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# Design and implementation of methodology for the preparation of energy diagnoses

# Diseño e implementación de metodología para la elaboración de diagnósticos energéticos

SIFUENTES, David†*, MARTÍNEZ, Estrella and BERUMEN, Giovanni

*Universidad Tecnológica de Durango, Carretera Durango-Mezquital Km 4.5, Gabino Santillán, 34308 Durango, Dgo., México*

ID 1st Author: *David, Sifuentes*

ID 1st Co-author: *Estrella, Martínez*

ID 1st Co-author: *Giovanni, Berumen*

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**Abstract**

The current document describes the design and implementation of a methodology to elaborate electrical energy diagnostics. The sequence to perform a correct energy study is to initiate with a diagnostic type one and if necessary, continue with types two and/or three. What is not entirely clear, are the steps to follow in each of them. For the design, it has been made a literature analysis, energy management systems and policy. The methodology named DESMB consists of two phases, two flowcharts that explain the steps to follow and 14 formats that are evidence of energy diagnostic (ED). The implementation was made in a rate 2 commercial electric system (ES) rate 2. After the application of phase one, 10 problems were obtained, which led to the performance of phase two, where measurements were made for a 10 days period. The information obtained on this phase allowed to determine two opportunity fields: electric installation and illumination. The DESMB made it possible to systematize and standardize the activities to execute in the ES and they have been documented as evidence that facilitate the identification of potential saving areas of energy and cost.

**Energy Diagnostics, Energy efficiency, DESMG**

**Resumen**

El presente documento describe el diseño e implementación de una metodología para elaborar diagnósticos de energía eléctrica. La secuencia para realizar un correcto estudio energético es iniciar con un diagnóstico tipo uno y si es necesario, continuar con los tipos dos y/o tres. Lo que no está del todo claro, son los pasos a seguir en cada uno de ellos. Para el diseño, se ha realizado un análisis bibliográfico, de los sistemas de gestión de la energía y de la política. La metodología denominada DESMB consta de dos fases, dos diagramas de flujo que explican los pasos a seguir y 14 formatos que son pruebas de diagnóstico energético (ED). La aplicación se realizó en un sistema eléctrico comercial (ES) de tarifa 2. Después de la aplicación de la fase uno, se obtuvieron 10 problemas, lo que llevó a la realización de la fase dos, donde se hicieron mediciones durante un período de 10 días. La información obtenida en esta fase permitió determinar dos campos de oportunidad: instalación eléctrica e iluminación. El DESMB permitió sistematizar y estandarizar las actividades a ejecutar en el ES y se han documentado como evidencias que facilitan la identificación de áreas potenciales de ahorro de energía y costo.

**Diagnóstico energético, Eficiencia energética, DESMG**

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* Correspondence to author (email: david.sifuentes@utd.edu.mx)
† Researcher contributing as first author.

## Introduction

For the majority of the productive sector, saving energy in all its manifestations is a very important goal in its development.

In Central America, the production per unit of energy (energy index), is high compared to the respective values of industrialized countries, improving these indexes depends on the efficient use of energy in production processes (FIDE, 2010).

Within the various manifestations of energy, without a doubt, electricity is one of the most used, there are currently various strategies and mechanisms to achieve the precious saving of electrical energy, such as: the implementation of electrical energy generation systems other than such as cogeneration from residual thermal energy from the process itself, the installation of renewable energy systems isolated or interconnected to the grid and, in recent years, energy management systems such as ISO 50001.

Whatever the activity that you want to implement to save energy, it is necessary to identify and characterize the current state of the electrical system, this is done through an energy diagnosis (DE).

The ED is the core part of any energy saving and efficiency (EE) project, since it will allow identifying areas with and without problems, danger zones or some risk, and areas of opportunity to generate potential savings, as well as determining improvements in the electrical installations and processes.

The typology of the EDs is divided according to the degree of complexity and depth of the analysis of the electrical system, there are three types of diagnoses: the first degree or level one energy diagnosis (DEN 1) which is basically a preliminary collection of information to through a visual inspection and/or interviews with those in charge of various areas in order to identify evident sources of some possible improvement in the use of energy; the second degree or level two energy diagnosis (DEN 2) is a continuation of DEN 1, in this diagnosis the energy flows are analyzed in depth through measurements with basic equipment (multimeters, lux meters, etc.) and implies the investment of time and money;

It is clear that the sequence to follow to carry out a correct energy study is to start with a type one diagnosis and, if necessary, continue with type two and/or three, but what is not entirely clear are the steps to follow within each one of the diagnoses, what do I observe and what do I ask in DEN 1?, within DEN 2: what do I measure?, where do I measure it?, what?How long do I measure it? Likewise, another even more complex question arises, how do I determine whether to go from one diagnosis to another? That is, based on what do I determine if the energy efficiency project is solidly supported with only a DEN 1 or if it is necessary to carry out a DEN 2 or if it is necessary to invest a greater amount of time and money in a DEN 3.

Although the answer to each of these questions may depend on the expertise, experience, mastery of regulations and knowledge on energy topics of each specialist, it is necessary to follow a path that facilitates the transition towards the identification of areas of opportunity for energy and economic savings. The objective of this research is to design a methodology for the elaboration of energy diagnoses with emphasis on electrical topics to implement it in a productive system. The article is divided into three sections: background; where a review of the existing literature is carried out on the subject of energy diagnoses, development; in which the way in which the methodology called DESMB was structured and finally the results obtained after the implementation of the methodology in a productive system with rate 2 is explained in detail.

## Background

Energy Efficiency Projects (EE), energy saving, efficient use of energy exist wholesale and the way to carry them out is equally enough, some of them do not make clear the way in which the saving opportunity area was determined and others follow a certain methodology. In the article called "Analysis of the energy efficiency of the Spanish industry and its saving potential" it intends to achieve two objectives, the first of which is to obtain the conditioned demands of the factors that participate in the productive process of the companies, to later calculate for each factor the different measures of economic efficiency, focusing the analysis on the optimal use of energy factors (Aranda, Scarpellini, & Feijoó, 2003).

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The second objective is to carry out Energy Diagnoses (DE) for companies, which follows a methodology divided into five phases:

- Selection of sectors and subsectors under study.
- Selection of entities to be analyzed within said sectors and subsectors.
- Measures to be analyzed in each entity studied.
- Mode of relation of diagnoses to said entities.
- Extrapolation of the results of the diagnoses of the industrial sector.

The results obtained for the second objective were the detection of areas of opportunity in thermal and electrical savings in three sectors: metal, chemical and agri-food (Aranda, Scarpellini, & Feijoó, 2003).

On the other hand, Morato (2009) presents his article "Reduction of electrical energy expenditure using six sigma" in which he illustrates an example of application of the Six Sigma methodology in energy management models for the Reduction of Electrical Energy Expenditure in a park. industrial.

This article explains how to apply the DMAIC troubleshooting methodology: Define, Measure, Analyze, Improve and Control. Within the Definition stage, the project is focused from the basic equation to solve problems from Six Sigma: Y= f(x), where Y is the dependent variable and X the independent variable, in the case of the energy project Y is the consumption (kw/h) and the independent variables were declared through different discussions of the work team defining the following: motors, power factor, lighting, thermal applications, distribution systems and operational management (Orozco, 2009).

The article "Development of an energy study in the water system of the CEMONOSA company" exposes an energy study with the intention of identifying the areas of opportunity for saving electrical energy and undertaking control actions.

This article presents a methodology to develop an ED that is based on the structure followed in energy saving projects, which implicitly contemplates basic methodologies in the development of investment projects, which include planning, organization, direction and control. The steps to follow within this methodology are the following (Cázares, A., & Ybarra, 2005):

1. Diagnostic planning
2. Data collection and review
3. Supplement preparatory work
4. Field work and measurements
5. Systematization and data analysis
6. SDIntification and analysis of opportunities and energy saving measures
7. Elaboration of conclusions with the staff of the company
8. Preparation of the final report (Cázares, A., & Ybarra, 2005).

In the same tenor, the article "Development and implementation of strategies focused on the reduction of electrical energy consumption in a brewing company" is presented, showing the development and implementation of the main strategies for the efficient use of electrical energy in a brewing industry, as a result After carrying out an ED, the proposed methodology basically consists of two stages: first, the main electrical energy-consuming equipment in the plant was identified and later, technically and economically viable solutions were developed to make the use of electrical energy more efficient (Caravantes , López, Velázquez, & López, 2005).

The methodology proposed in this study is as follows:

1. Collection of basic information and general inventory of the facilities.
2. Prepare energy balances.
3. Determine the incidence of the energy consumption of each piece of equipment or group of equipment in the total energy consumption and therefore in the total cost.
4. Obtain energy consumption rates.
5. Determine the potential for energy savings by

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equipment, areas or cost centers, through a detailed technical evaluation in the different fields.

6. SD Identify appropriate energy saving measures.

7. Evaluation of energy savings in terms of costs (Caravantes, López, Velázquez, & López, 2005).

The regulatory aspect in our country is represented by the Secretary of Energy (SENER) through the National Commission for the Efficient Use of Energy (CONUEE), which in its manual for the implementation of an Energy Management System ( SGEN) embodies a methodology to achieve continuous improvement of energy performance in organizations in a cost-effective way (Abel Hernández Pineda, 2014).

The methodology for the design and implementation of an SGEN proposes eight stages that are shown in Figure 1.


**Figure 1** Stages for the design and implementation of SGEN (Abel Hernández Pineda, 2014)

Within stage 2 "Evaluate energy performance" the uses that are given to energy, the way in which it is consumed, the energy intensity and the measures available to promote efficiency and energy saving are considered, that is, the energy diagnosis.

On the other hand, the European regulation UNE 216501 on Energy Auditing, which aims to: obtain reliable knowledge of energy consumption, identify and characterize the factors that affect energy consumption and detect and evaluate the different saving opportunities and their impact on cost. energy, proposes a methodology that consists of (Sánchez, 2010):

Generalities

1. State of the facilities.
   a. Analysis from the energy supplies.
   b. Analysis from the processes of production.
   c. Analysis from the horizontal technologies and services.
   d. Measurement and data collection.

2. Realization from a cenergy accounting.

3. Analysis of improvement proposals.
   a. Development of improvements.
   b. Concatenation of improvements.
   c. Recommendations and good practices.

4. Said standard has a direct relationship and predecessor of another standard, the UNE-EN16001 SGE, the following figure shows it:

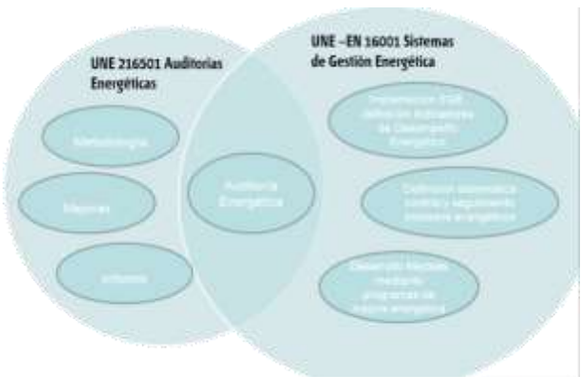


**Figure 2** Relationship between UNE 216501 and UNE-EN16001 (Sánchez, 2010)

## Developing

As analyzed in the previous section, energy studies are made up of a series of sequenced steps, this project focuses only on one part that we consider essential to achieve energy savings, the DE.


**Figure 3** Scheme of energy saving project
*Own Elaboration*

## IDESMB methodology for the elaboration of Energy Diagnoses

The DESMB methodology was carried out covering the various guidelines set by organizations such as CONUEE and SENER and based on the following Official Mexican Standards (NOM):

A correctly carried out DE will allow, in the first instance, to characterize the electrical system (ES) and later to determine the problems that will become an area of opportunity, then the possible solutions will be analyzed and when they are implemented, the energy and economic savings obtained will be determined, the Figure 3 shows a diagram of what we consider an energy saving project.


**Figure 4** Standards involved in DESMB Met

The methodology is organized by three stages structured by flowcharts (DF) that allow the student to follow a sequence of activities and 14 formats that will provide the student with evidence and truth to the results.

The first stage, which represents a time of approximately two days, corresponds to DEN 1 itself, which has eight formats that lead the student to a general characterization of the SE and its consumption through a visual inspection, later, when analyzing the information, it is determined the problem presented by the installation or decide whether to go to stage 2.

If you follow the second alternative (DEN 2) is carried out in a time of 10 to 15 days, consists of a DF and six formats, within this stage measurements of the variables found in stage 1 will be made and these will depend on the instrumentation that is available. When analyzing the information, it is determined if there are arguments to declare a problem or decide to carry out a DEN 3, which is carried out in the same way as DEN 2 but with a duration of 30 to 90 days of analysis. Figure 5 and 6 show the DF of each stage.

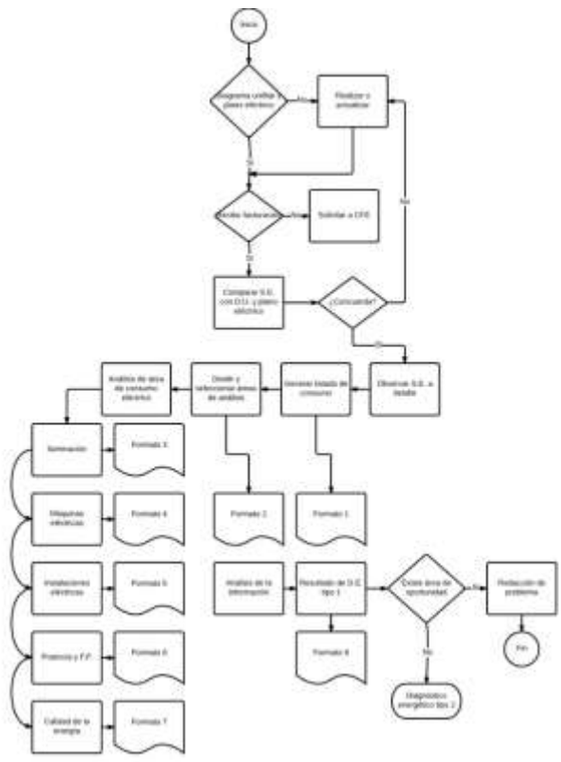

**Figure 5** Flowchart stage 1 DESMB methodology
*Own Elaboration*

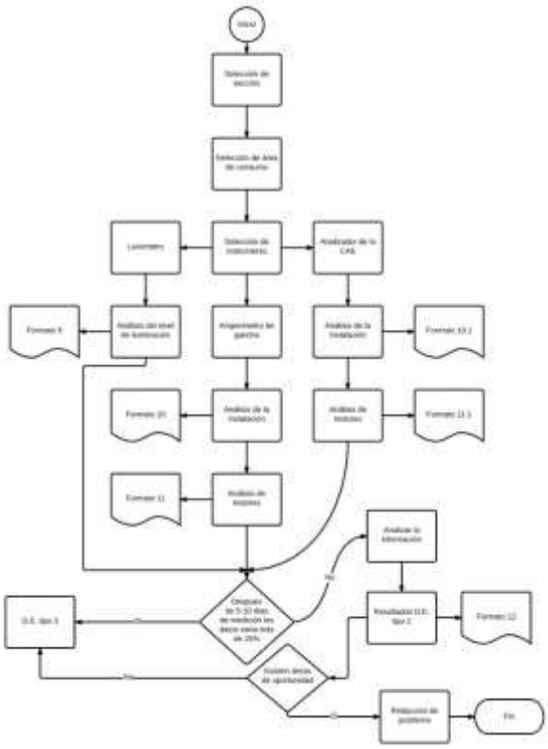

**Figure 6** Flowchart stage 2 DESMB methodology
*Own Elaboration*

## Results

To determine the results of the DESMB methodology, it was given to a group of students in the fifth semester of the Renewable Energies specialty for its implementation within an energy saving project in an electrical system of a Rectifier.

After the application of stage 1, the team obtained 10 problems when analyzing this information, the team decided to go to stage 2 of the methodology and perform measurements of electrical parameters for a period of 10 days. "In the diagnosis it was observed that the electrical installation of the grinding machine is not in good condition, nor is it safe because machines are presented without connection pins, there are no splices in the main cabinets, the lighting does not comply with regulations current.

For this, a diagnosis 2 will be carried out in order to find the specific problem that the premises present." When analyzing the information obtained in stage 2, the team was able to declare the problem to be solved, which focused on two relevant points: electrical installation and lighting.

## Conclusions

The implementation of the methodology provided the student with a clear path about the activities that should be carried out within the SE, it generated in the student a feeling of security since their proposals and assertions were supported by a series of documented evidence in 14 formats that in the end they would be useful for the preparation of your technical report.

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