led it to integrate different infrastructures in intelligent networks [22]. So China has focused on including 360 million smart meters in its transportation and distribution systems by the end of the year. 2030 [10].
- South Korea: Model has additional commitment to mitigate greenhouse gas emissions [10].
- Japan: Establishing new technologies due to its crisis with the Fukushima nuclear power plant [10].
- India: India's electricity system scheme focuses on mitigating losses and controlling energy theft [10], [23].
- South American countries: Given the emerging economy in South America whose case tends to be similar to that of India, the models have been based on reducing energy theft. Brazil is the country with the most significant development in this area, and its focus is directed towards the replacement of conventional meters by intelligent systems. [24].

At present, the energy demand on the Atlántico coast between regulated and unregulated market is between 107.47 kWh and 205.81 kWh in 2017 with an unmet need of 20.13 GWh, which implies the use of non-conventional energy sources [25]–[27], in this way, Colombia's energy policy is directed towards satisfying the needs of economic agents and the population, making use of available resources with criteria of economic, social and environmental sustainability [28], [29]. For this reason, the National Energy Plan (PEN) considers the ecological component as a strategy that cuts across all its objectives: the conservation and improvement of environmental quality at all decision-making levels, production processes and future investments in the energy sector are primary objectives of the national energy strategy.

2. Materials and Methods

The aim of this study is to evaluate the behavior of the residential consumption of socioeconomic level 1, 2 and 3 in the different municipalities of the Department of Atlántico to determine the current energy needs of the communities and to propose the formulation of alternative energy and energy efficiency projects. In this way serving research as a reference to replicate similar studies in other regions looking to consolidate a national map showing consumption habits of its inhabitants.

IOP Conf. Series: Materials Science and Engineering **844** (2020) 012034 doi:10.1088/1757-899X/844/1/012034

2.1. Estimated consumption
Consumption estimates are made through surveys that precisely determine the daily consumption of the population per dwelling. Therefore, a community was chosen 442,341 customers, taking into account a 5% margin of error and a 95% confidence level. The survey is carried out with the support of the Association of Municipalities of the Department of Atlántico ASOATLANTICO and the community action boards 50% of the population.

It was carried out in person (50%) and by telephone (50%) during September 2018 for standardized users with individual measurement of ELECTRICARIBE S.A. E.S.P. and ENERGÍA SOCIAL DE LA COSTA. The survey asked about the inventory of electrical equipment and household appliances and their hourly use and asked about the consumption of the last three months recorded in the invoices of energy. It was considered different socioeconomic levels: level 1 (48,657), level 2 (203,476), level 3 (115,008), level 4 (61927), level 5 (4423), level 6 (8850).

2.2. Characterization of energy consumption in the municipalities of the Department of Atlántico
In the second measure, the average residential energy consumption of socioeconomic level 1, 2, and three were identified, where the consumption habits and trends by area and socioeconomic level were determined. For this purpose, the data of the Superintendence of Public Domiciliary Services is taken into account, which indicates that in Colombia the number of residential users corresponds to 89%, who consume 11% of the country's total electrical energy, with the Department of Atlántico representing 5% of residential and non-residential users [30].

Table 1. Study characteristics in the Department of Atlántico

Description	Studied item
Public Service to which you belong	Energy
Region covered	Interconnected Zone
Time range	2010 - 2018
Entities providing information	Utility companies with marketing activity registered with the Single Register of RUPS Service Providers.

3. Results
Initially, differences of up to 30% were found between the departmental average of consumption for residential level 1, 2 and three published by SSPD [30]. This is because the survey does not include elements causing technical or non-technical losses of the low-voltage network, nor does it include small commercial premises associated with the residential sector or public lighting that may be registered by these same community systems. [32]. The values corresponding to the consumption of the departmental average (kWh month) for the volumetric energy according to the survey is 193.22, for the reported power it is 248.90 according to the SSPD Superintendency.

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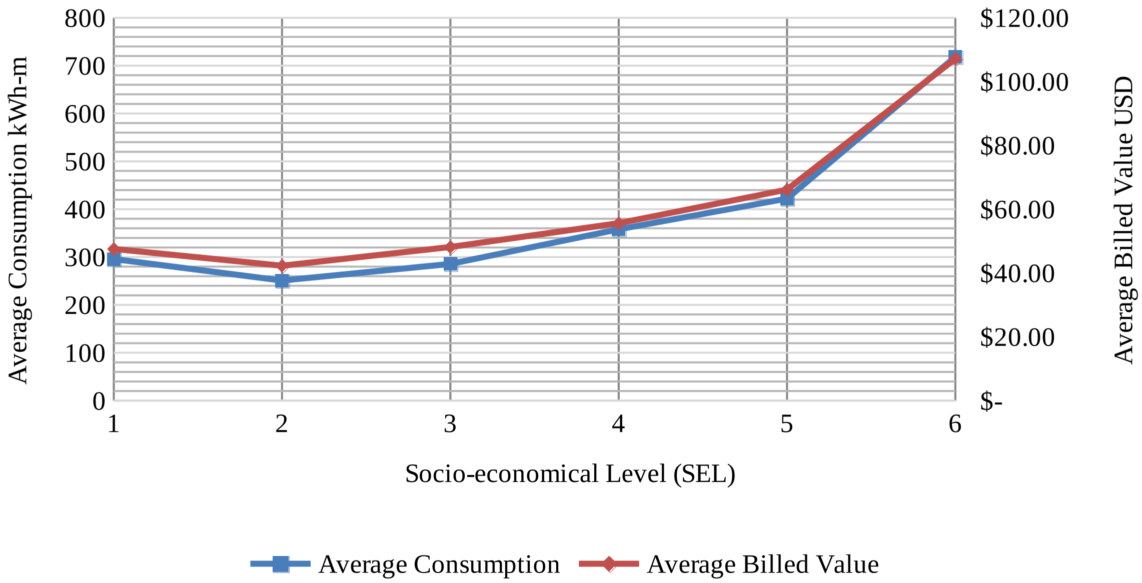

Figure 2. Average Consumption Vs Average Billed in the Department of Atlántico

On the other hand, energy consumption is directly related to the socioeconomic situation of the inhabitants as shown in Figure 2. In this case, the higher consumers were identified in the urban district that make up the metropolitan area.

The other municipalities have lower consumption rates and have an economy with an agricultural or livestock tradition. Another important indicator is the average per capita consumption. In the case of the department, according to the survey is located at 42.64 kWh month, while in the studies of energy consumption published by the Ministry of Mines and Energy which characterizes energy consumption in the residential, commercial and tertiary sectors [33] it is established a range of consumption per capita of 40 kWhm for stratum 1, 38 kWhm for stratum 2 and 62 kWhm for stratum 3. The average consumption for the Barranquilla district is 43.74 kWhm.

Figure 3 describes the Growth in users and energy consumption in the Department of Atlántico 2010-2018. The average energy consumption of homes in the socioeconomic department considering the average typical use among the three socioeconomic level. You identify yourself The levels of energy consumption in the Department of Atlántico are directly related to the socioeconomic level of the inhabitants and the proximity they have to the capital of the department. The city of Barranquilla and its surrounding municipalities such as Soledad, Puerto Colombia, Galapa, and Malambo, which make up the metropolitan area of the department, represent a higher energy consumption due to their population and economic activities developed in them; the municipalities bordering free trade and industrial zones represent an average energy consumption. The cities with less waste are far from the industrial zones and have a more significant population and connected users; these have an agricultural, fishing and livestock economy.

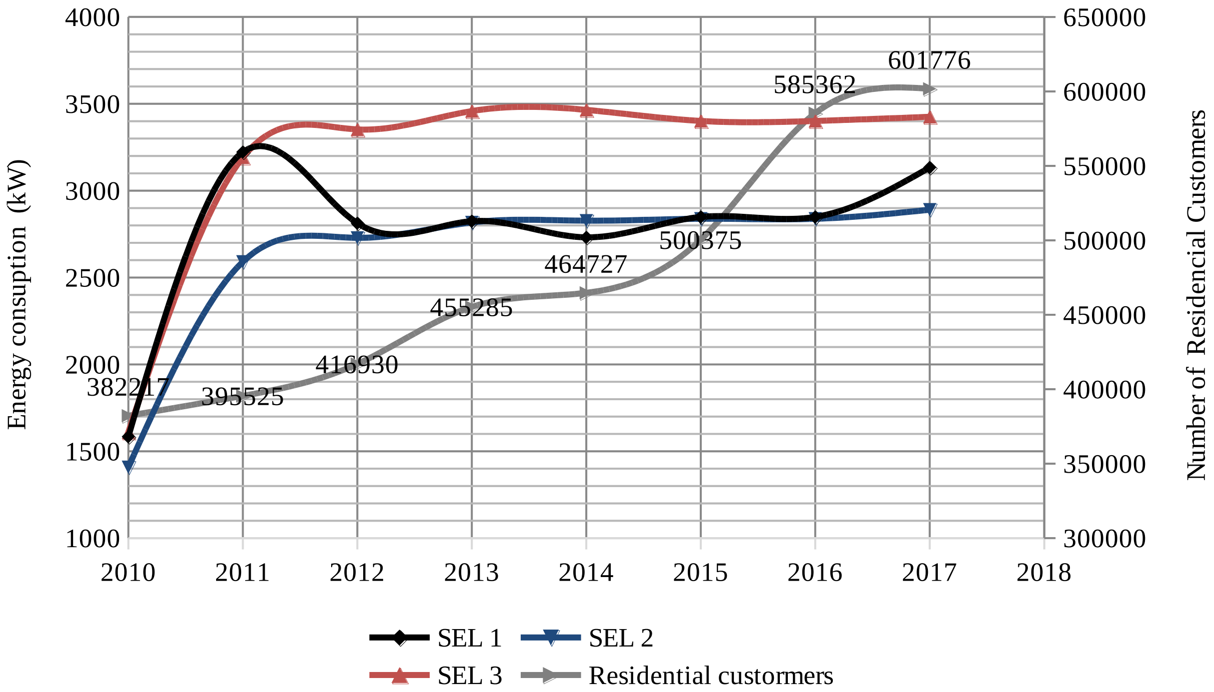

Figure 3. Average annual consumption in the Department of Atlántico by socio-economic level (SEL) 2010-2018

In Figure 4, it can be seen that the highest consumption is from 5 pm to 10 pm, while the lowest consumption is from 12 m to 10 am, so from 10 am to 5 pm there is an average consumption. On Saturdays, Sundays and public holidays there may be a 20% increase. The consumption habits surveyed show that the lowest demand is between 4 am and 10 am, while in weekend, the energy consumption can increase by 20%.

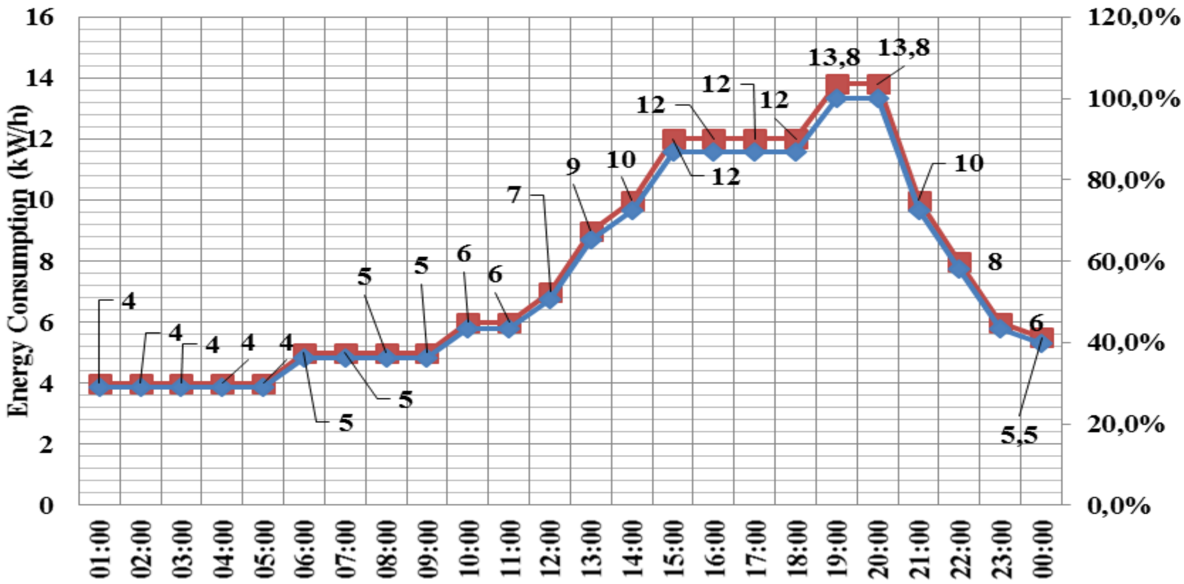

Figure 4. Average daily energy consumption in homes in the Department of Atlántico. Prepared by the authors. Survey results.

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4. Discussion

The use of electricity for residential uses in rural and urban areas increases related to technological development and modern needs. According to the Colombian statistics established in by UPME, residential energy demand in Colombia is typified at 44%, characterizing the country with a residential consumption activity. However, utilities in Colombia, as mixed-economy (private-public) entities within the energy distribution activities, use to focus their strategies for customer service such as unregulated users, those users with an installed capacity greater than 0.1 MW, being then, the highest economic incomes recorded in this type of user. For other hand residential users are often regulated, who do not exceed this installed capacity and whose individual consumption does not represent a strong income for utilities.

Also, in rural areas, energy needs and consumption are lower, and these types of users are less attractive to utilities and energy retailers. However, according to Law 142 of 1992, public services must be guaranteed by the state and their supply quality by utilities is a responsibility to accomplish by rural users. However, rural projects electrification often considers sub-normal, or non-standard users which difficult electricity connection, which difficult to connect them to the available electricity networks. For another part, the nation usually supports these projects through standardization electricity network projects and funds for the integration of non-interconnected areas with the purpose to guaranteeing connection to final users and guaranteeing access to the networks as is established in current regulations.

On the other hand, subnormal and non-standard users do not have payment culture and often have negative experiences with quality of electricity supply in the department, making difficult the utilities activities such as energy reads, repair electrical grid problems and changes of technologies. At the same time, in many cases they do not have the internal electrical installations able to connect to the electrical power system, causing electrical failures inside homes, which compromises the security of the electrical circuit supply to which they belong and affecting other users.

The above suggests that electricity connection projects for rural and urban users in socioeconomic strata 1, 2 and 3 should have a management and direction plan based on ensuring proper electrical connections and access to the electricity networks in a regulated and organized manner. The development of rural communities and the overcoming of conditions of extreme poverty begin with actions that promote the proper management of public services to which communities have access as the fundamental axis of urban and rural development.

With the opening of Law 1715 of 2014 and the new models of commercialization for renewable energies, there are opportunities to guarantee that users can access renewable energy projects as an alternative for self-sustainability and consumption management. However, these projects must consider the joint participation of the state, utilities and sector-based committees to provide an integrated service that satisfies the needs of the communities, which is why this work is a reference point to identify the growth and monitoring of consumption of rural and subnormal communities in the department of Atlántico

5. Conclusion

The economic models established to achieve sustainable energy development that has been validated and are currently has been implementing can have been classified into two categories, an energy efficiency-based model, demand management models, and one based on the use of renewable energy, supply-driven model. Demand management proposes a robust model capable of supplying and meeting all the needs of its users with high efficiency and the reduction of demand in peak hours; Similarly, the supply drive model proposes a decentralized system where users who are capable of generating energy to meet their needs with renewable sources, however, although it contemplates an interconnection system, its primary objective is not to reduce losses or guarantee operating conditions that optimize the system; these models focus on reliability in the same way that they stimulate the development of new technologies and methodologies.

Colombia is developing a renewable energy inclusion model over a period of no more than 25 years, evaluating the probable fluctuations of a generation with renewable energy sources, with the assumption that the country's Caribbean coast can produce 21GW, which would supply twice the country's current demand. In the case study, the conditions for solar and wind farms in the department of Atlántico are evaluated, while establishing the consumption patterns of the population, with the result that stratum 1 in most cases is the cause of the highest consumption that occurs from 5 pm to 10 pm, while the lowest consumption occurs from 12 m to 10 am, so that from 10 am to 5 pm an average consumption occurs.

On Saturdays, Sundays and public holidays there can be an increase of 20% in the municipalities, of which the district and its metropolitan area represent the most considerable consumption, as evidenced by the results of the study, transversally the potential of the department for wind and solar exploitation is good guilty.

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