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Energetic Competencies in Electronic Engineering Education: A Sustainable Social Commitment

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Abstract: In this article, we present electronic engineering as a discipline called to propose solutions to achieve energy sustainability. This field of knowledge has been supported to accelerate energy consumption with technological contributions to allow the comforts of the modern world. Consequently, electronics has influenced advances such as transport systems, innovations in means of communication, automation of production, domotics, and all direct impacts in the economic, political, and educational sectors. In the same way, it is then possible for electronic technology to promote development both in generating energy resources in a sustainable way and by reducing micro and macro consumption. Up to now, engineering education has promoted scientific and technological training to provide solutions that address the different needs of society, including alternative energy transformation systems. However, it has not been concerned with including in each lesson an awareness of energy efficiency and developing solutions based on sustainable use of energy. Up to now, engineering education has promoted scientific and technological training to provide solutions that address the different needs of society, including alternative energy transformation systems. Nevertheless, it has not been concerned with including in each lesson an awareness of energy efficiency and developing solutions based on sustainable use of energy. As a resource of help, we propose in this work the inclusion of "energy competences" in each topic and learning space from an Electronic Engineering program. The work presented shows that it is possible to include energy competences in electronic engineering curricula as a part of an educational sustainable social commitment.

Keywords: Learning spaces, sustainability, energy, engineering education, energy competencies, syllabus.

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1. Introduction

Within the context of learning; a competence is the ability to use a framework of interrelated knowledge necessary to successfully perform actions or tasks of work in a complex scenario of intervention (Senthil, 2020). Competences are established as the basis for skills standards that specify the level of knowledge required for workplace success, as well as possible measurement criteria for assessing achievement of competence.

Within the framework of the Santo Tomás University, all educational actions are aimed at

comprehensive training, that is, the training of a human being implies skills in "knowing how to do" and "knowing how to be" (knowing how to live and know how to act). This implies that an engineer in training must integrate skills to perform as a leader in different sectors of social, environmental and scientific life as an educational sustainable social commitment. Establishing a framework of competencies around the energy management of each situation in the professional life of an engineer complements the educational proposal of the University.

Considering the training profile of the Electronic Engineer of the Santo Tomas University, who is a humanistic, comprehensive, ethical, critical professional, with the ability to solve problems, innovate, model, design, develop, integrate, manage and undertake in the fields of electronics, control, automation, robotics, instrumentation and information and communication technologies, oriented towards the optimization and efficient use of energy resources in a globalized world, with environmental responsibility, social commitment and investigative culture, the initiative to include skills in the management of energy resources is a requirement within their training.

This document briefly presents the context of the management of competences or capacities in education systems. Special emphasis is placed on the application of competence education in electronic engineering as a preamble to make the proposal of including energy competences in the education of electronic engineers.

Finally, the general energy competences for each area and educational nucleus that make up an engineering program are summarized. In addition, some of the references used in the complete work are included.

2. Literature survey of competences in education

As the first step to understand the requirement to implement energy competences, it is normal to know what it is about. A competence is the domain of a "know how" in which the thoughts, knowledge and skills intervene coherently (Aruna, 2020).

When speaking of competences in the educational environment, it is about the capacities that, combined with the different knowledge, skills, thoughts, attributes and values in an integral way, lead to the different interactions of human beings to develop activities in a coherent and synchronic way in the personal, social, labor and environmental. The competences are the knowledge, skills and abilities that a person develops after an experience measured by educational experiences to understand, transform and preserve the world in which he coexists with the environment (Urbina-Nájera, Rodríguez-Huesca, & Pérez-Camacho, 2012) (Rundgren, 2018).

A. Competences as an engineering educative strategy

When speaking about competences in education, a characteristic that has been implemented in different educational systems worldwide is recognized. Also, in engineering education has taken into account the development of skills and abilities that qualify the professional or a group of professionals. In some cases, they have differentiated between generic and specific competences according to each area of knowledge.

It is considered that being competent requires that the person knows that and how to develop a specific task, but also understanding the process and it is made, assuming the responsibilities, implications and consequences of the solutions proposed and made for the benefit of the environment and human well-being (Khawaja, 2016).

Education systems not only need to consider strengthen the knowledge appropriation but also learning competences and adaptation to the evolution of the environment, in order to appropriate the capacity of sustained response in developed competences. In this way, engineering education encourages students to permanently adjust their competences while experiencing their profession and continually developing new competences.

However, considering the above, it is necessary an environmental education that includes transversal competences, that take into account the energetic weave so that in each professional experience the analysis of the energy cost is included and, in this way, verify the best use of the resources. This consideration in this proposal is called "energy competences" and is set to be implemented in education in an electronic engineering program.

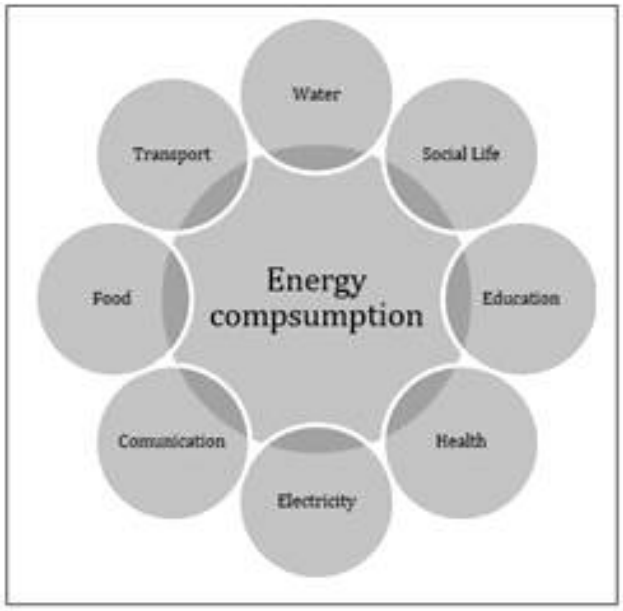

Fig. 1. Energy consumptions activities (Bernard Yannou, 2016)

B. Energy and education

Education is nowadays a subject linked to the rational use of energy. It is not possible to continue an educational development without the awareness of the close relationship between education and energy. All the human activities that we carry out today involve energy costs in any field. Modern human life implies the use and corresponding dissipation of energy that integrates entropically to the planet and then consider a new transformation to continue carrying out our activities (see Fig. 1). The consequences of this energy use are not only the exhaustion of non-renewable common resources, but also the impact on the environment due to the environmental costs of exploitation. The alternative that is available today to redirect society in general to a conscious vision of the use of energy resources is education.

Engineering as art and technique that applies scientific knowledge for the solution, design, implementation, innovation and maintenance of energy production systems, transportation, services is one of the areas of knowledge called to make changes required for the establishment of a new relationship between society and nature.

Educating in engineering and specifically in electronic engineering to awaken an energetic conscience implies giving the student the tools to develop competences with which he can always establish, and at every moment, act as a professional and as a person, the calculation of the energy cost of his actions. Mix naturally in the theoretical learning of basic sciences, electrical circuits, electronics and its experimental practice with the thermal effects causing dissipation in real elements and their corresponding implications of losses in watt-hours, CO2 emissions, energy resource and pollution of water and air, since its production allows at least awareness of the presence of the phenomena and the rational use of the resource.

Also, from the education in applied areas of the electronic engineering like the systems of control, the communication and the same systems of energy, it is possible the appropriation of energetic competitions that are directed to have sustainable engineering actions. In conclusion, all the education received by a student of electronic engineering is susceptible to imbue energy competences.

In this sense, from the initial training in engineering a new way of linking the future engineer with the natural framework is considered. That is to say, that educating an engineer with energy consciousness not only implies considering the inclusion of energy issues in theoretical training, but also awakening the belonging that he has as an individual and collective subject with the environment (Khawaja, 2016).

With this you will have a professional who not only projects and executes a solution to the problem, but the solution is sustainable from its conception, through the building and operation to it's dismantle.

C. Energy, engineering and electronic technology

The actions implied by the words energy and engineering have defined the technological and economic development of the existence of the human race on earth. The greatest experiences of transformation that humanity has find, have taken place in recent centuries; leading to the technological modernity and globalization of today's world. We are citizens with the skill and ability to choose and experience what we could never have imagined from our local culture, thanks to a self-sustaining communication network called the internet (Rothe, 2016). We enjoy and experience in most of the planet massively every technological development in means of transport, health, food, communication, and comfort thanks to economy of scale. All these significant advances sustained in a progress of basic sciences, the complicity of engineering, combined or interwoven with the commercial vision and the

financial ambition of humanity. Today the planet faces the fear of the continuity and evolution of these experiences, not because of the paralysis of creativity and innovation of the human mind, but because of the impacts of development on the environment itself and the availability of common resources.

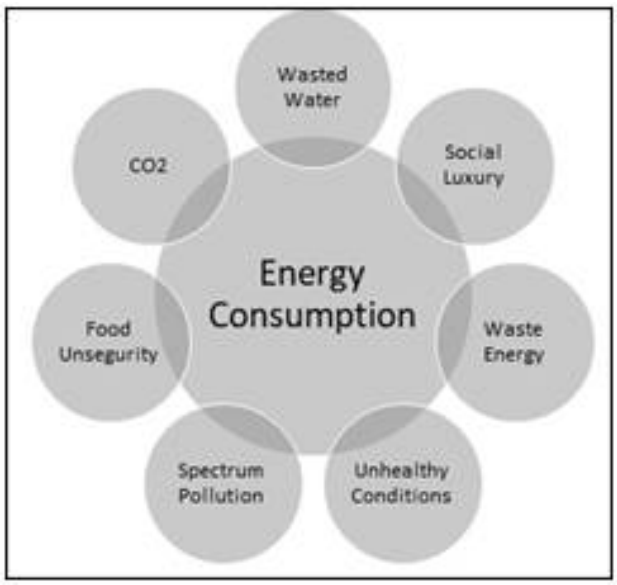

Fig. 2. Energy consumptions implications (Bernard Yannou, 2016)

Although one of the tasks of engineering is the optimization of energy resources, and from the different disciplines of engineering have been raised and resolve different problems in social, economic, technological and even environmental have been made without consideration of energy consumption. This is justified in the immediate requirement of wanting to respond to economic models that, regardless of the secondary and tertiary impacts, drive ideas, fashions and luxuries that are supported by science, technology and engineering make indiscriminate use of energy resources that contaminate and destroy life in the accelerated planet, if we consider the times of formation of the ecosystem in which we lived (see Fig. 2). However, the same engineering that has driven and allowed these changes is capable of transforming to return to a human life in synchrony with the environment.

The required transformations are born from a new energy cultural proposal that is linked to the world of life. In other words, engineering requires leaving laboratories, academic and specialized environments to get involved in society. Economic growth demands finding a limit on social and environmental impacts.

D. Energetic competences as part of electronic engineering education

Electronic engineering as one of the disciplines responsible for technological development in the last decades requires considering within its educational routes the inclusion of energy competences. This action is justified in the generation of environmental awareness that every engineer needs to take into account when generating technological solutions. The inclusion of average energy competences between the solutions proposed from the engineering and the impact they have on the environment. In this context, all the thematic contents of the syllabus proposed in the electronic engineering program require to include an energy analysis that considers the evaluation of the consumption and the different alternatives that have for the best use of the resource. This promotes learning and the appropriation of energy competences (M. A. Rau, 2017).

As mentioned above not only must be educated assuming static competences in the time or in the professional experiences. The evolution of lifelong learning is completely coherent with the continuous appropriation of energy competences (Tavakoli, Alghassi, & García, 2017) (Milosz, 2017). Therefore, in the education of electronic engineers, competences that promote an energy transition towards efficiency through the use of science and technological application are proposed.

In order to involve the student of electronic engineering from a first contact with the subjects of study, the energy competences to be considered are shown in this proposal.

3. Methodology

The first stage that was developed focuses on the exploration to identify research related to energy education, where a logical sequence was built that would allow the construction of a concept of energy competence based on analysing the educational proposal of a program in electronic engineering.

As an objective of this work, the different techniques for the creation of methodologies that facilitate the breakdown of the thematic contents of the academic space that is worked together with their respective competences and didactic strategies were studied.

Finally, work was done on the electronic engineering curriculum, identifying the energy skills to be implemented in each area. As a model, the academic space of electromagnetic conversion was used, through participant observation as a qualitative method to determine the skills in each of the topics to be discussed in the course.

4. Results of an implementation of energetic competences in electronic engineering program

The drafting of energy competences revolves around the areas and cores that make up the educational program in terms of generation, transformation or energy consumption. Since these competences arise from the Electronic Engineering curriculum of the Santo Tomas University, the general structure that leads to the formation of electronic engineers is presented in the Fig 3.

A. Energetic competences in electric circuit area.

As part of the basic training in Electronic Engineering, the behaviour of currents, voltages and powers in the presence of active and passive elements is studied, this area that bases the movement of electrons is called electrical circuits. From this knowledge, the student understands and appropriates the operation of the electric phenomenon both at low and high power, together with the laws that govern them (Assante, 2017). In the course of the studies in electronic engineering, the student will have the tools and competences to understand the different principles on which electronic technology is based, as well as the tools required to understand and appropriate knowledge in the areas of control, communications and systems. Energy. However, the greatest importance of this area of study is the formation of competences in the understanding of the phenomena of consumption and dissipation of power that occurs in the real passive and active elements present in an electric circuit. In this way, the future electronic engineer will conceive, design, implement and operate energy solutions based on the competences acquired throughout their studies, respecting and attending to the consequences of their actions.

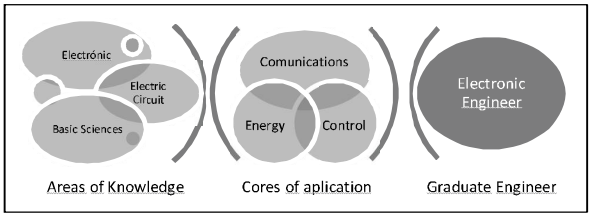

Fig. 3 : Components of Electronic Engineering Educational Structural Program.

The following is an example of a possible energy competence to be established: "Design electrical circuits using components with very low energy losses".

B. Energetic competences in electronic area.

The core of electronics represents the mathematical study, behaviour and application of semiconductor components (operational amplifier, transistors, diodes and their configurations) for the design of electronic systems.

The area of electronic engineering contributes to the training of the engineer in the study of the phenomenon of semiconduction where knowledge is appropriated and the way in which the flow of electrons is controlled in a natural way is understood. This core includes the study of basic semiconductor elements such as diodes and transistors, together with their energetic behaviour where criteria for selection according to the power dissipations characteristic of their operation are appropriated (Pagiatakis & Evangelou, 2017).

As the electronic technology is constantly evolving, the contents are permanently adjusted so that the student is updated in new developments in terms of power handling and switching speeds. The purpose is then to always have a competent engineer with innovative and energy-conscious solutions.

In this area, the study of digital electronics and programming of microcontrollers and microprocessors is also considered, as well as the elaboration of high-level algorithms (Hubwieser, 2017). From this scenario, the competences to identify energy consumption are considered, which although they can be considered small, it is known that the massification of digital electronics represents a good percentage of world energy consumption.

A competence for this core is: "Design filters taking into account the calculation of efficiency losses in the components used"

Programming is also an important foundation in the education of electronic engineers, who will face the design of digital solutions in the industry.

The education given to students of this discipline in this core does not take into account the energy work required to store, send or receive information.

A competence for this core can be: "It makes use of devices whose operating capacity is proportional to their energy expenditure".

C. Energetic competences in basic science area.

The electronic engineering is a discipline that intervenes in a number of fields of action of the human being. The electronic engineer focuses its action on the control of electron flows. This means that this professional is competent to understand and use electronic technology to allow or not the passage of electrons, or regulate their flow. In this way, solutions and contributions have been generated that in 99% of the existence of humanity had never been believed possible. However, these electronic developments have not arisen solely through the study of electronics, but are the sum of a complex framework of science that was developed from curiosity and human experimentation (Schreiber, 2017).

The electronics for its understanding and learning is then supported by the different sciences that have interpreted nature. In this sense, not only to understand the basis of the operation of semiconductors and their interaction with current flows, but also to know how to interpret the requirements and propose efficient and effective solutions.

The contributions of the basic sciences in electronic engineering programs evidently allow a better understanding and appropriation of knowledge in terms of energy balances. This is how physics, mathematics and chemistry are considered as support for the education of electronic engineers. From physics, it is possible to explain all the phenomena involved in electronic flows, along with the understanding of magnetic and electrical fields that are part of knowledge required by engineering; but it also bases macro phenomena from classical and analytical mechanics. Mathematics allows the modelling of electrical and electronic systems, as their understanding is vital to make a competent electronic engineering in energy terms. Meanwhile, chemistry bases the phenomenon of semiconduction, as well as the understanding of other fields in which the discipline has an influence.

For the above the basic sciences represent the physical, chemical and mathematical sustenance that govern the behaviour of electricity and semiconductor materials. Proper understanding and application of these sciences allows an engineer to design and execute energy efficient and effective solutions:

Applies physical and mathematical knowledge appropriately to awaken energy consciousness in all processes of daily life, considering the implications that each personal or professional action has on the environment (Martínez & Forero, 2018).

D. Energetic competences in control core.

Control is the ultimate goal of electronic engineering, represents the application of all knowledge acquired by students during their studies, therefore, must have skills to identify the quality of the solutions that the student can propose to the situations established.

From the energetic point of view, the contribution that from electronic engineering is made to the controlled systems, the optimization of them, considering the lower energy cost in its implementation. In this sense the electronic engineer harvests the skills that from the basic cycle, with the basic sciences, the circuit analysis and electronics are combined for the understanding of control systems implemented in force systems, classification, dosing, and communications among many others (Wenting, 2010).

The study of control systems includes fundamental concepts in control systems and industrial automation infrastructures, especially in smart grid environments, including PLCs, RTUs, SCADA, MESH and Batch systems among others that by their nature include energy management, as well as the aspects fundamental cybersecurity that affect them.

Automation can count with this competence: "It proposes solutions whose sensors and actuators allow the maximum efficiency of the system without meaning an increase in the energy that requires for its correct function".

E. Energetic competences in communication core.

Communications is one of the areas in which an electronic engineer can develop and be an important base in the solutions he will propose during his career.

Communication systems today are part of the essential public services almost in all the countries that make up the terrestrial globe. Electronic engineering, together with related branches are responsible for implementing, maintaining and evolving such systems. However, communications are not only present to communicate to human beings, but they are fundamental parts of all industrial, transport, economic systems among many others. The intervention of electronic engineering is done with the use of state-of-the-art devices that make connections, terrestrial, satellite, wired and transparent wireless to the entire population.

In the same way that the control systems the communications are based on the basic training of the engineer for their understanding. The purpose of training in this field is to make the electronic engineer competent to rationalize the energy resource used in communication systems. For this core, an important competence will be: "Proposes solutions for the efficient management of energy in radiant systems, taking into account the environmental impact that these can produce to the environment where they are applied".

F. Energetic competences in energy core.

It is essential to have a nucleus of academic training in energy in an electronic engineering educational program where energy competences are privileged throughout the curriculum.

The energy core considers the formation of competences around obtaining electricity by using sources of energy free of CO2 generation. In this sense, there are academic spaces oriented to the study of energy transformations focused on considering tools that, from the engineering point of view, contribute to the reduction of the environmental impact by generating energy. In this sense, the following section shows an example of a syllabus where the energy competences are implemented and then their execution.

In the core of energy is also privileged the study of power electronics oriented to the formation of competition in reduction of consumption, but also to the reduction of environmental impacts caused by the same use of electronic loads in industrial, commercial and domestic environments.

The general energy competence for this nucleus is: Capacity for integration and consideration of all the tools of science, technology and human experience to reduce the consumption of the common energy resource to the maximum in each proposed solution"

The purpose of this proposal is to insert in the curriculum of electronic engineering actions that contribute to the care and protection of the environment from the application of electronic engineering as a motor of the technological development of modern society. The inclusion of energy competences transversal to all types of training to raise awareness of the efficient use of energy resources.

G. Operative model of energetic competences in a syllabus.

As an example of the implementation of energy competences, the syllabus structure of electromagnetic conversion of the Electronic Engineering program is synthetically presented, where the proposed energy competences are added to the conventional educational competences to guarantee the student an awareness of the energy costs involved (see table 1). In the processes of energy transformation where the mechanical, electrical and magnetic powers intervene (Wenting, 2010). Electromagnetic Conversion is a course placed in the fifth semester of electronic engineering formation, at this stage, the student has the abilities for understand and manage electric circuit models, which is required for the comprehension of energetic analysis in an electric machine.

Table 1 . Example of Energetic Competences for Electromagnetic Conversion Syllabus

General Introduction to electromagnetic theory	
Conventional Educational competences	Energetic Competences
It develops the knowledge of the electromagnetic field at a relational level, with the purpose of making use, and applying the acquired knowledge and skills, in the approach and	Know the energetic implications of electrical and magnetic phenomena. Performs the energy analysis of the unification of the electromagnetic phenomenon. Recognizes electromagnetism as one of the fundamental forces of nature.

resolution of theoretical and practical problems.	Relates in complex form to electromagnetism with the different branches of science and engineering, highlighting the lack of scientific frontiers in the search for knowledge, and the need for cooperation and the formation of interdisciplinary teams
Direct current machine	
Conventional Educational competences	Energetic Competences
Explain the structure and operation of direct current machines, as well as their characteristics and applications of both generators and motors.	It recognizes the electromagnetic process that occurs in the machine and identifies the losses in the transformation process both in generators and in motors. Locates and quantifies the power losses that occur in the magnetic induction process in a direct current motor Dimension the capacity of the DC machine according to the energy requirements avoiding power losses due to under sizing or oversizing.
Transformers	
Conventional Educational competences	Energetic Competences
It analyses the structure and the basic principle of operation of the transformer, the different connections for a specific application, as well as its electrical modelling and basic operation tests.	Models the transformer through the equivalent electrical circuit and identifies the power losses. Sizes and selects considering the power losses according to the application. Recognizes the energetic convenience of using or not using a transformer in an electrical service system, considering losses, savings and operating times. It quantifies the implicit losses in a high and low power transformation system, considering the electronic systems according to a pertinent energy evaluation.

Induction Motors	
Conventional Educational competences	Energetic Competences
Knows the structure and basic principles of operation of the induction motors, as well as its electrical modelling, basic tests and practical applications.	Handles the variability of the relationship between output power and input power of an induction motor. Explore the advantages of the use of the induction machine as generated in non-regular motor sources. Recognizes the equivalent circuit of the induction machine to identify losses associated with power dissipation in conductors and losses due to magnetic effects in the core and between the iron. Sizes and selects induction motors according to the characteristics and optimal operating points according to the application.
Synchronous Machine	
Conventional Educational competences	Energetic Competences
Know the structure and basic operating principles of synchronous machines, generators and motors, and justify their selection according to their characteristics and needs to be solved.	It recognizes the electromagnetic process that occurs in the machine and identifies the losses in the transformation process both in generators and in motors. It considers the use of the different configurations of synchronous generators for the different energy transformations with the least environmental impacts.
Elements of protection and control	
Conventional Educational competences	Energetic Competences
Knows the structure and basic operating principles of synchronous machines, generators and motors, and	Recognizes in the protection of the electromagnetic systems the saving of the energetic resource, by means of the prevention of failures

justifies their selection according to their characteristics and needs to be solved.	

H. Implementation and evaluation strategies.

For the implementation and evaluation of the proposal in a real learning environment, the following experience is presented as an example:

A. The induction machine as a generator:

An alternative for obtaining energy from non-constant flows.

1. Presentation:

In an environment of natural, scientific and technological interactions, finally understood as globalized from the economic point of view, the contributions that can be made from engineering as a contribution to the reduction of the carbon footprint that leaves the day-to-day existence human on the planet earth (Davis, 2012), are found in every element used in the force of industrial production and global energy consumption. An alternative to obtain electricity in a clean way is found in the strengthening of energetic competences in the education of electronic engineers with the use of induction machines as generators, taking advantage of their simple constructive characteristics and their possibility of operating in a variable speed range. In this way it is possible to take advantage of small water currents with variable flow rates with obtaining electrical power from 100 W and up.

2. Strategy:

As a strategy for mediating this learning, we use the verification of previous knowledge about the operation of the induction machine as an engine. Based on the above information sources will also be provided regarding the different forms of operation of the induction machine as a generator. In this way it is motivated to always verify the different possibilities of use that electric machine have, contrary to their conventional use, forming energy competences of inquiry and experimentation. Once the theoretical information is consulted and appropriated, the student is guided to the mathematical verification of the theoretical postulates, verifying in this way the results that can be obtained. Subsequently, learning mediation is supported in simulation tools such as SIMULINK, where it is possible to obtain models and generation curves in systems with real parameters. Finally, the student is motivated to design and calculate the generation system for different requirements (Forero-García & Páez-Pino, 2017).

3. Goals:

a) Appropriate knowledge required to understand the operation of the induction machine as a generator.

b) Understand and manipulate the variables to be considered in a real design of energy capture using asynchronous generator.

c) Motivate the continuity of learning and training of professional energy competences in journeys to verify the energy's savings and environmental benefits of alternative energy transformation systems.

4. Contents:

a) Module 1: Induction Machine – General.

b) Module 2: Induction machine as generator.

c) Module 3: Equivalent and mathematical model of the induction generator.

d) Module 4: Simulation of the induction generator.

e) Module 5: Sizing of energy transformation systems using asynchronous machine.

5. Evaluation:

The evaluation strategy proposes the verification of design competencies and analysis of energy systems that are implemented through the use of induction machines as an element of transformation of mechanical energy into electricity. Assuming in the student the appropriation of previous skills in electronics and electrical circuits, the integration of the machine to the electronic systems of energy collection and storage is evaluated (FOGUET, 2012). In this sense, the management and ability that the student demonstrates by integrating a mechanical force system to a rotating electrical system by linking the electronics necessary for the use of the electricity

obtained in a consumption system is considered. Likewise, creativity and personal contribution are evaluated to obtain an effective solution and use the energy resource efficiently. Finally, the projection and the new learning possibilities that the student considers after the academic experience worked are considered (Paez & Forero, Julio 2016) (Reigeluth, 2004).

6. Activities:

a) Validation of previous competences and verification of appropriate knowledge in electrical and electronic circuits.

b) Critical and directed readings to form competences in understanding and configuring induction machines as generators.

c) Practical exercises that mathematically verify the operation of the induction machine by means of the transformation phenomenon and in the energetic losses that are implied.

d) Use of simulation software as motivation of the learning experience and verification of expected results.

e) Practical realization of a design for a real system contemplating the different variables of the scientific, technological, environmental and human environment, to form integral energy competences.

In table 2 we present an example of the level evaluation according to the purposed activities.

Table 2 : Example of Level Evaluation of Energetic Competences

Activities/ Evaluation	Low Level	Medium Level	High Level
Activity a.	Knows the different measurement parameters of an electrical circuit and its components but does not understand the relationships of the System	Understands the mathematical and physical relationships in an electrical circuit, but does not do physical experimentation	Understands the mathematical and physical relationships in an electrical circuit and performs experimental physical comparison.
Activity b.	Know theoretically how the induction machine works without performing physical experimentation	Know theoretically the operation of the induction machine and verification of the operation in simulation	Know theoretically how the induction machine works and verify its physical operation and identify and quantify its energy flow
Activity c.	Understands the mathematical and circuit model of an induction machine	Understand and obtain the mathematical and circuit model of an induction machine	Understands and obtains and analyzes the mathematical and circuit model of an induction machine and identifies its energy flow
Activity d.	Uses software tool for the simulation of electrical machines and circuits	Use simulation tools for energy analysis of an induction machine	Use simulation tools for the energy analysis of an induction machine and consider different modes of operation
Activity e.	Find out about the possibilities of saving energy by alternatively using electric machines	Design alternative electrical systems for the efficient generation and use of electrical energy	Designs, evaluates and maintains alternative electrical systems for the efficient generation and use of

5. Conclusions

In all aspects of life, education is always a social commitment, however, when we talk about the education of electronic engineers, the commitment we have regarding energy competences is a priority. This work provides an action in which the importance of including said competencies in the education of engineers is promoted. An educational context is presented in which the inclusion of the efficient use of energy was justified and an educational example of this proposal is presented.

The work presented shows that it is possible to include energy competences in electronic engineering curricula. Emphasis is placed on the importance of

specifying these competences in each area and core of training so that the formation of energy competences is completed.

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