International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2019, 9(4), 1-11.

Analysis of Energy Management and Financial Planning in the Implementation of Photovoltaic Systems

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Received: 21 January 2019 **Accepted:** 12 May 2019 **DOI:** https://doi.org/10.32479/ijeep.7587

ABSTRACT

This paper presents the analysis of energy management and financial planning that is carried out in the design and implementation of photovoltaic systems in urban areas of the city of Barranquilla, Colombia. A questionnaire with a Likert scale and 36 items was designed, which was answered by subjects with managerial functions of the 16 companies dedicated to the implementation of photovoltaic (PV) projects in Barranquilla. The instrument was validated by expert judgment with a reliability of 0.84 with Cronbach's Alpha. For the analysis of results, techniques of central tendency and variability were used. The results show that energy management in the implementation of PV projects is moderate, indicating that there is no predominant presence of indicators of improvement and energy performance in these projects. Financial planning has a moderate significance, indicating that the financial analysis methods that are being used in these PV systems projects have a basic analysis.

Keywords: Energy Management, Financial Planning, Photovoltaic Energy
JEL Classifications: P18, P11, Q20

1. INTRODUCTION

An energy management system aims to develop and implement its energy policy, as well as manage activities and services that interact with the use of energy, using guides that standardize what should be done in order to implement, maintain and improve it continuously (Prías and Campos, 2013). Due to the growing importance of energy management systems, since 2005, leading countries in this field such as Denmark, Norway, Spain, the United States and China have established guidelines and standards for energy management, which contributed to the 2011 was approved by the International Organization for Standardization, the ISO 50001-Energy management standard, whose global application contributes to a greater availability of energy supply, improvement of competitiveness and a positive impact on the environment (Shakeri et al., 2017).

Since the creation of this standard, Europe is the main player in the ISO 50001 certifications, where Germany leads the most certifications of this regulation, followed by Spain, Denmark, Sweden, Italy, Romania, France, Ireland, Austria and the United Kingdom (De Sousa et al., 2017). The use of energy efficiency measures and renewable energy sources, has its origin from the initiative of several governments in response to international crises in the oil market. These actions were aimed at the implementation of energy management systems in the organizations aimed at reducing energy consumption and CO_2 emissions (Cabello et al., 2012).

In this context, the high impact that the application of energy management systems can have on the increase in energy efficiency becomes of fundamental importance to ensure electricity supply, reduce costs for electricity consumption and reduce greenhouse gases (Hernández and López, 2017). This is achieved through the integration of renewable energy sources, which reduce the impact of energy demand from the grid (Paez et al., 2017).

In terms of energy management, according to the Inter-American Development Bank (IDB, 2017), countries such as Mexico and Brazil stand out because they have consolidated their institutional policies to support energy management activities. In contrast, in countries such as Ecuador, Nicaragua, Peru, Panama, Uruguay, Venezuela and Cuba, despite the enactment of energy efficiency laws, the creation of agencies and the incorporation of energy management plans, advances in this field have been slow (Pablo-Romero and De Jesús, 2016).

In Colombia, in recent years, policies have been formulated that generate a favorable scenario to promote energy management (Castillo-Ramírez et al., 2017), as is the case with law 697 of 2001, which encourages the rational and efficient use of energy as a matter of social interest and of national convenience (Mejía, 2014). At present, the Ministry of Mines and Energy adopted the new Energy Efficiency Action Plan 2017-2022 (PAI PROURE, 2016), which aims to define the strategic actions to achieve the goals in terms of energy efficiency (Zarante et al., 2018).

In this national context, the Colombian Commission for the Regulation of Energy and Gas approved Resolution 030 of 2018, (Eras et al., 2018), on small-scale self-generation and distributed generation, which defines an easy mechanism for residential, commercial and small industry users to produce energy for meet your needs (Rodríguez-Urrego and Rodríguez-Urrego, 2018). In addition, these users can sell surplus energy to the interconnected system. In this scenario, it is where it is necessary to implement energy management in the residential sector (López-García et al., 2018).

In the local context, the field of construction in the city of Barranquilla maintains a positive dynamic, which is reflected in the growth that the city has had in recent years and as confirmed by the Colombian Chamber of Construction (Camacol Atlántico, 2017). This growth produces an increase in the consumption of electrical energy, due to the need to satisfy building requirements and user comfort: Heating, cooling and lighting (Eras et al., 2017).

Under this perspective, it is vital to make the residential sector more efficient in the use of energy, for which regulations should be designed to promote efficiency in the use of energy and the sustainability of homes (Nejat et al., 2015). Of all the sectors, in this work the residential sector was chosen, because there are no actions developed in this regard in Colombia. Also, because our country is increasingly urbanized. People spend almost 90% of their time inside buildings, which leads to an increase in energy consumption (Zomorodian et al., 2016).

In Colombia there are barriers to the development of energy markets and the execution of energy management programs and renewable energy sources (Edsand, 2017). The difficulty for the residential, industrial and commercial sectors of accessing financing resources is highlighted, due to the lack of instruments where the behavior of an economic balance is projected in terms of energy financial planning using renewable energies. Financial planning helps to evaluate the viability of electricity generation projects using financial indicators and taking into account sources of financing, costs, revenues and taxes (Ospino-Castro et al., 2017).

The Mining and Energy Planning Unit (UPME), through decree 0570 of 2018, registered at least 300 large and small projects totaling >4000 MW of non-conventional renewable energy generation (Sáenz, 2018). The new projects focus on small-scale self-generation of residential or business users. Of these initiatives, 255 correspond to solar-photovoltaic (PV); 18 to small hydroelectric plants; 10 to biomass; 8 to solar-thermal initiatives; 6 to wind energy; one to geothermal and another to hybrid (UPME, 2018; Pagola et al., 2019). This situation highlights the importance of having financial planning in these emerging energy markets that will be presented in urban areas of Colombia from the use of PV energy mainly.

This paper presents an analysis of energy management and financial planning carried out by companies dedicated to the design and implementation of PV systems in urban areas of the city of Barranquilla Colombia. It highlights as a contribution a set of strategic guidelines for the research variables of Energy Management and Financial Planning; that can be used as support by companies in the energy sector to improve their management and planning processes.

2. RESEARCH VARIABLES

To perform the analysis of energy management as a support tool for financial planning in the city of Barranquilla, Colombia, two research variables, 4 dimensions and 12 indicators were defined (Table 1).

2.1. Energy Management

Energy Management is defined as the sum of actions planned and carried out in order to use the minimum possible amount of energy while maintaining comfort levels (in offices, buildings and homes) and production levels (in factories) (Mapfre, 2011). In addition, energy management systems contribute to the reduction of greenhouse gas emissions, energy costs and other related environmental impacts. With energy management, an organization can detect opportunities for improvement in various aspects such as the quality and safety of energy systems, identifying peak

Table 1: Research variables

Variable	Dimension	Indicators
Energy management	Stages of energy management	Energy planning Implementation and operation Verification
	Energy performance	Energy consumption Energy Efficiency
Financial planning	Financial planning processes	Short-term and long-term goals Classification of financial planning Financial planning models
	Financial indicators	Liquidity Operations Indebtedness Profitability

consumption to implement improvements and thus achieve high levels of energy efficiency (Madrigal et al., 2018; Sarduy et al., 2018).

2.1.1. Stages of energy management

Energy management in a building has a series of stages that constitute a closed cycle with the objective of achieving continuous improvement (Dzene et al., 2015). These stages include the energy analysis, the detection of saving areas and the needs of the target area; in order to establish a procedure for controlling the sources of energy consumed, analysis of the best alternatives, control and reduction of consumption points. The cycle is closed with periodic reviews and the improvement of the system in order to obtain maximum energy efficiency without reducing the level of benefits (Kanneganti et al., 2017).

In this context, Gopalakrishnan et al. (2014) designed a guide for the implementation of an energy management system based on the standard ISO 50001. The model proposed by the authors consists of three fundamental stages: Strategic decision, installation and operation. The purpose is to take full advantage of all available resources and strategically analyze the organization in terms of efficiency with an impact on productivity and the consolidation of a culture. The indicators defined in this dimension are:

1. Energy planning: It is a process that identifies, analyzes and compares the significant uses of energy, the personnel associated with these uses, the legal requirements and others that are subscribed related to the uses and consumption of energy and the opportunities to improve energy performance (Introna et al., 2014). Energy baselines, performance indicators, energy goals and action plans for energy management are established (Müller et al., 2013).
2. In this stage it is necessary to define the period for the implementation of the system, as well as the activities, results, responsible parties, deadlines, resources and observations. This process helps to focus efforts, strategies and resources in the areas, processes and personnel that have a greater energy impact in the organization.
3. Implementation and operation: This stage is very important for the fulfillment of the policies of the energy management system (Brown and Desai, 2014). It covers all the personnel of the organization: Director, heads of areas, operators, cleaning and auxiliary personnel, permanent and occasional contractors (Oliveira et al., 2016). It mainly involves personnel related to equipment and areas of significant uses of energy. Energy management documents are established with the rules, controls and characteristics for the development of an activity (De Sousa et al., 2017). These documents can be internal, such as the energy management manual, procedures and work instructions, as well as external, such as rules, standards and specifications (Restrepo et al., 2014).
4. Verification: The purpose of this stage is to implement procedures to monitor, periodically measure and analyze the main processes that can have a significant impact on the use of energy (Kanneganti et al., 2017). To do this, the data to be controlled, the type of control, periodicity, control reason, control method, type of measurement and the indicator are established. In this stage, the previously chosen indicators are used according to the energy system. Through the comparison with reference indicators, the success or failure of the planning and the actions to be implemented (modification, maintenance or improvement) are determined.

2.1.2. Energy performance

Energy performance includes the need to establish indicators that describe the evolution of the different trends of energy parameters of interest to the organization (Gopalakrishnan et al., 2014). For the International Energy Agency (Kumar and Sudhakar, 2015), energy indicators are an important tool to analyze interactions between economic and human activity, energy consumption and emissions of carbon dioxide (May et al., 2015).

These indicators show policy-makers where energy savings can be made. They also provide information on trends regarding historical energy consumption. Energy efficiency indicators can also be used in the modeling and prediction of future energy demand. The indicators defined in this dimension are:

1. Energy consumption: This indicator defines the energy consumption as the amount of energy consumed by the installation. It depends directly on the production level of the installation (Introna et al., 2014). The values are obtained from meters, measures of control instruments and energy balances (Antunes et al., 2014).
2. Energy efficiency: This indicator makes it possible to establish in percentage terms how much energy consumption has improved compared to theoretical consumption, under equal conditions (Johnson et al., 2014). In this way, a comparison is made between the consumption of the real installation and the consumption that would have a reference theoretical installation with the same characteristics and with the same activity (Javied et al., 2015).

The periodic monitoring of this indicator allows deducing the maintenance and operation status of the installation (Aksoezen et al., 2015). To determine the energy efficiency index for a business unit, it is sufficient to know the specific consumption values for a reference year and the projected production values (historical data or future estimates), both for the base year and for the year studied.

2.2. Financial Planning

Financial planning is a generic activity that consists in the allocation and distribution of resources, in order to reach an objective. The authors Elliott and Timmermann (2016) define it as a technique that brings together a set of methods, instruments and objectives in order to establish forecasts, economic and financial goals to achieve in a company.

2.2.1. Financial planning processes

There are three key elements in the financial planning process: Cash planning consists of the preparation of cash budgets. Profit planning is obtained through the pro-forma financial statements, which show anticipated levels of income, assets, liabilities and social capital. Finally, cash budgets that are useful for internal financial planning (Lichfield et al., 2016). The indicators defined in this dimension are:

1. Short-term and long-term goals: According to the cited in Gamboa (2016), financial planning allows the company to obtain guidelines, to coordinate and control their activities in order to achieve their goals. The importance of the correct elaboration of the short-term plans is that they are conceived with the idea of obtaining results that allow obtaining the long-term plans. These plans are part of an integrated strategic plan, which considers the dispositions of funds for the acquisition of fixed assets, research and development activities and promotion and marketing actions.
2. Classification of financial planning: Financial planning is classified into strategic, tactical and operational (Nuss et al., 2015; Papazov, 2014). Strategic financial planning indicates the actions to be undertaken to achieve the goals, taking into account the competitive position and the forecasts and assumptions about the future. Tactical financial planning is one that contributes to the setting of the specific objectives of the company, which help with the fulfillment of the objectives already established (Siminica et al., 2017). Operational financial planning is the process that allows selecting, organize and present in an integrated manner the objectives, goals, activities and resources assigned to the components of the project, during a determined period.
3. Financial planning models: The tools of financial planning are conceived under economic and financial models, where the authors in (Juárez, 2014) define that the economic model has been designed in order to analyze separately the profitability of the commercial strategy and the efficiency of the structure; being a variant of the equilibrium point and that is constructed from the data of the loss state.

2.2.2. Financial indicators

Financial planning is supported by financial analysis techniques that allow the collection, interpretation, comparison and study of the financial statements and operational data of a business (Caldara et al., 2016). This involves the calculation and interpretation of percentages, rates, trends and indicators, which evaluate the financial and operational performance of the company and in a special way to facilitate decision-making.

The financial indicators include several indexes of income reports, and economic summaries of the movements made by the company. The indicators of financial planning are classified as liquidity (Ehiedu, 2014), operations (Tuomikangas and Kaipia, 2014), indebtedness and profitability.

1. Liquidity: The liquidity indicators measure the overall capacity of the company to meet its short-term obligations. Liquidity indices are used by analysts to establish with some degree of certainty whether the company can meet its obligations on the due date (Ehiedu, 2014).
2. Operations: This indicator measures the intensity with which the company is using its assets to generate sales and, therefore, measures the profit margin. These are rotation of accounts receivable, of inventories, of total assets, average term of replacement of inventory, average term in which accounts receivable will be made effective.
3. Indebtedness: This indicator measures the capacity to support debts, creditors can know through these indicators if the assets and profits are sufficient to cover the interest and capital owed. Indebtedness means the proportion of debt or liabilities that the company has with respect to the total resources invested (Brunetti et al., 2016).
4. Profitability: This indicator measures the degree of efficiency in the company to generate profits through the rational use of assets and their sales, in order to be able to reinvest. Profitability is a key variable in investment decisions, since it allows comparing the current or expected profits of several investments with the levels of profitability that are needed (Enqvist et al., 2014).

3. METHODOLOGY

The sample selected for the investigation consists of 16 companies in the energy sector of the city of Barranquilla, Colombia, which are dedicated to the sale, design and implementation of PV systems. In each company an employee with managerial functions was consulted.

For the collection of information, a questionnaire with a Likert scale, (Pacheco-Granados et al., 2018; Robles et al., 2017), with 36 items was designed, with five options of answers: (1) Never, (2) rarely, (3) sometimes, (4) very often and (5) always. The Likert scale is a set of items where a question is presented in the form of an affirmation to know the respondent's assessment, to finally assign a score for an answer and one for the total (Robles-Algarín et al., 2018). In total, the 12 indicators presented in the previous section were defined. For each indicator, three questions were designed to establish the perception of the respondents. The questionnaire designed is shown in Annex 1.

The designed instrument was subjected to a content validation, for which 5 experts in PV energy were surveyed, in order to guarantee the coherence, pertinence and reliability of the research. The application of this test allowed obtaining reliable data and carrying out a preliminary analysis with the results obtained. Then, the reliability of the elaborated instrument was determined. Therefore, Cronbach's Alpha was used, which is one of the consistency methods most widely used by researchers to estimate the reliability of questionnaires (Taber, 2018).

The authors Hernández et al. (2014) establish that a value of 0.25 means low reliability, if the result is 0.5, the reliability is medium or regular. If the coefficient exceeds the value of 0.75 it is acceptable, for a result >0.9 it is a high reliability. Using the Statistical Package for the Social Sciences software, a reliability coefficient value of 0.84 was obtained with the Cronbach's Alpha, which is in the reliability range >0.75, which is equivalent to acceptable reliability.

In this context, for the study of the data obtained, descriptive statistics was applied, using the real frequencies and their percentage ratio by item. The techniques of measures of central tendency and variability were used, by applying the mean and the standard deviation. The use of the mean allows the categorization of items, indicators, dimensions, as well as the variables under study. For the interpretation of the results, the scale shown in Table 2 was designed.

4. RESULTS AND DISCUSSION

In this section the results and discussion are presented, according to the 12 indicators defined in Table 1. Subsequently, the summarized results are presented for all the indicators, dimensions and variables of the research, according to the scale established in Table 2.

4.1. Results of the Dimension Stages of Energy Management

This section presents the results obtained for the dimension of stages of energy management through its three indicators: Energy planning, implementation and operation and verification; which are summarized in Table 3.

The results obtained show that the energy planning indicator has a total average of 3.69, which indicates a high presence of this indicator when implementing PV projects in the city of Barranquilla by the 16 companies surveyed. Item 1 presented an average of 3.44 with a moderate penetration in PV energy projects, items 2 and 3 present a score of 3.81 simultaneously, showing high presence in the design and implementation companies of PV projects.

In relation to the indicator of implementation and operation, it is observed that item 4 has an average of 3.06, moderate significance, this concludes that the companies surveyed mostly have few resources needed to implement a management system. Item 5, with a score of 3.06 and moderate significance, states that these companies have few trained personnel to meet the needs of an energy management system. The item 6 with a score of 2.38 and low significance, allows us to infer that most companies are indifferent to apply regulations for the realization of documentation. This indicator in general has a score of 2.81, with a moderate significance.

For the verification indicator, all the items evaluated have a moderate significance, this reveals that the verification stage in energy management has a moderate significance with a value of 2.81. In relation to this result, it can be established that this verification stage presents a medium level of implementation by the companies surveyed.

4.2. Results of the Energy Performance Dimension

In this section the results for the energy performance dimension are presented through its 2 indicators: Consumption and efficiency Table 4.

For the indicator of energy consumption, it is observed that item 10 has a score of 3.38 (moderate significance), that item 11 obtained a value of 3.06 (moderate significance) and that item 12 has a score of 3.25 (moderate significance). In general, the score of the energy consumption indicator obtained a score of 3.23 with moderate significance. It can be inferred that this moderate result is due to the particularity of each project carried out of PV energy, which

Table 2: Scale designed for the analysis of results

Mean			Standard deviation		
Range	Interval	Category	Range	Interval	Category
1	4.21-5	Very high	1	3.21-4	Very high dispersion
2	3.50-4.20	High	2	2.41-3.20	High dispersion
3	2.61-3.50	Moderate	3	1.61-2.40	Moderate dispersion
4	1.81-2.60	Low	4	0.81-1.60	Low dispersion
5	1-1.80	Very low	5	0-0.80	Very low dispersion

Table 3: Results obtained for the dimension: Stages of energy management

Dimension	Indicator	Item	Mean±SD (item)	Mean±SD (indicator)
Stages of energy management	Energy planning	1. Use of energy	3.44±1.15	3.69±1.10
		2. Performance	3.81±1.11	
		3. Savings plans	3.81±1.05	
	Implementation and operation	4. Resources	3.06±1.12	2.83±1.11
		5. Personnel	3.06±1.00	
		6. Documentation	2.38±1.20	
	Verification	7. Procedures	3.00±0.89	2.81±0.99
		8. Identification	2.69±1.14	
		9. Review	2.75±0.93	

SD: Standard deviation

Table 4: Results obtained for the energy performance dimension

Dimension	Indicator	Item	Mean±SD (item)	Mean±SD (indicator)
Energy performance	Energy consumption	10. Amount	3.38±1.45	3.23±1.21
		11. Production	3.06±1.12	
		12. Parameters	3.25±1.06	
	Energy efficiency	13. Production unit	3.13±1.15	2.79±1.18
		14. Real energy	2.75±1.13	
		15. Real energy versus theoretically	2.5±1.26	

SD: Standard deviation

is associated with the needs and economy of the client. In many cases clients only need the generation without taking into account any measurement parameter.

In the case of the energy efficiency indicator, it is found that item 13, has a score of 3.13, moderate significance, item 14, obtained a value of 2.75, moderate significance, and item 15 presented a value of 2.50, low significance. The indicator in general presented a value of 2.79, moderate significance. It is intuited that the surveyed companies apply little this indicator because it is associated with the consumption indicator. This means that due to the characteristics of some projects it is not necessary to carry out a measurement of real consumption, which leads to not being able to apply energy performance comparisons.

4.3. Results obtained for the Financial Planning Processes Dimension

The results for the dimension of financial planning processes are presented with its 3 indicators: Short-term and long-term goals, classification of financial planning and financial planning models Table 5.

For the indicator of short and long term goals, item 16 obtained a score of 2.94, moderate significance, item 17 presented a value of 3.19, moderate significance, while item 18 presents a result of 2.63, associated with a significance moderate. In general, the indicator has a score of 2.9 with moderate significance. This behavior is associated with each client's particularity that requests a PV generation project. As stated above, this type of project is closely related to the needs and economy of the client, causing this type of behavior regarding financial planning.

For the financial planning classification indicator, item 19 has a value of 2.88, followed by item 20 with a score of 3.06, ending in item 21 with a value of 3.19. The three items have a moderate significance, giving as a general result of the indicator a score of 3.04, with a moderate significance. This behavior reflects that the surveyed companies apply this indicator in some way. The trend shows that the projections in their financial plans are medium and short term, this is due to the fact that many of their projects are of low energy generation.

For the financial planning models indicator, item 22, has a score of 3.38, moderate significance, reflects that a large part of the companies surveyed (14 of the 16), apply economic models for the analysis of profitability of their projects. As for item 23, its score is 2.81, moderate significance, shows that the financial analysis in PV generation projects is applied in a low relation with the economic analysis of profitability. Item 24 has a score of 3.44, moderate significance, this indicates that in general that the companies surveyed apply economic and financial models to analyze the behavior associated with financial planning variables.

4.4. Results of the Financial Indicators Dimension

This section presents the results of the dimension of financial indicators in its 4 indicators: Liquidity, operations, indebtedness and profitability Table 6.

In relation to the liquidity indicator, item 25 has a high significance with a score of 3.63, this is because the companies to be able to install the PV systems request payment in advance, leading to the clients having availability of the total payment of the project. Item 26, has a value of 3.13, moderate significance, shows that most

Table 5: Results obtained for the dimension: Financial planning processes

Dimension	Indicator	Item	Mean±SD (item)	Mean±SD (indicator)
Financial planning processes	Short-term and long-term goals	16. Schemes	2.94±1.06	2.92±1.09
		17. Short term	3.19±1.18	
		18. Long term	2.63±1.02	
	Classification of financial planning	19. Strategies	2.88±1.20	3.04±1.14
		20. Tactical	3.06±1.06	
		21. Operational	3.19±1.17	
	Financial planning models	22. Profitability	3.38±1.20	3.21±1.26
		23. Financial	2.81±1.38	
		24. Resources	3.44±1.21	

SD: Standard deviation

Table 6: Results obtained for the financial indicators dimension

Dimension	Indicator	Item	Mean±SD (item)	Mean±SD (indicator)
Financial Indicators	Liquidity	25. Capacity	3.63±1.31	3.42±1.35
		26. Certainty	3.13±1.36	
		27. Capital	3.50±1.37	
	Operations	28. Intensity	3.63±1.20	3.38±1.13
		29. Operational efficiency	3.31±1.14	
		30. Inventory	3.19±1.05	
	Indebtedness	31. Capacity	3.69±1.14	3.46±1.07
		32. Indebted capital	3.50±1.03	
		33. Percentage	3.19±1.05	
	Profitability	34. Degree of efficiency	3.25±0.86	3.44±0.98
		35. Earnings	3.44±1.21	
		36. Profits	3.63±0.87	

SD: Standard deviation

companies (11 of 16), take into account a degree of certainty in the financial projection. Item 27, has a score of 3.5, high significance, this shows that companies take into account sufficient working capital to carry out the project. In general, the indicator has a moderate significance with a score of 3.42.

For the operations indicator, item 28 has a high significance, score of 3.63, which shows that it is very common to compare expenses with income to have a projection of the recovery of the investment. Item 29 with a value of 3.31, moderate significance, indicates that it is necessary to have mechanisms to measure the operational efficiency of PV systems to establish their real performance and have more accurate financial and economic projections. Item 30 with a value of 3.19, moderate significance, shows that 11 companies apply the activity of inventory rotation to know the financial context of their projects. The general score of the indicator is 3.46, with a moderate significance.

In the case of the indebtedness indicator, it is found that item 31 has a score of 3.69, high significance. This is due to the fact that in the country there are banks and private entities that offer cash capital loans for PV generation projects and many of the companies surveyed work together with these entities.

Item 32 obtained a value of 3.5 and high significance, which is due to the recent regulation of being able to sell surplus energy to the grid, giving the opportunity that the surveyed companies offer their clients this model of producing profits from the sale of surplus energy. Item 33 with a value of 3.19, moderate significance, shows a behavior associated with item 31, where companies study the percentage of indebted capital based on cash capital loans. The general score of the indicator evaluated was 3.46, with a moderate significance.

For the profitability indicator, item 34 has a score of 3.25, moderate significance. This result is due to the fact that in the city of Barranquilla there are few projects for the implementation of PV power with connection to the grid because resolution 030 of 2018, which allows these projects to sell surplus energy, was recently enacted in 2018. The item 35, obtained a score of 3.44, moderate significance, which shows that in relation to the new resolution 030, the tendency of the companies surveyed is to start offering these activities to have a greater penetration and sale of generation PV systems in urban areas of Barranquilla.

Item 36 obtained a score of 3.63, with a moderate significance, which is presented due to the emerging models of energy sales businesses, which arise by law 1715 and resolution 030 that allow the interconnection of PV systems to the network and be able to sell surplus energy. This shows that the companies dedicated to the sale and implementation of PV systems show as an added value the recovery of effective capital investment, emphasizing the net benefit versus the investment made.

4.5. Results of Research Variables, Dimensions and Indicators

In this section we present the results for the 2 research variables, the 4 dimensions and the 12 indicators. Table 7 summarizes the results analyzed in the previous sections. It can be seen that the energy management with a value of 3.06 and the financial planning with a value of 3.23, have a moderate significance. This situation reveals the need to propose a set of strategic guidelines and improvement actions that can be accepted by companies dedicated to the design and implementation of PV systems.

5. STRATEGIC GUIDELINES

In this section we present a set of strategic guidelines organized according to the two research variables (energy management and financial planning). These guidelines are presented as improvement actions that can be implemented by companies dedicated to the design and implementation of PV systems.

5.1. Strategic Guidelines for Energy Management

The results obtained for the energy management research variable through its 2 dimensions and 5 indicators, show that the main trend regarding the stages of energy management focuses on energy planning and, to a lesser extent, the implementation, operation and verification stages. Regarding the consumption and efficiency performance indicators, it presents a moderate behavior, leaving it seen that it is necessary to strengthen these activities. For such strengthening the following guidelines are proposed:

It is proposed that companies carry out an analysis of the energy system under study with the qualitative and quantitative evaluation of energy consumption in the different consumption centers. To do this, an energy accounting system must be established, which allows knowing the consumption of each energy source. It is necessary to perform an energy audit to know the instantaneous

Table 7: Research results

Variable	Mean	Dimension	Mean	Indicator	Mean
Energy management	3.06	Stages of energy management	3.11	Energy planning	3.69
				Implementation and operation	2.83
				Verification	2.81
		Energy performance	3.01	Energy consumption	3.23
				Energy efficiency	2.79
Financial planning	3.23	Financial planning processes	3.05	Short-term and long-term goals	2.92
				Classification of financial planning	3.04
				Financial planning models	3.21
		Financial indicators	3.42	Liquidity	3.42
				Operations	3.38
				Indebtedness	3.46
				Profitability	3.44

consumption, losses by radiation, effluents, waste of energy, energy yields, condition of the equipment and possible measures to improve them.

It is important to establish the action plan that incorporates the objectives to be achieved with the implementation of the PV system, actions to be developed to achieve the objectives, material, economic and human resources, operating methodology, procedures, monitoring and evaluation.

As for the analysis of possible savings plans, the implementation of improvements that do not require a high investment, such as staff training, is proposed first. Secondly, the modification of equipment by more efficient ones is recommended. For each possibility of saving, it is calculated: The cost of implementing the PV system connected to the grid, expected energy savings, return time, quality improvements, efficiency improvements and inconveniences.

5.2. Strategic Guidelines for Financial Planning

Regarding the study of the financial planning of PV systems connected to the network, it is found that the dimensions studied, processes and indicators of financial planning have a moderate participation. The analysis of the financial viability is fundamental to determine the cash flows resulting from the implementation of a PV system connected to the grid and the long-term profitability. It is also useful to obtain profitability indicators that justify the financial viability of the investment. Based on the results obtained, the following guidelines are proposed.

The most common method to apply economic engineering to PV systems is to reduce all future revenue streams to their current value. It is proposed to implement the economic analysis method, life cycle cost, where each cost associated with the PV installation is added during a period of analysis, which is usually the expected useful life of the installation.

The basis of this method is the discount rate, which converts the expected monetary income of a system to its current market value. Although it is important to choose a realistic number for the discount type, only an intelligent guess can be made. For PV systems, this may be the interest on the loan that financed the PV installation.

Inflation is another economic parameter that should be evaluated and should be based on historical parameters and current inflation rate. An estimated discount rate is necessary to evaluate the value of the parts that may need a replacement after a certain time, as inverters and controllers, the future cost of the services, as well as the value of the entire system after a certain period.

In addition to evaluating the cost of spare parts, the operation and the cost of maintenance must be evaluated. This cost is generally considered stable every year during the useful life of the PV installation, but, like all monetary sums, its real monetary value is decremented every year. For the calculation of the operation and the maintenance cost, it is necessary to evaluate the capital recovery factor.

6. CONCLUSIONS

With the analysis of the energy management research variable, it was possible to show that the energy planning indicator has a high presence in the PV system implementation projects, in the urban areas of the city of Barranquilla. This behavior occurs because in these projects it is necessary to know the energy production of the system in order to estimate the implementation costs.

It can also be concluded that the companies surveyed base their consumption calculations on theoretical values, implementing spreadsheets and design simulators of PV systems, in order to reduce costs associated with the installation of specialized measuring equipment that allows the measurement of consumption in real time.

In the analysis of financial planning it was established that it is necessary for companies to implement improvement actions that allow them to estimate and forecast the sales made, as well as income and assets. In addition, it can be concluded that the presence of liquidity, operations, indebtedness and profitability indicators are moderate in the implementation of PV systems. This is associated with the fact that few of the companies surveyed have a good structure regarding the financial processes studied. These emerging models of energy sales with PV systems in Colombia, are particularly new, arise from regulation 030 of 2018, this causes that these companies must restructure their projects, offering new forms of financing and investment profitability to their customers.

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ANNEX

Annex 1: Questionnaire (A: Always, VO: Very Often, S: Sometimes, R: Rarely, N: Never)

No.	Question: ¿How often:	A	VO	S	R	N
Variable: Energy management						
Dimension: Stages of energy management						
Indicator: Energy planning						
1	Do you compare the effective uses of energy?					
2	Do you analyze opportunities to improve energy performance?					
3	Do you consider the use of energy saving plans?					
Indicator: Implementation and operation						
4	Do you have the necessary resources for the implementation of an energy system?					
5	Do you have trained personnel to comply with the energy management system?					
6	Is the energy management document established with control rules, as well as characteristics?					
Indicator: Verification						
7	Are procedures implemented to track the use of energy?					
8	Is the data identified to control the type of control, the method of control, among others?					
9	Is the periodic review of the use of the energy system carried out?					
Dimension: Energy Performance						
Indicator: Energy consumption						
10	Does it measure the total amount of energy consumed to generate a volume of activity?					
11	Is the production level of the installation determined with respect to the energy consumed?					
12	Are the parameters of the energy activity measured?					
Indicator: Energy efficiency						
13	Is the energy needed to obtain a production unit measured?					
14	Does it compare the real energy consumed by the productive processes?					
15	Does it compare the actual energy consumed with the energy consumed theoretically?					
Variable: Financial planning						
Dimension: Financial planning processes						
Indicator: Short-term and long-term goals						
16	Do you take advantage of the schemes that serve as a guide to coordinate the activities that lead to the proposed goal?					
17	Do you plan to get results in the short term?					
18	Do you carry out capital movement operations in the long term?					
Indicator: Classification of financial planning						
19	Do you design strategies for obtaining the goals taking into account the relative competitive position?					
20	Do you set the objectives of the company according to the tactical planning?					
21	Do you take the necessary actions to select, organize, and present the proposed goals?					
Indicator: Financial planning models						
22	Do you analyze the profitability of the business strategy that you apply in the company?					
23	Do you acquire the skills for mathematical analysis that describe the interrelation of financial variables?					
24	Does it help minimize risk by taking advantage of opportunities, in addition to financial resources?					
Dimension: Financial indicators						
Indicator: Liquidity						
25	Does it measure the overall capacity of the company to meet its short-term obligations?					
26	Does it establish some degree of certainty so that obligations can be fulfilled by the due date?					
27	Is it reported with respect to working capital to meet the commitments made?					
Indicator: Operations						
28	Do you measure the intensity with which assets are used to generate profit?					
29	Do you execute actions to measure the operational efficiency of the company?					
30	Does the inventory rotation apply to know the financial situation of the company?					
Indicator: Indebtedness						
31	Do you adapt the debts to the financial support capacity of the company?					
32	Does it propitiate enough profits to cover the indebted capital?					
33	Do you determine the percentage of the assets of the company that are committed to third parties?					
Indicator: Profitability						
34	Do you propose to measure the degree of efficiency in the company to generate profits through the rational use of assets?					
35	Do you compare the current or expected earnings of several investments with the profitability levels?					
36	Does it emphasize the net profit generated by the company in relation to the investment made by the owners?					