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Business model for the optimization of energy consumption by VAC equipment in service sector buildings

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Abstract. Electricity consumption has been growing in recent decades, and it is estimated that air conditioning accounts for 30% of a building's total electricity consumption. However, in hot climates this percentage may be even higher, which has led to the development of energy management techniques aimed at reducing the high electric bills paid by end users. This article proposes a business model for the commercialization of intelligent solutions for the optimization of electricity consumption by air conditioning equipment (VAC) in service sector buildings. The study used the Canvas methodology to validate the proposed model, in combination with other techniques such as SCAMPER, interviews, and discussion groups, among others, to validate the proposed business model aimed at the introduction of new techniques for the commercialization of air conditioning. Service-sector buildings exposed to the climate conditions of the Colombian Caribbean region were used as case study. The results summarize the characteristics of the business model, including the respective validations of the nine "Canvas" modules, which enabled reviewing two possible scenarios offering different alternatives for implementation of this initiative.

1. Introduction

Research has found that energy consumption is primarily concentrated in three sectors: industry, transportation and others (agriculture, services and residential). Buildings account for between 20 and 40% of total final energy consumption [1,2]. Authors such as Lemmet [3], Lin y Liu (2015) believe this percentage may be higher, at between 40 and 50% of global energy consumption in buildings due to heating, ventilation and air conditioning (HVAC) systems. Additionally, the electricity consumed by buildings for the operation of ventilation and air conditioning system is close to 60% [4].

The energy policies of several countries take into consideration the development of energy efficiency and savings strategies, due to the high levels of energy consumption and of CO^2 emissions [2]. The impact is two-fold: on the economy and on the environment. Financially, it involves high costs of facilities, of equipment maintenance and high energy consumption, which translates into higher costs. Environmentally, CO^2 emissions have been found to produce the greenhouse effect and the consequent global warming [5]. In Spain, according to the Ministry of Industry, energy

consumption by air conditioning systems accounts for approximately 2.5% of the country's energy consumption. Efforts to reduce this consumption level have focused on three techniques: the reduction of demand for heat by buildings, energy recovery, and more efficient use of air conditioning systems [6].

In the United States, the three main energy consumption factors in the retail industry are heating, lighting and air conditioning of stores, which account for close of half of energy consumption at the buildings [7]; in the residential sector, heating and air conditioning account for 54% of energy consumption by households [8].

In Colombia, the residential sector accounts for approximately 20% of the country's final energy consumption. Some of the major sources of energy inefficiency in this sector have been found to be: the high use of electricity for air conditioning, due to the use of energy-intensive equipment due to factors such as technology (low energy efficiency), insufficient maintenance and age [9]. According to a study carried out by UPME in 2013, the business, public and services sectors account for close to 6% of total energy demand in the country [9].

As part of global initiatives aimed at addressing the above, the Kyoto Protocol includes agreed commitments by participating nations to reduce greenhouse effect gases [10]. However, such commitments are often merely rhetorical, and in practice few actions have been implemented in this regard due to the non-binding nature of the signed agreements, which reduces it to a compendium of good intentions. For this reason it is important to view new technologies not only positive for the planet, but also beneficial for the finances of the business sector, by generating new business ideas and strategies to commercialize new products focusing on the reduction of energy consumptions, without loss of efficiency or quality of living [11].

From an energy perspective, the main option for addressing these challenges and the alternative for reducing the propagation of CO^2 emissions are energy products and services that consume less energy. In the climatization and air conditioning industry, in response to these energetic and environmental issues, in recent years VRF (Variable Refrigerant Flow) equipment has been installed in different types of building, including residential and business units, because of their high energy saving potential [12]. This system offers significant advantages, such as: low-noise operation, use of integrated controls, design and installation of compact units, flexibility, lower life cycle and maintenance costs [13].

Additionally, it has been found that an excellent complement for cooling systems are non-invasive monitoring systems incorporated into HVAC (Heating, Ventilation and Air Conditioning) equipment, which produce consumption statistics in real time, thereby providing data for energy savings decision-making. A recent trend in HVAC systems is the development of models that predict energy consumption in different types of buildings [3], [14–16]. A noteworthy example is the work performed by the firm *Johnson Controls* at the El Dorado International Airport, which was contracted to provide HVAC equipment through the implementation of a technology contracting model that reduces high front-end costs, eliminates the duplication of systems and infrastructure, assures quality and manages innovation, while at the same time maintaining and preserving integration between the various subsystems and technologies used at the airport [17]. **¡Error! No se encuentra el origen de la referencia.** displays business models that take into consideration the inclusion of various technologies to reduce energy consumption in buildings, incorporating monitoring, energy management and energy rationalization systems that affect cooling and heating consumption.

Table 1. Business Strategies for Reducing Energy Consumption.

Country	Reference	Business strategy	Contribution
United States	[18]	*Power Purchase Agreements* (PPAs).	PPAs are performance-based contracts whose purpose is to achieve fair payment for the purchase and sale of energy between the public utilities company (the buyer) and a generator (the seller). Use of this strategy has been increasing worldwide and is commonly used in Europe, United States and Latin America.
Italy	[19]	*Vertical Greening System* (VGS).	VGS produces a favorable impact in terms of thermal performance. Studies have demonstrated potential energy savings on air conditioning of up to 40-60% in the Mediterranean region.
Iran	[20]	*Green Roof*	Green Roof's main advantage is that it reduces a building's energy consumption costs on cooling and heating by increasing the thickness of the roof's insulation, providing natural shade against direct sunlight. Green Roofs are most suitable for the European and North American regions.
China	[21]	*Smart Home System*	The intelligent home system enables more systematic management of household appliances and facilitates energy management at the home. It provides information in real time of the home's energy consumption.
United States	[22]	*Demand Response* (DR)	Clients hire them to reduce demand during emergency periods. The final use of energy in the residential and business sectors is allocated to cooling, heating and ventilation, among others.

In this study, based on the objective of designing, developing and validating a Business Model for a smart solution for the optimization of energy consumption by VAC (Ventilation and Air Conditioning) in service-sector buildings, the Canvas method was used to develop a business model. The selected object of study was service-sector buildings in the city of Barranquilla; additionally, interviews were also carried out in the cities of Bucaramanga and Cartagena.

2. Description of the canvas model.

Market Segment: In this module we define "our customers", i.e., the various groups of people or companies to which the product or service is to be sold. To this end, [23] consider that market segmentation is appropriate because each customer group has differences in terms of:

- Their specific needs;
- The distribution channel required to reach them;
- Profitability index;
- Willingness to pay for different aspects of the offering.

The market segment was defined as service-sector buildings that use VAC equipment. In order to understand the potential market, a search was performed on the sectors that account for the largest shares of energy consumption. The standard categories for energy consumption are three sectors: industry, transportation and others (agriculture, services and residential). Buildings account for

between 20 and 40% of total final energy consumption, and its main uses are: lighting, use of electrical appliances, water heating, building heating, air conditioning, etc. [24]

Value proposition: The initial hypothesis was pivoted through interviews and the development of empathy maps between the customer segments and the value proposition, in order to identify the customers' real and potential needs, i.e. the real "pain", which is associated primarily with "the cost of energy consumption associated with the use of air conditioners."

In order to take advantage of the opportunities identified in the market niche, a value proposition was formulated [23], adjusted to the needs and obstacles they currently face, by proposing modern technologies and innovative solutions that produce benefits and gains for potential customers:

"Intelligent solution to achieve savings in electricity consumption by air conditioning equipment".

Channels: In developing a business model, definition of the distribution channel is particularly important after having defined the market segment and the value proposition, because of the benefits provided to customers in terms of time savings for not having to travel long distances to find the product or service they require; and for setting prices for the products or services based on the cost of distributing products in the market [25].

The shorter it is, the more it can be controlled, even though coverage will be limited, and the price will be higher; instead, a longer channel offers less control because there is greater product coverage, which in turn has lower costs [26].

Customer relations: In the business world, customer relations are of utmost importance and are often the company's most valuable asset; the business does not depend on the company, but quite the contrary, it depends on the customers, because they are the ones who produce revenues for the organization. But it is essential to identify customers as humans, with both reason and feelings, who understand, have emotions, preferences and tastes, among others [27].

Due to the above, understanding the customer enables focusing the company's actions on satisfying the customers' needs through strategies that help build sustainable relations over time and increase their loyalty in favor of buying the company's products and/or services. However, achieving this is not an easy task, given the ever-changing characteristics of markets, which make customers increasingly demanding; new technologies, innovation and competitiveness lead customers to search for products with added value.

Revenue sources: In this module, the cash flow generated by the company is analyzed for each segment. The company needs to ask itself: how much is each market segment willing to pay? It is important to understand the various price-setting mechanisms [23]. According to Osterwalder and Pigneur [23], most business models have two different types of revenues: Revenues from individual transaction payments and recurring revenues of periodic payments made in exchange for the supply of a value proposition or customer care post-sales services. In this study, validation was performed based on forecast demand for the services in the market, interviews and trend analysis of VAC equipment sales and their energy consumption.

Key results: All business models require key resources that enable companies to create and offer a value proposition, reach markets, establish relations with market segments and earn revenues. Each business model requires different key resources. A microchip manufacturer requires capital-intensive production facilities, whereas a microchip designer depends more on human resources [24], [28-30].

These resources are directly associated with the key activities, because their transformation into activities is what enables the delivery of the company's value propositions. In the Osterwalder business model, the key resources are classified as physical, intellectual, human and financial. Additionally, the company may either own them, lease them or obtain them from its key partners [23], [31].

Key activities: In a business model, an activity can be defined as a commitment of human, physical and capital resources to be used to fulfill a given purpose that leads to the achievement of an overarching goal [32], through the company's core activities, i.e. all the things a business does to achieve customer satisfaction. A business model must clearly define this module, because all the efforts carried out are aimed at achieving the company's corporate purpose. Often, when an inventory is made of all the potential activities that a business model can have, it becomes conceptually

challenging, because the number of activities is often very large, and their technical or strategic identification is complex [33].

The activities associated with the business model developed in this project involve resolving issues and the platform/network. This is because the nature of the value proposition defined as "Intelligent solution to achieve savings in electricity consumption by air conditioning equipment" focuses on solving a problem for potential customers, which requires having a service platform available that offers an attractive value proposition based on the use of a device that monitors different variables involved in electricity consumptions by VAC systems in order to achieve costs savings in electricity consumption by air conditioners. This device operates through an Arduin platform, which is considered a disadvantage for the model, given the scalability of its main functionality.

Key partnerships: This module presents a company's relationships in terms of strategic suppliers and partners that have direct influence on the operation of our business model. It is important to understand the partnerships to be worked with; an entrepreneur must be aware that in the business context he/she must work with others in order to publicize the business. Companies partner up for a variety of reasons; a widely used technique is networking. "It is difficult to find a general definition for networking; however, this technique, strategy or discipline points to the same objective: increasing the network of professional contacts" [34]. Effective networking requires working on establishing and maintaining relationships. The key partnership considered in a business model is that with the suppliers of payment and technology [35].

Cost structure: This module describes all the costs incurred in working with a given business model, both for creation and delivery of value, once a clear picture is available of the key resources, partnerships and activities [23]. Two scenarios were considered in this study: The creation of a company that provides energy consumption monitoring and control services, or the development and sale of a device that enables monitoring a building's energy consumption. In other words, either the total or partial transfer of the rights to use the system's intellectual property. In this module, the value are in Colombian pesos.

3. Methods

In the development of this business model and the validation of its relevance as an intelligent solution to optimize energy consumption in VAC equipment, this study was structured in three stages: the first was a diagnosis of the target audience, during which characterization and segmentation of the market was performed in terms of existing needs for the use and management of technological climatization alternatives. The second stage involved designing the operating structure of the model to be used, product commercialization and generation of the value chain. Lastly, the model was validated in order to assess its relevance.

3.1. Market characterization and segmentation

The proposed business model used as case study companies of the service sector located in the city of Barranquilla, to which end a specific query was made on the companies registered under the "Uniform International Industrial Classification of all economic activities adapted to Colombia" (CIIU, by its acronym in Spanish). Based on this query, 4 companies were selected from Barranquilla and the department of Atlántico, where there are 49,696 registered companies, approximately 40% of which engage in activities closely related to the tertiary (service) sector. However, for the effects of this project, only companies grouped under the sections displayed in table 2 were selected as potential clients, because of their close relationship to the model's business objective.

3.2. Model Definition

The conceptualization of the business model took into consideration the development and validation of each of its components, using the Canvas methodology as guiding strategy to develop and assemble the model. Table 3 summarizes the conceptualization of the initial business model, which was the starting point for its development.

Table 2. Companies registered in the city associated with the service sector. Source: [36]

COMPANY TYPE	NO. OF COMPANIES
Food and lodging services	3074
Administrative and support services	2713
Other service activities	2943
Human healthcare and social assistance activities	1490
Information and telecommunications	1306
Financial and insurance activities	941
Education	546
Public administration and defense	144
TOTAL	**13157**

Table 3. Model definition

No.	Segmentation based on CANVAS	Description of activities to be considered
1	Market segments	Identification of potential customers
2	Value proposition	Development of the value proposition for the customer, i.e. the product or service
3	Channels	Identification of the means for distribution to the customer
4	Customer relations	Development of strategies to establish good customer relations
5	Revenue sources	Explore and propose revenue generation alternatives for the proposed initiative
6	Key resources	Identify the resources required to carry out the initiative
7	Key activities	Identify the business model activities that contribute to growth of the value proposition.
8	Key partnerships	Identify strategies to achieve successful relations with partners, suppliers and others.
9	Cost structure	Based on the project's development, identify the cost structure to support subsequent implementation of the initiative.

3.3 *Model validation*

During the process of validating the customer segmentation and value proposition modules, group sessions were scheduled in three hot-climate cities, distributed as follows: sixteen (16) hotels, ten (10) service sector companies, six (6) universities and two (2) hospitals. Additionally, interviews were held with two (2) subject-matter experts on energy efficiency, in order to validate the model's effectiveness.

The model validation process with the companies took into consideration the following components, included in the assessment form: presentation of the model's structure and segmentation, description of activities, willingness to pay, characterization of energy consumption, dimensioning of the technologies to be used.

4. Results

It was found that according to the National Statistics Administration (DANE, by its acronym in Spanish, 2016), 66% of the companies registered in the city are in the tertiary (services) sector, and the following services: Food and lodging, Administrative and support services; financial and insurance companies, education, public administration and defense account for 12% of the records provided by the entity.

The above information indicates that a business opportunity exists in this sector, since there is a potential target audience with existing needs relating to the use and management of climatization technological alternatives, taking into consideration market situations at the global, national and regional level.

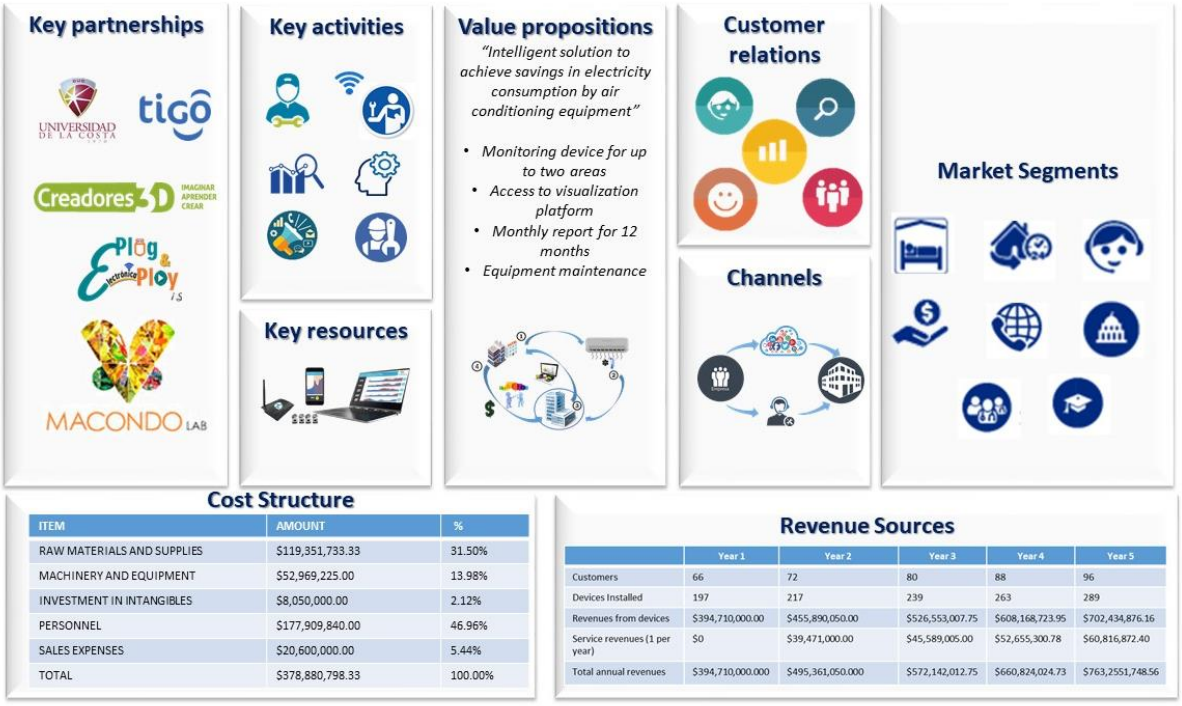
In order to validate this possibility, the methodology proposed by Osterwalder and Pigneur [23] was used, which is based on an initial working hypothesis as starting point, a need of a customer segment associated to the costs of maintaining, repairing, acquiring and installing air conditioning equipment for service sector buildings in Table 4.

Table 4. Initial business model (Hypothesis)

CANVAS SEGMENT	HYPOTHESIS OF THE STUDY
	H_1
VALUE PROPOSITION	Customer's pain: Associated with the maintenance, repair, acquisition and installation costs of HVAC equipment rather than consumption
	H_2
CUSTOMER SEGMENT	Customers exist for the proposed business idea
	H_3
SOURCES OF REVENUE	Charging for cool air consumption (Ton) / % over savings
	H_4
COST STRUCTURE	The company acquires, installs and maintains the equipment.

We thereby obtained a business model that enabled the interaction of specific segments to generate an attractive value proposition for companies in this sector.

Figure 1 shows the final Canvas obtained as a result of the validation process of each of the components of the proposed business model. The validation exercises enabled making several adjustments to the initial business model, by identifying some specific customer needs that could be turned into functionalities to provide additional value to the final solution. In order to validate the business idea, a service was designed using the minimum amount of resources achieved from the initial to the final iteration.



ITEM	AMOUNT	%
RAW MATERIALS AND SUPPLIES	$119,351,733.33	31.50%
MACHINERY AND EQUIPMENT	$52,969,225.00	13.98%
INVESTMENT IN INTANGIBLES	$8,050,000.00	2.12%
PERSONNEL	$177,909,840.00	46.96%
SALES EXPENSES	$20,600,000.00	5.44%
TOTAL	$378,880,798.33	100.00%

	Year 1	Year 2	Year 3	Year 4	Year 5
Customers	66	72	80	88	96
Devices Installed	197	217	239	263	289
Revenues from devices	$394,710,000.00	$455,890,050.00	$526,553,007.75	$608,168,723.95	$702,434,876.16
Service revenues (1 per year)	$0	$39,471,000.00	$45,589,005.00	$52,655,300.78	$60,816,872.40
Total annual revenues	$394,710,000.000	$495,361,050.000	$572,142,012.75	$660,824,024.73	$763,2551,748.56

Figure 1 Final Business Model
Note: The cost structure and revenue sources have its value in Colombian pesos.

Based on the nine modules of the Canvas model, the main finding was that the target market segment are buildings in the services sector (retailing, transportation and communications, business services and social services). The value proposition of the monitoring and control service on energy consumption by air conditioning equipment displays a clear differentiation from the model currently used for energy consumption management.

It was also found that the distribution channel for the service should be direct marketing (Company to Customer). Similarly, the marketing strategy is to manage the Green Consumption brand for the energy sector.

Based on the defined market niche, sustainable relationships with customers are to be based on dedicated personal relations, and self-service: the customer serves itself and effective communications are achieved through ICT. All the key resources required to develop the service were defined, the most important of which are human talent and technological resources (monitoring devices, website, among others).

Delivery of the value proposition implies carrying out the following key activities: technical and/or sales visits, installation of transmission, monitoring and information analysis equipment, maintenance of equipment and platforms, marketing and customer service. Such activities are actively involved in reinventing and updating the energy consumption monitoring and control service for air conditioning equipment, because adequate operation of the business model involves the constant search for individual solutions to each customer's problems.

Regarding key partnerships, there are two strategic alliances for adequate development of the proposed business model: firstly, with suppliers of equipment and supplies to develop an energy consumption monitoring device, and secondly, with universities and technology-based business accelerators to reduce risks and acquire key resources.

5. Conclusions

This study presents a business model based on the Canvas methodology proposed by Osterwalder y Pigneur. The model was designed and validated with the purpose of finding an intelligent solution for the optimization of energy consumption by VAC equipment in service-sector buildings. The proposal calls for using VRV technology, which is considered profitable based on a feasible economic investment for a model of this type, taking into considerations that service-sector buildings need to assure suitable infrastructure for application of this technology.

Development of the model enabled the incorporation of existing buildings with a common need, which is to save energy; the first step was to review energy consumption in buildings and existing energy business models worldwide.

This study shows that VRF technology is not considered the most profitable, taking into consideration its high cost and the delicate handling required for installation. Validation of the model was important in order to understand customer needs and their most important considerations that would lead them to buy into the model. For this it is necessary to create an attractive value proposition that would provide greater benefits to both parties. Initially customer surveys were made to get to know their "pain" and "wishes", which was valuable information for understanding how the value proposition should work and the characteristics it should have in order for it to be attractive for end users, finding as a result the need to achieve considerable energy savings at their companies.

Two alternative scenarios were created for model validation: 1. The creation of a company responsible for monitoring and control, and 2. The development and sale of an energy consumption monitoring device for VAC in service-sector buildings. The main challenge for future work of this study will be to implement this business model in different market segments that seek energy efficiency not only for air conditioning equipment, but also in other types of equipment connected to the electricity grid.

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