Reduction of CO2 Emissions to Achieve Energy Efficiency in Small and Medium Enterprises

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ABSTRACT: *In this paper, we conducted energy efficiency research in selected Small and Medium Enterprises of some industries. We aim to introduce energy efficiency in the industrial system. Finding suitable solutions to minimise energy consumption to reduce CO2 emissions is imperative. It is possible if the thermoelectric way generates electric energy. We have detected the technical failures in the analysis, which may help optimise the energy use in small and medium enterprises. We advocate utilising this study's applications in other industrial systems when the proposed energy efficiency is optimum.*

Keywords: Energy Efficiency, Energy Study, Research, Industrial SMEs

Received: 2 November 2022, Revised 1 March 2023, Accepted 16 March 2023

DOI: 10.6025/jism/2023/13/2/46-52

1. Introduction

The new regulatory framework in Colombia for the development of industrial competitiveness, emphasis is placed on rational use and energy efficiency, as an instrument to encourage the optimization of energy consumption on industrial production facilities, so in their Operating and production processes reduce consumption and energy losses without reducing the quality of the service provided, thus reducing energy costs and the environmental impact generated by these processes.
Goals of the energy efficiency:

- Energy savings, to mitigate the increase in the demand and to reduce the use if resources like water used to in the hydraulic generation or fossil fuel which are CO2 producers, in the thermic processes to generate electric energy.

- To implement improvements in the industrial operation and production processes, using the equipment upgrade to the new technologies.

- Continuity and quality in the energy supply. Which avoids economic losses in the industrial and commercial and industrial sectors.

Stages of the energy efficiency:
Measurement of the consumption to make an energetic efficiency diagnosis and find opportunities to improvement. Perform energy leak adjustment, upgrading or replacement the machinery a new technology. To optimize the consumption proposing improvements in the energy quality or automating processes in isolated equipment, engines and lighting, devices that allow to manage the use and consumption. Monitor consumption permanently.

2. Developed Procedure.

To obtain and record the energy diagnosis in the 6 sample companies, visits were made to each of the companies to record the information on cards incorporating administrative data, the range and sector of the production to which it belongs, production data , general consumptions of KWH (invoice of energy consumption), flow chart of the process, photographic records with the identification and general description of the equipment and survey of the single-line diagram.

As part of the energy characteristic in the plant, of each one of the industrial companies evaluated, the installation of the measurement equipment that allowed the validation of the information in relation to the electric power consumption was carried out. For this, a network analyzer (HIOKI 3196) was installed in the electrical distribution network, mainly in the totalizers of the distribution boards and in the equipment that was taken into account in the energy consumption in the plant.

The network diagnosis allows:
- Evaluate, Detect and prevent excess consumption (KWH)
- Visualize the maximum energy demand.
- Verify reactive power consumption to perform capacitor bank calculation.
- Observe voltage variations (overcurrent, overvoltage), current and frequency fluctuations.
- Detect harmonics in the network.
- Find issues in the electrical network such as disturbances, resonances, imbalances in the network, among others.

Thermographic records were made with a thermography camera (Camera FLIR T440), which allowed to determine temperature increases in different equipment and in the conductors of the main connections. For analysis purposes, it is taken as the electrical faults and criteria defined in the ANSI / NETA ATS / 2009 standard, this reference contains criteria that allow classifying, through levels, the actions to be taken based on the temperatures found in the inspected equipment.

The data obtained from the images of the thermography camera and the measurements of electrical parameters with the network analyzer, were studied to determine the electric power consumption and the points where there are issues of electrical type and wasting of electric energy are located, this allowed to quantify the waste of energy.

Based on the results obtained, comparisons were made and applied existing energy management models, to determine and implement the use of new technologies, and to record the results of electric energy savings and the optimization rate of this service in each one of the companies studied.

3. Registered Data of Companies

The information related to the production sector, voltage levels, location and 'maximum and minimum consumption' were related to each company in the following tables. During the study, the time in which the equipment worked was also taken into account.

The cost of energy was approximated to millions of Colombian pesos, since this is the local currency. The analysis was performed on the network analyzer installed on the general board of the company's facilities and the data was compared with the energy meter installed by the network operator, the thermographic records were made on the same board and on the equipment with the highest energy consumption.

Activity	Sector	Location	Companies
Plastic and rubber extrusion	Plastic	Puente Aranda	1
Clean and disinfection of metals	Chemical	Mártires	2
Production of leather articles	Leather	Usaquén	3
Food selection and marketing	Food	Suba	4
Lodging and food	hotel	Chapinero	5
Manufacture of medicines	Pharmaceutical	Puente Aranda	6

Table 1. Companies data

Schedule of activities. (D-day)	Monthly energy value (COP)	Average monthly energy	Maximum daily consumption	Average daily Consumption (KW/day)	Tension level	Companies
D	9.226M	784.65	81.2 / 59.7	32.7	2	1
D	1.844M	298	23 / 27	23	2	2
D	11.300M	861.35	79 / 45.3	35	2	3
N	0.13 M	32.76	12.71/ 12.82	4.72	2	4
D-N	0.706M	176.5	47.38/75.47	28.92	1	5
D	5.65 M	440	14.8/ 8.9	11.2	1	6

Table 2 Companies consumption. Tension level 1:(220/128-208/120) Tension level 2:(11.4KV)

4. Record of Electrical Failures and Waste of Energy.

Company 1:
- Presents current imbalances between phases +/- 10% in angle and magnitude.

- Lack of maintenance in the distribution boards and adjustments in terminal connections presenting high temperatures and electrical risk due to the presence of arcs and short circuits that lead to fires.

- Low power factors recorded when working at night time = 0.33.

- The electrical resistance used in the thermosealing and press injection equipment presents high temperatures.

- High currents circulating on the neutral line of the electrical connection of the equipment.

Company 2:
-The electrical system presents voltage variations outside the limit plus 110%, presenting consequences for the operation of existing electrical equipment, shortening the useful life.

- There are current imbalances above 5% in each of the phases its magnitude and angle.

- It does not have a capacitor bank, it does not invoice reactants to the network operator.

- Presents harmonic distortion of tensions, Phase A Max 5- 89% minimum 0-95%, Phase B Max 6-25% minimum 1-15%, and Phase C Max 6 68% minimum 0-12%.

- It presents voltage drop in the feeders of the motors, generating increases in current, overheating in the conductors and reducing the efficiency of the motor.

Company 3:
- It presents low tension in the boards of feeding equipment.

- It presents current imbalance in the phases, which produces increase of current through the neutral, faults in the system and equipment, overheating of conductors and lower performance in the system.

Company 4:
-It presents high temperatures in semiautomatic thermoforming machines of the order of 32 to 62 ºC, especially in electrical resistances.

- There is current unbalance in the phases between 12% and 52%, currents greater +/- 10% in angle and magnitude.

- The power factor is found at 0.82.

- THDV harmonic distortion values exist: Phase A 5.23% max, 1.94% min, Phase B 5.26% max, 2.79% min, and Phase C 5.83% max 2.76% min.

Company 5:
The records were made to systems that are connected to a general distribution board fed from a 225 KVA substation. Air Conditioning System

- It has low power factors between 0.86 and 0.79, even though it has a capacitor bank.

- Voltage drops are recorded between 94.99 V and 20.84% with a duration of one minute.

- There are voltage lags of 4.24%. Food Refrigeration and Freezing System

- Presents low power factors between 0.8 and 0.76, this results in higher current consumption, losses in the form of heat in the conductors, higher consumption therefore higher cost of energy payment and low efficiency of the system.

- It has current phase shifts of 7% and 15%, which causes high current to flow through neutral.

- Voltage harmonic distortions (THDV) are present in Phase A of 5.6% max, and 1.58% min.

Company 6:
This company is connected in medium voltage, Level 2, the power measurement is in low voltage without reactive meter, its power is made from a 225 KVA transformer installed in a structure in type H poles and shares the service with three companies more than sector.

- The maximum current recorded in 40 minutes was 289.4 A of 624.53 A given by the transformer, which is equivalent to 46% of the total load of the transformer.

- It presents a total distortion of the demand in current (TDD) of 12% out of the norm.

- The power factor is 0.75 on average, without a capacitor bank.

- The equipment used in their processes are 43% deficient evaluated in the thermodynamic analysis, 38.6 ºC in the main connection, 29.2 ºC in the main protection (3 * 100 A), and 33ºC in the connection conductors, to give a example. Which suggests electrical problems from the main connection.

- The motors of the machines and tools of the shop do not have a motor guard or starter, which in its startup produce high currents and transients of voltage and intensity, overloading the respective connections.

5. Corrective and Suggested Improvements.

Company 1:
- Balance the loads of the equipment and the system in general and the phase currents, to minimize the current flowing through the neutral.

- Change the work routine to night hours to save energy.

- Change voltage level from 1 to 2 to reduce energy tariff.

- Check and adjust the existing capacitor bank, to correct the power factor.

- Change the electrical resistances of injection and thermoformed equipment due to obsolescence by current technologies.

- Carry out modernization and / or conversion of equipment such as presses, injectors and heat sealers for obsolescence.

- Promote the sequential automation of some processes.

- Replace fluorescent lighting with LED technology, take advantage of natural light.

Company 2:
- Inform the operator of the existence of harmonic distortion, or otherwise install electronic equipment (Install harmonic filters) to correct these distortions.

- Install a capacitor bank to correct the power factor.

Company 3:
- Inform the network operator and / or correct the low voltage on the equipment power boards.

- Balance the current in the phases from the main board.

Company 4:
Change by current technologies the electrical resistance of the thermoforming machines due to obsolescence.

- Carry out system load balancing.

- Install a capacitor bank.

- Install harmonic filters which allows to improve the presence of harmonics in the system and increase the useful life of the equipment, efficiency and improve its performance.

- Change the electrical resistances of the sealer and thermosealer by resistance of current technology.

- Install temperature controllers in the equipment of the sealer and thermosealer.

- Perform thermal insulation in the sealer and heat seal reducing the electricity consumption.

- Install a soft starter or variable speed drive as the case to avoid excessive consumption.

- Check the air circuit and correct leaks in the compressed air duct and include control valves at the terminals of the water pipe.

- Ensure that the air intake to the compressor is outdoors, avoiding the heating of these equipment subjected to high temperatures and little free space.

- Report to the network operator the voltage variations and the harmonic distortion in the electrical system so that they take corrective measures.

- Install an AVR voltage regulator to the boards that present voltage variations.

- Carry out preventive maintenance, adjust connections and terminals of the protections of the motor and starter boards.

- Carry out measurements of the earthing system and visual verification to verify connections of outlets to the ground.

Company 5:
- Adjust the existing capacitor bank in the general board or install a bank of capacitors in the boards of each of the air conditioning and refrigeration and freezing systems respectively.

- Report to the network operator the voltage variations and the harmonic distortion in the electrical system so that they take corrective and / or install harmonic filters which allows to improve the presence of harmonics in the system and increase the useful life of the equipment, effectiveness and improve their performance.

- Install an AVR voltage regulator to the boards that present voltage variations.

- Perform equipment modernization and / or conversion due to obsolescence.

- Perform sequential automation of processes in air conditioning systems and refrigeration systems.

Company 6:
- It is necessary to correct F.P with the installation in the general board, of a capacitor bank of 808.1 Pf.

- Make the change of the mechanized T3 distribution board.

- Change the connections of the T2, T3 mechanized boards, lighting board and workshop outlets, the lighting board and office outlets.

- It is suggested to change the voltage level from low to medium voltage, Level 1 to level 2, which would require the installation of a 75 KVA transformer.

- Install saves motors and soft starters to the equipment of machines and tools of the workshop.

6. Conclusion

Thermographic records made by the six companies show that the equipment used in the production and operation processes have high temperatures due to lack of maintenance, especially due to the adjustment of the electrical connections, which leads to electrical faults that are removed from operation the equipment and interrupt the processes and in other of these companies the lack of adequate isolation in thermal systems, carries with it the energy losses in the form of heat transfer and greater electrical consumption in the equipment. If an adequate electrical maintenance is carried out and the use of thermal insulation in the equipment that requires heat production in its processes, the consumption of energy will be significantly reduced.

To each of the 6 companies evaluated, the reports of the studies carried out on energy efficiency were sent, each of them is expected to implement and execute the suggested proposals to optimize the use of electric power and that these results also serve as a basis for the other SMEs implement energy management aimed at the efficient use of energy and its saving so that they improve and increase the operation and production processes. The benefits of energy efficiency applying as an additional model to industrial production, were determined a significant reduction in production costs. Moreover, a better control of tension, current and temperature levels, a better functioning can be seen in production machinery. It may reduce the maintenance costs, and possible losses due to machinery replacement. Finally, must be mentioned the environmental benefits of the energetical efficiency. Since a lower consumption means a better use for the produced energy, thus , if this model generalizes, can be possible a big city supplied with less quantity of energy, giving a place to clean energy production away from fossil fuels.

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