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Assessment of Energy Conservation Resource in Academic buildings seeking sustainable Energy planning

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***Keywords*— Energy Efficiency Energy Demand Side Management, Energy Management, Full Potentials Accounting and Valuation, Integrated Resource Planning.**

***Abstract*— *The objective of this work is to evaluate the application of the Full Potentials Accounting and Valuation (FPVA) method for ranking Energy Resources in a faculty of a large private Brazilian company. This work is justified by the importance and complexity in decision making for the implementation of energy efficiency projects in a consumer company. The method for developing this work is divided into three steps, first the inventory of Energy Resources is carried out, then Resources are analyzed within the sub-attributes of the four dimensions of Integrated Resource Planning (IRP) and based on the opinion of internal stakeholders of the company, the ranking of the Resources identified is obtained. The work demonstrates that it is possible to have synergy for the application of methods developed in academic studies in the corporate market, in addition to opening the possibility of carrying out the same study in other teaching units of the studied company or in companies from other economic sectors.*

I. INTRODUCTION

Energy efficiency started to have a bigger prominence in the society from the decade of 1970, which was explained as a form to guarantee the security in the energy supplying, as a result of the worldwide crisis of the oil in 1973 [1]. The implementation of energy efficiency projects has also been stated to be considered a good opportunity to reduce costs for consumers who initially began to be guided through educational programs for efficient energy consumption [2]. In a second stage, energy efficiency projects began to be implemented through the modernization of equipment that consume little energy [3].

From the beginning of the 21st century, energy efficiency is considered a strategy to reduce costs of companies [4], besides also reducing negative impacts on the environment, thus becoming, critical subject in the debates on sustainability [5]. The energy efficiency now incorporates all the previous concepts, being considered a set of actions that, when combined, can offer socio-environmental options, economic development, cost reduction for companies, and guarantee of energy supply to society [6].

This work recognizes energy efficiency projects as any type of Energy Resource that in one way or another makes the management of the energy bill more beneficial for the consumer company. Such an Energy Resource can have an impact on energy consumption in kilowatt-hours, as well as on reducing the value of the energy bill, without necessarily changing consumption in kilowatt-hours [7].

Considering that the decision-making for choice and implantation of an energy efficiency project can encompass many variables and become quite complex, different studies are designed to rank the prioritization of the implantation of Energy Resources. Within this context, this article aims to rank Energy Resources that can be implemented by an energy-consuming company through the CVPC method. Differently from what is seen in other studies on the subject, rank ranking is based on the opinion of internal stakeholders of the company, as to the degree of importance that is given to each dimension of the IRP, since the simulations are made based on the percentage of importance attributed in the four dimensions by 8 employees of different departments and positions.

This direct participation of the decision-making and operational stakeholders of the company studied makes the results obtained more consistent with the strategic planning designed by the analyzed company. Thus, making them, more secure about decision-making.

In the work are simulated the implantation of 9 different types of Energy Resources described in TABLE 1 and is, 8 of them Demand Side Energy Resource (DSER) and 1 Supply Side Energy Resource (SSER) in a building of a large private company in the education sector, where a college works, in which they study approximately 4,500 students, it has 104 classrooms and a built area of approximately 31,000 square meters.

Table 1: Detailed description and summary description of the analyzed Energy Resources

Description	Explanation
DSER: environmental conditioning	It represents the replacement of 171 air conditioners, with the new ones having the inverter technology, 40% more efficient than the devices with conventional technology [8], and they are supplied by R410 gas to replace R22, the not degrading the ozone layer and not being flammable [9].
DSER: automation with presence sensor	It does not consider the replacement of light bulbs or air conditioners, it only considers the reduction in consumption resulting from the reduction in the operating period of the teaching unit, in accordance with the building's opening hours. According to information presented by the company studied, with the installation of this type of equipment the annual consumption in hours of use is reduced from 1,485 to 1,287 [10]. And it is precisely this reduction that impacts the valuation of the Resource in the dimensions analyzed.
DSER: migration to FECE	Migration of the consumer unit to the Free Energy Contracting Environment (FECE), which reduces the value of the energy bill without reducing consumption in kWh.
DSER: tax efficiency	Management of tax opportunities in the energy bill, based on tax regulations, which reduces the value of the energy bill without reducing consumption in kWh.
DSER: Demand Tuning	Request an adjustment of the demand contracted with the distributor, for more or less, in order to reduce the value of the energy bill, not impacting energy consumption in kWh.
DSER: Educative actions	Develop educational actions to raise awareness among students and employees, with the purpose, but without guarantee, of reducing energy consumption in kWh.
DSER: tariff framework	Adapt the consumer unit to the most beneficial tariff range, from a financial point of view, compared to the distributor, which reduces the value of the energy bill.
SSER: own energy generation	It is considered the generation of electric energy through solar energy in the morning and afternoon and the generation of electric energy with diesel generators during peak hours, from 5:30 pm to 8:30 pm, and use of energy from the grid during the remainder of the day [10].

Source: self-elaboration based on [10]

As a basis for analysis, consumption data for the year 2019 were used, given the irregularity of energy consumption in 2020, which was affected by the Coronavirus pandemic and which can be easily identified in Fig. 1.

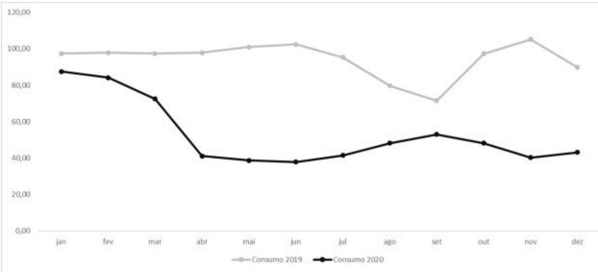

Fig. 1: Energy consumption between 2019 and 2020 in MWh

Source: self-elaboration based on [10].

Given that this study uses consumption information from 2019, and the financials analyses is made in the Brazilian currency (BRL) to show the same financials results in USD, is considered the exchange rate from December 31st of 2019, which was 1,00 BRL equivalent to 0,25 USD.

II. STATE OF THE ART

There are different methods of project evaluation, for example the Goal Question Metrics (GQM), whose approach begins with goals and strategies are drawn from them [11]. Furthermore, Life Cycle Assessment (LCA), which analyzes the environmental impacts associated with a particular product, process, or activity [12].

In addition to the evaluation methods mentioned above, as well as others that exist in there are those that are specific to evaluate energy efficiency projects. This work uses CVPC, which consists of the process of valuation of all Energy Resources in the four dimensions of the IRP and aims to value each Resource quantitatively and qualitatively [7 and 13].

In short, the CVPC is made by applying the Full Cost Assessment (FCA) methodology, inset with the Hierarchic Analysis of Processes (HAP) [10].

Within the scope of the IRP, the FCA attributes points and value the Energetic Resources inside the four dimensions [14 and 15]. The HAP, on the other hand, is a method that requires hierarchy or relationship structure in a given problem, to create comparison measures between the groups or objects analyzed [16].

The hierarchy and relationship between these evaluation methodologies are best explained in Fig. 2.

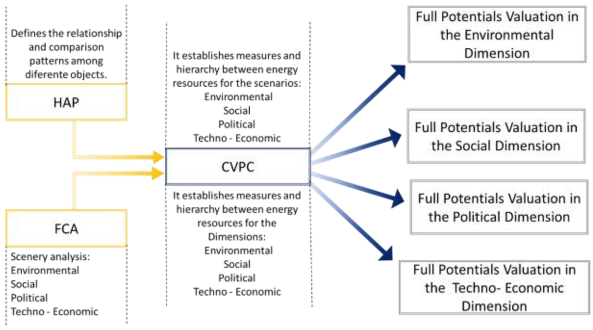

Fig. 2: Relation between HAP, FCA and CVPC

Source: Self elaboration.

III. METHODOLOGY

This work adapts the CVPC methodology of the PIR for the valuation of energy resources in the building where a teaching unit works, with the result obtained here it is possible to establish a practical and applicable method to other buildings with the same profile. Such method follows the steps of the Fig. 3:

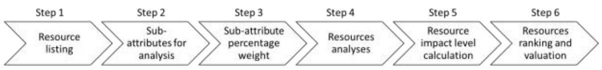

Fig. 3: Working method steps

Source: self-elaboration based on [10].

Step 1: Resource listing

It consists of making an on-site visit at the study site to raise all the Energy Resources, to select and list those that can be analyzed.

Step 2: Sub-attributes for analysis

Each type of company, as well as the place where the Resources are implanted have their specificities, therefore, must select and adjust the sub-attributes for analysis [10].

Step 3: Sub-attribute percentage weight

The company's internal stakeholders must establish the weight of importance for each dimension. In this work, the weights are established by 8 different employees of different functional levels and departments. Through the percentile weight in each dimension, it is possible to obtain the weight of each sub-attribute, according to i.e., (1) and i.e., (2).

$$\frac{Dimension\ weight}{Attributes\ amount\ in\ the\ dimension} = \quad (1)$$

$$= Each\ attribute's\ \text{weitght}$$

$$\frac{Each\ attribute's\ weight}{Subattributes\ amount\ in\ the\ attribute} = \\ = Each\ subattribute's\ weight \quad (2)$$

The percentage weight of each dimension was obtained from the company's stakeholders through the application of a questionnaire, reaching the values in TABLES 2, 3, 4 and 5

Table 2: Assignment of weights by dimension by the Social and Environmental Responsibility department

Dimension	Management	Operating
Environmental	60%	50%
Social	20%	30%
Policy Statement	5%	5%
Technical-Economic	15%	15%

Source: self-elaboration based on [10]

Table 3: Assignment of weights by dimension by the Supply department

Dimension	Management	Operating
Environmental	20%	20%
Social	30%	10%
Policy Statement	30%	0%
Technical-Economic	20%	70%

Source: self-elaboration based on [10]

Table 4: Assignment of weights by dimension by the Teaching Unity studied

Dimension	Management	Operating
Environmental	25%	40%
Social	25%	30%
Policy Statement	10%	15%
Technical-Economic	40%	15%

Source: self-elaboration based on [10]

Table 5: Assignment of weights by dimension by the Engineering department

Dimension	Management	Operating
Environmental	23%	24%
Social	23%	17%
Policy Statement	31%	17%
Technical-Economic	23%	42%

Source: self-elaboration based on [10]

Step 4: Resources analyses

All the Resources of step 1 are analyzed in great detail all the sub-attributes of each dimension, and quantitative and qualitative analyses are made. In first the results, are obtained through mathematical analyses from numerical data informed by the company studied and through bibliographic research.

The resulting logic assigned to each Resource is presented in TABLE 6, where in the first column are the sub-attributes that are analyzed quantitatively, the second column presents the average obtained in the calculation performed with all Energy Resources, and the third column describes the interpretation that should be had in each sub-attribute, to then obtain the output of this step in the fourth column.

Table 6: Criteria for establishing the level of impact on sub-attributes with quantitative analysis

Sub-attribute	Average	Analysis	Output
Water demand, consumption and flow (m^3)	19,848.38	Above average	A positive impact
		Below Average	Negative Impact
Greenhouse Gases (tonnes)	26.24	Above average	A positive impact
		Below Average	Negative Impact
Direct jobs	4	Above average	A positive impact
		Below Average	Negative Impact
Economic Activities / Infrastructure	$ 77,919.00	Above average	A positive impact
		Below Average	Negative Impact
Development	$ 23,996.30	Above	A positive

		average	impact
		Below Average	Negative Impact
Implementation cost	$ 77,919.00	Above average	Negative Impact
		Below Average	A positive impact
IRR (Internal Rate of Return) 5 years	33%	Above average	A positive impact
		Below Average	Negative Impact
Inv./NPV (Net Present (Value) Index 5 years	1.24	Above average	Negative Impact
		Below Average	A positive impact
Payback (months)	12	Above average	Negative Impact
		Below Average	A positive impact
Useful life (years)	14.21	Above average	A positive impact
		Below Average	Negative Impact
Energy volume (MWh)	4,718.84	Above average	A positive impact
		Below Average	Negative Impact
Energy Integration (MWh)	4,718.84	Above average	A positive impact
		Below Average	Negative Impact

Source: self-elaboration based on [10]

For the above-mentioned sub-attributes, the calculations were made as shown in TABLE 7.

Table 7: Sub-attribute calculation method

Sub-attribute	Calculation method
Water demand, consumption and flow (m³)	Relationship between energy consumption (kWh) and water demand, based on the Brazilian water matrix.
Greenhouse Gases (tons)	Relation between energy consumption (kWh) and CO2 emission, based on the 2019 National Energy Balance (BEN).
Direct jobs	Number of vacancies created is based on information obtained from the company studied
Economic Activities / Infrastructure	The investment value for each Energy Resource through the purchase and installation of equipment. In the case of the Tax Efficiency Appeal, the payment of court costs is considered.
Development	It is the income generated to employees directly involved during the project period. In this case, the account is made by combining the number of vacancies generated, the employee's functional levels, the number of minimum wages that each functional level receives and the minimum wage in 2019, $ 261.25.
Implementation cost	It is the investment value for each Energy Resource.
IRR 5 years	Internal rate of return of the Energy Resource
Inv./NPV Index 5 years	The investment value for each Energy Resource divided by the Net Present Value calculated on the resource.
payback (months)	Return on initial investment
Useful life (years)	Duration of the Resource as informed by the studied company.
Energy volume (MWh)	It is the amount of energy saved over the lifetime of the Resource.
Energy Integration (MWh)	It is the amount of energy saved over the lifetime of the Resource.

Source: self-elaboration based on [10].

Qualitative analyzes are done in three different ways. For the policy instruments sub-attribute, the logic in TABLE 8 is followed.

Table 8: Analysis logic of the political instruments sub-attribute

Condition	Analysis	Output
Regulation on the Resource is already approved and	positively consolidated	A positive impact

positively		
Regulation on the Appeal is under review in court, with a positive perspective	positively under review	Low positive impact
Regulation on the Resource is already approved and negative	negatively consolidated	negative impact
Regulation on the Appeal is under review in court, with a negative perspective	negatively under review	Low negative impact
There are no regulations on the Resource.	There is no political instrument	There is no impact

Source: self-elaboration based on [10]

As for the sub-attributes: waste; land occupation; water quality, consumption and flow; degrading gases from the ozone layer; social impact due to occupied space; visual pollution; noise pollution; olfactory pollution; thermal pollution, through the analysis, classifications are assigned to the Resources, thus generating the output of the analyzes as shown in TABLE 9, where N/A means Not Applied.

Table 9: Analysis logic of sub-attributes classified by the researcher

Classification given by the researcher	Output
N/A with high positive impact	A positive impact
N/A with low positive impact	Low positive impact
N/A with high negative impact	negative impact
N/A with low negative impact	Low negative impact
N/A no impact	There is no impact

Source: self-elaboration based on [10]

The last type of qualitative analysis is made through questionnaires answered by experts from the energy market to the energy market to evaluate the sub-attributes: technologies and equipment, design and logistics, organized societies, NGOs and associations; generators, producers, and distributors; governments; consumers; legal aspects. To all, 152 different institutions had been contacted, of which 40 had answered, being 18 organized energy management consultancies, 4 organized companies, NGOs, or associations, 17 companies considered generators, traders, or distributors of energy, and 1 governmental institution [10]. For each one of these market sub-attributes, specialists should respond from 1 to 5, with the interpretation and respective output in TABLE 10.

Table 10: Logic of the analyzes carried out by specialists in the electric market

Reply	Interpretation	Output
1	extremely pessimistic	negative impact
2	Pessimistic	Low negative impact
3	No preference	There is no impact
4	Optimistic	Low positive impact
5	extremely optimistic	A positive impact

Source: self-elaboration based on [10]

Step 5: Resource impact level calculation

This step is summarized in equation 3.

Step 4 x mulplication facto x subattribute weight = resource ranking in the subattribute (3)

Where the sub-attribute weight is obtained through equations 1 and 2.

The relationship between the output from the previous step and the multiplication factor is better explained as shown in TABLE 11

Table 11: relationship between output from step 4 and multiplication factor

Output	Multiplication factor
A positive impact	+1
Low positive impact	+0.25
No impact	0
Low negative impact	-0.25
negative impact	-1

Source: self-elaboration based on [10]

Step 6: Resources ranking and valuation

This step consists of the sum result of formula 3, to consolidate the score separately in each dimension and consolidate form with all the dimensions.

Having this sum, the Resources are ranked, so that it is easy for decision-makers to choose the order of preference for implementing the Energy Resources studied.

Valuation of the Resources

All the Resources had been explained in TABLE 1 of the work, this topic is presented in step 4 of the work, as shown in figure 3, including output denominated in each Energy Resource and all the sub-attributes.

1. DSER Modernization of the lighting installation

Within the environmental dimension, in the water litigation sub-attribute a reduction of 7.838, 93 m³ is calculated and in the greenhouse effect gas sub-attribute, a reduction of 9,44 tons of CO_2 is not emitted in a period of one year. For the terrestrial attribute and sub-attribute water quality pollutant emission, it should be considered that when substituting the lamps, the waste of more than 12 a thousand fluorescent lamps is prevented and almost 46 grams of mercury in the environment throughout 16 years [10]. This result, when compared to other Resources, is highly advantageous, since mercury is an extremely pollutant chemical in the terrestrial and aquatic environment.

In the social dimension, this Resource creates 7 direct jobs and generates an income of $ 1,349.79 for the project implantation period - 5 days [10], in addition, to injecting $ 31,095.29 through the investment made for the installation of the lamps of the efficient lighting system [10]. Due to the technical characteristics and advantages of LED lamps, it is possible to say that this Resource is beneficial within the sub-attributes visual and thermal pollution [10].

In the sub-attribute cost of implementation of the technical-economic dimension, the investment of $ 31,095.29, 8,52% IRR is considered for valuation, the index used in the calculation of NPV of 0,334, the useful life of 16,8 years, and potential reduction in energy consumption by 1,805.18 MWh [10]. In the other two sub-attributes evaluated, the Resource is positively evaluated by external stakeholders [10].

In the political dimension, in the energy integration sub-attribute, the value is 1.805,18 MWh. In the sub-attributes in which evaluations are carried out by external stakeholders, the Resource is evaluated optimistically in two of them and indifferently in the other sub-attributes, technologies, and equipment, and design and logistics, the Resource is evaluated with high positive impact [10].

2. DSER Modernization of the conditioning system of the environment

Initiating the assessment for the environmental dimension, a reduction of 69,597.35 m³ in water consumption and 83.78 tons of CO_2 that are not emitted into the atmosphere over a year is calculated. In the other sub-attributes, the elimination of degrading gases from the ozone layer stands out, as R410 does not degrade the ozone layer, the Resource is evaluated as having a high positive impact on the sub-attribute in question.

Within the social dimension, this Resource creates 9 direct jobs and generates an income of $ 3,396.25 for the period of implantation of the project 10 days [10]. Since the investment required to implement the Resource is $ 255,649.50, this is considered as a necessary value for comparison in the sub-attribute economic activities and infrastructure [10]. As for the comfort perception attribute, more specifically in the noise pollution sub-attribute, it is emphasized that equipment with the technology to invest is quieter than conventional equipment.

In the Technical-Economic Dimension, starting with the implementation cost sub-attribute, there is the same $ 255,649.50. In the other attribute sub-attributes, IRR of 9.22%, NPV analysis index of 0.303, payback in 11 months, the useful life of 10 years, and 9,520.10 MWh saved over its useful life [10]. As for the two sub-attributes evaluated by external stakeholders, the Resource is classified as indifferent [10].

In the political dimension, for the energy integration sub-attribute, the Resource is well evaluated, since it considers the value shown above in the energy consumption sub-attribute. For all sub-attributes in which evaluations are carried out by external stakeholders, the Resource is evaluated indifferently, that is, there is no impact on valuation [10]. In the sub-attributes technologies and equipment and design and logistics, the Resource is positively evaluated by external stakeholders [10].

3. DSER Automation with presence sensor

First, within the environmental dimension, the reduction of 11,006.71 m³ of water and 13.25 tons of CO_2 in one year is identified. In the ozone layer degrading gases sub-attributes, it is evaluated that the Resource does not cause any impact, whereas, for the other sub-attributes of the dimension, the evaluation is based on mathematical analysis [10]. Given that the Resource reduces the unit's operation, it is understood that fluorescent lamps last longer, thus postponing the disposal of lamps and, consequently, the disposal of mercury in the environment [10].

In the social dimension, the Resource creates 9 jobs, generating total income during its implantation of $ 5,094.38 [10]. As evaluated in the studied company, the investment for implementing the Resource is $ 17,421.75, which is, therefore, the value for evaluating the Resource in the sub-attribute economic activities and infrastructure. For the other sub-attributes of the dimension, the Resource is considered to have no impact.

In the technical-economic dimension, for the sub-attribute implantation cost, considers the value of the cited investment the same above, in addition to 21.24% in the IRR, 0.113 in the NPV index, 5 months of payback, 5 years of useful life, and reduction 752.79 MWh in energy consumption over its lifetime. For the two sub-attributes technologies and equipment and design and logistics, the Resource was evaluated as indifferent [10].

In the political dimension, the Resource is optimistically evaluated by institutions considered to be organized societies, NGOs, and associations and indifferently by other external stakeholders [10]. In political instruments and tenure and/or ownership, the Resource is evaluated as positively consolidated and with a high positive impact, respectively [10]. Finally, in the energy integration sub-attribute, the volume 752.79 MWh is considered.

4. DSER Migration to the Free Energy Contracting Environment (FECE)

Knowing that the studied unit already is in the free market, to analyze this Resource inside of the ambient dimension, TABLE 12 is used to demonstrate water consumption according to the source of energy generation, also considering TABLE 13 with the proportional distribution of primary sources of the energy consumed by the unit and respective water consumption in each source.

Table 12: water consumption for power generation, by primary source

Source	m^3 / GJ
Biomass	72.00
Coal	0.20
Wind	0.00
Natural Gas	0.10
Hydroelectricity	22.00
SHP	22.00
Nuclear	0.10
Petroleum	1.10
Solar	0,30

Source: self-elaboration based on [17]

Table 13: Water consumption proportional to energy consumption in the studied teaching unit, where SHP means Small Hydroelectric Plant

Source	Energy matrix: Teaching Unit	kWh Consumption	m^3
Biomass	6.0%	67° 51 '	17.5
SHP	82.0%	928.91	73.6
Wind	12.0%	135.94	0.0
Total	**100.0%**	**1,132.36**	**91.07**

Source: self-elaboration based on [10]

With this Resource and for a period of one year, there is a reduction in the emission of CO_2, 6.45 tons. Within the sub-attribute that deals with the reduction the water consumption, the increase of the water consumption occurs, in 8.293, 34 resultant m^3 of the high consumption of deriving energy of biomass plants, which is due to the high-water consumption for generation of energy for biomass plants [10].

In the social dimension the Resource, due to the investment required for implantation, inserts $ 3,595.75 into the economy and creates 3 work units. Even though the number is low, within the social impact and human development sub-attribute, the Resource is what causes greatest impact.

It generates $ 62,700.00 in total, during project execution, which takes place through an energy management consulting contract [10]. In the other sub-attributes of this dimension, no type of impact caused by the Resource is identified.

In the technical-economic dimension, the implementation cost sub-attribute is considered the same value as the investment, which is positive in this assessment as it requires low cash outflow by the company, in addition to 85.02% in the IRR, 0.023 in the NPV index and 2 months payback. Within the lifespan sub-attribute, it is evaluated as a low positive impact, as the Resource depends on energy purchase and sale contracts, and regulatory issues imposed by the government. In other words, within this scenario, even if the company remains in the FECE, it will not know how long it can stay in this environment. In the volume of saved energy sub-attribute, by keeping the same level of energy consumption, changing only the primary source, the Resource is evaluated neutrally. The other two sub-attributes evaluated by external stakeholders, technologies and equipment and design and logistics, are optimistic about them.

In the political dimension, the Resource is optimistically evaluated in all sub-attributes of the acceptance, motivation, and stakeholder interest attribute. In political support, it is evaluated as positively consolidated, as there are already consolidated laws and optimistically by stakeholders, however, within the sub-attribute tenure and/or ownership, it is evaluated as a low negative impact because it is not a Resource that has full control of the consuming company, in a way, it is subject to other public and private institutions that influence the energy market [10].

5. DSER Tax efficiency

This Resource analyzes the possibility of exempting the consumer company from the payment of the Tax on Circulation of Goods and Services (ICMS) levied on the tariff for the use of the energy distribution system (TUSD). In the studied unit, the energy consumption costs related to TUSD are equivalent to 30% of the energy bill and the ICMS rate is 18% [10]. Assessing the possibility of ICMS exemption involves - in addition to the initial expense with legal fees- the payment to a hired law firm of 8% of the monthly amount saved on the energy bill [10].

In all attributes of the environmental dimension, as it is a Resource that has no impact on reducing energy consumption or replacing equipment, it is evaluated as neutral.

The same occurs in the sub-attributes of the perception of comfort in the social dimension attribute, as well as in the social impact due to occupied space sub-attribute. However, still in the social dimension, the Resource has an impact on direct jobs sub-attributes, 2 vacancies are generated, a lawyer and an administrative assistant for one year, a contractual term identified with the company studied [10]. This result impacts the human development sub-attribute, with a value of $ 34,485.00 [10], above the average found. Finally, in the sub-attribute economic activities and infrastructure, there is a positive impact due to the investment of $ 150.00 in the number of legal fees identified [10].

Within the technical-financial dimension, considering the initial investment, which is considered in the implementation cost sub-attribute, there is an IRR of 69.99%, an NPV index of 0.011, and a payback of 2 months. In the other sub-attributes, the Resource is evaluated as indifferent by external stakeholders, with a low positive impact on the useful life sub-attribute and neutrally on the energy volume sub-attribute, as it does not reduce energy consumption at all.

The analysis of this Resource is very important in the political dimension, as it is directly influenced by regulations published by the federal government, as well as authorized, altered, or denied by the legal body of the national tax system [10]. Considering these variables, stakeholders say they are indifferent in the sub-attributes organized society, NGOs and association, generators, producers and distributors and government, which does not occur with the consumer sub-attribute, where they consider themselves pessimistic about the Resource, it is considered by the stakeholders in the sub-attribute tenure and/or ownership. In the political instruments sub-attribute, the Resource is evaluated as positively under analysis, since lawsuits are being processed in court and, for the time being, in a positive way to consumer companies [10]. And, finally, in the energy integration sub-attribute, the Resource is neutrally evaluated as it does not impact energy consumption at all.

6. DSER Demand Tuning

Contracted demand is a technical parameter used in contracting electricity and must be adjusted according to the power demand characteristics of the consumer unit.

The Resource has no impact on the environmental dimension, as its implementation does not change energy consumption and does not require replacement of equipment, that is, it is evaluated as neutral in all attributes.

The same occurs in the sub-attributes of the attribute perception of comfort in the social dimension, as well as in the social impact sub-attributes due to occupied space and economic activities and infrastructure, since, in the first, there is no space occupation by the Resource and in the second, for not requiring initial investment. However, also in the social dimension, the Resource has an impact on the direct jobs sub-attribute, 1 job opening is generated for an engineer, for one year, a contractual term identified with the studied company [10]. This result impacts the human development sub-attribute, with the value of $ 28,215.00 in the same period [10].

Within the technical-economic dimension, as it does not require an initial investment, it is not possible to calculate the IRR, NPV index, and payback, however, it is possible to simulate the financial gain that the unit has with the change in contracted demand. In the studied unit, the contracted demand is 200 kW, with the maximum demand registered from January 2019 to December of the same year of 487.4 kW and, in this same period, the average consumed demand was 370.2 kW [10]. Thus, two simulations were carried out with demand adjustment, the first considered a contracted demand of 370.2 kW and the second of 487.4 kW. The financial savings found were, respectively, $ 82,288.83 and $ 79,814.40 in one year. That is, even though it is not possible to calculate the IRR, NPV index, and payback, the Resource is evaluated in the sub-attributes referring to these indexes as a high positive impact. It is also positively evaluated in the useful life sub-attribute, as it is a Resource that has no degradation, however, it is linked to regulatory issues, that is, without full control by the consumer company. Also in this Dimension, the Resource is evaluated by external stakeholders optimistically in the technologies and equipment sub-attribute and indifferently in the design and logistics sub-attribute, in addition to being neutrally evaluated in the energy volume sub-attribute, as it does not change the consumption of unit power.

In the political dimension, stakeholders assess the Resource indifferently in terms of sub-attributes that generate, products and distributors, governments, consumers, and legal aspects, however, optimistically in organized society, NGOs, and associations. Also neutrally, the Resource is evaluated in the political instruments sub-attribute, since there is no political instrument that regulates it and in energy integration, as it does not change the unit's energy consumption in any way. However, it is assessed as having a low negative impact on the sub-attribute tenure and/or ownership, as it is not under the company's full control and can be changed as the regulatory body wishes.

7. DSER Educative actions

Within the environmental dimension, the Resource is evaluated neutrally, that is, without causing any impact on all sub-attributes.

Likewise, within the social dimension, there is also no impact on the perceived comfort attribute and the social impact sub-attributes due to occupied space and economic activities and infrastructure. In the direct employment and human development sub-attributes, the Resource has a positive impact. In the first, it is understood that 1 job is created for an engineer, for a year, which, consequently, generates an income of $ 28,215.00 [10], which is the value attributed to the second sub-attribute cited.

In the technical-economic dimension, the Resource is also neutrally evaluated, without impacting all the sub-attributes of the generation cost and technological domain attributes. In the first, because there is no investment and no identifiable financial return, and in the second, through evaluations made by external stakeholders who were indifferent to the Resource. In the energy potential attribute, no impact is identified in the energy volume sub-attribute either, since, as explained, with the implementation of this Resource, it is not possible to identify changes in the energy consumption of the studied unit. However, the Resource is positively evaluated with low impact on the useful life sub-attribute, as it has no expiration date, however, it can be implemented when necessary and for as long as necessary.

In the last dimension of this Resource, within the attribute acceptance, motivation, and interest of Stakeholders, it is seen optimistically by organized societies, NGOs, and associations and indifferently by other stakeholders. It is also neutrally evaluated in the political support attribute, as there is no political instrument for or against the Resource, and as indifferent by stakeholders within the legal aspects sub-attribute. Finally, it is seen as a high positive impact on the sub-attribute tenure and/or ownership, in this case, it is understood that the consumer company has full control over the Resource and is neutrally evaluated in the energy integration sub-attribute, since, as explained above, it is not possible to identify whether its implementation in any way alters the energy consumption of the unit.

8. DSER Tariff framework

As there is no change in energy consumption, as well as equipment change, no environmental impact is perceived with this Resource, that is, in all sub-attributes of the Environmental dimension, the Resource is evaluated neutrally, with no impact on valuation.

In the social dimension, its implementation creates 1 job opening for an engineer and a year, considered in the evaluation of the direct jobs sub-attribute. That impacts the human development sub-attribute, with income generation in this period of $ 28,215.00.

In the technical-economic dimension, specifically in the generation cost attribute, the Resource does not require an initial investment, but it is known that after implemented by company decision, it will generate a financial return, thus, the IRR, NPV index and payback with low positive impact sub-attributes are evaluated. The same logic is used in the energy potential attribute, the Resource does not change the energy consumption at all and, as it is not possible to calculate its useful life, it is evaluated with a low positive impact. For the stakeholders, responsible for evaluating the technological domain attribute, the Resource is evaluated indifferently, that is, without any impact on the final valuation.

Finally, in the political dimension, the Resource is seen optimistically in the sub-attribute organized societies, NGOs, and associations, however, indifferently towards other stakeholders. In the political support attribute, the same assessment is made by stakeholders in the legal aspect sub-attribute, in addition to being neutrally assessed in the political instruments sub-attribute, since it does not involve any type of statutory and legal decision for implementation. Finally, within the attribute property of the resource, it is evaluated with a low negative impact on tenure and/or ownership, as it is under full control of the consuming company and neutrally in the energy integration sub-attribute, as it does not change energy consumption at all.

9. SSER Own energy generation

In the environmental dimension, within the terrestrial environment attribute, the Resource is evaluated as a low negative impact, both the photovoltaic equipment and the Diesel generator occupy the terrestrial space in some way, the latter also eliminates waste from the terrestrial environment through combustion for generation of electricity [10]. However, as it is not possible to calculate the impact, the Resource is evaluated as N/A with a low positive impact on the medium terrestrial attribute. In the aquatic environment, with the analyzes carried out, it is known that the Resource saves 19,092.27 m³ of water in a year after its implementation, whereas in the water quality and pollutant emissions sub-attribute the Resource is evaluated as N/A with low negative impact, given that the Resource emits pollutants from the aquatic environment, however, it is not possible to calculate this impact. Finally, in the air and in one year, the Resource reduces the emission of carbon dioxide by 18.29 tons per year and is evaluated as N/A with no impact on the ozone layer degrading gases sub-attribute, as it does not impact the ozone layer.

In the social dimension, the Resource generates a total of 7 job openings, 1 engineer, 5 electricians, and an administrative assistant, which, within three months, the Resource's implementation period, generate an income of $ 24,296.25. In the social impact sub-attribute due to occupied space, it is evaluated as N/A with high negative impact, it is known that both the solar panels and the diesel generator occupy space, regardless of where they are installed in the building. In the sub-attribute of this dimension, economic activities, and infrastructure, the Resource is evaluated at $ 159,601.67, which is the amount necessary for investment [10]. Finally, in all sub-attributes of the comfort perception attribute as N/A with high negative impact, given that none of these 4 sub-attributes can be analyzed mathematically, however, it is known that it generates visual pollution, noise pollution, olfactory pollution, and thermal pollution, especially the diesel generator [18].

In the technical-economic dimension, as already shown in the initial investment value, $ 159,601.67 is considered in the evaluation of the implementation cost sub-attribute, in the other sub-attributes evaluated through mathematical analysis, 1.36% is obtained in the IRR, 6,634 in the NPV index, 36 months of payback, 25 years of useful life and 6,797.30 MWh in a volume of energy saved [10]. In the sub-attributes that are evaluated by external stakeholders, the Resource was evaluated as optimistic and indifferent in terms of technology and equipment and design and logistics, respectively.

In the political dimension, the last analyzed, the Resource is evaluated as optimistic in the organized societies, NGOs, and associations sub-attribute and indifferent in the generators, producers and distributors, governments, consumers, and legal aspects sub-attributes. Within the political instruments sub-attribute, the Resource is evaluated as positively consolidated, since there are already laws that safely positively regulate the Resource. In the tenure and/or ownership sub-attribute, the Resource is evaluated as N/A with high impact, since the goods, photovoltaic panels, and diesel generator, belong to the consuming company and, finally, within the energy integration sub-attribute, once it is dealt with self-production of energy, it should be considered that 6,797.30 MWh are saved, which, in turn, would be a demand on the electricity grid itself.

IV. OBTAINED RESULTS

After all the analyzes performed, the result is obtained according to the weight assigned to each dimension of the IRP, presented in TABLES 2, 3, 4, and 5, and according to the combination that is made between them, so that, with different interpretations and opinions be able to make the best decision as to which Energy Resource should be prioritized.

The following combinations are made to present the results:

Fig. 4: Equal division between the 4 dimensions: the Resource ranking is done with an equal weight of 25% for each dimension

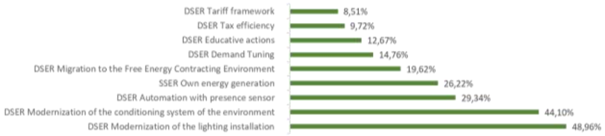

Fig. 4: Equal division between the 4 Dimensions

Source: self-elaboration

Fig. 5: division according to managers: ranking is done according to the average of the weights assigned by area managers, that is, decision makers

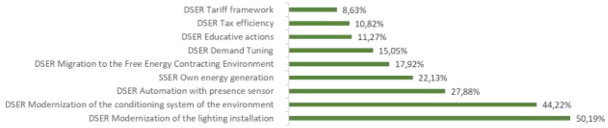

Fig. 5: Ranking according to managers

Source: self-elaboration

Fig. 6: Division according to operational employees: the ranking is based on the average of the weights assigned by the operational employees in each area.

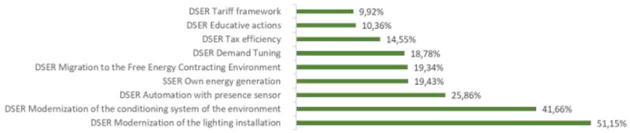

Fig.6: Ranking according to operational employees

Source: self-elaboration

Fig. 7: Division according to the vision of the sustainability department: in the ranking the averages of the weights assigned by the manager and operational employee of the area are considered.

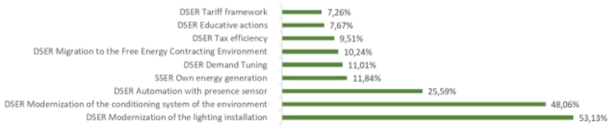

Fig. 7: Ranking according to the sustainability area

Source: self-elaboration

Fig. 8: Division according to the view of the supply department: in the ranking the averages of the weights assigned by the manager and operational collaborator of the supply department are considered

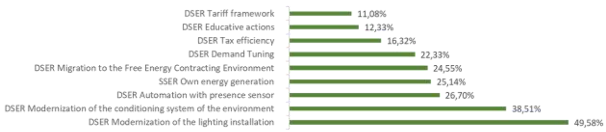

Fig. 8: Ranking according to the supply department

Source: self-elaboration

Fig. 9: Division according to the vision of the engineering department: the ranking is done considering the averages of the weights assigned by the manager and by the operational areas.

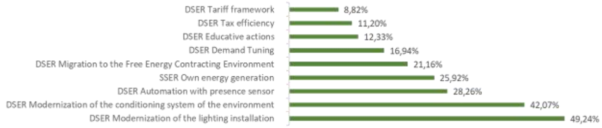

Fig. 9: Ranking according to the engineering department

Source: self-elaboration

Fig. 10: division according to the view of the teaching unit studied: ranking is based on the averages between the weights assigned by the manager and by the operating unit of the unit where the study is carried out

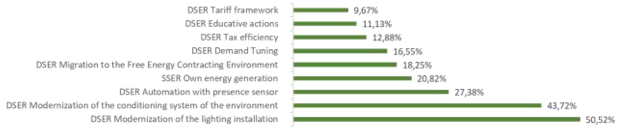

Fig. 10: Ranking according to the unit in which the study was carried out

Source: self-elaboration

Fig. 11: Division according to all stakeholders involved: the ranking considers all the weights assigned by all employees together, that is, the overall average for each dimension.

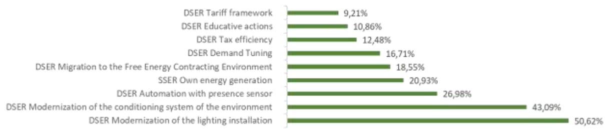

Fig. 11: Ranking according to all employees

Source: self-elaboration

V. CONCLUSIONS AND DISCUSSIONS

The work develops and validates the application of the CVPC method for valuation and ranking of Energy Resources in energy-consuming companies so that it can fill in the academic literature the gap that exists between studies on the valuation and ranking of Energy Resources applied to consumer companies. The fact that the method applied in this work uses the opinion of different internal company stakeholders as to the degree of importance in each Dimension, makes it unprecedented in the literature.

The work leaves as a legacy the proof to academics and professionals in the area that the application of the CVPC method, as described here, allows for obtaining the ranking of Energy Resources in an energy-consuming company. The possibility of associating analysis methods developed in academia with their application in the corporate market is proven, thus enabling joint work between the corporate market and academic studies.

For future work, it is suggested that the same method is applied in the same teaching unit studied after having implemented one of the Energy Resources valued here, it is understood that the application of the best ranked Resource, in this case, DSER lighting, will change the profile of energy consumption in the unit and, therefore, it will modify variables used for valuing the other Resources. In addition to allowing the application in other teaching units of the same company as a possibility, given that the size, location, opening hours, etc., impact the energy consumption profile and, therefore, also impact the ranking of Energy Resources. And, finally, to enable the application of the same method in other companies from different economic sectors.

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