Challenges and recommendations for the massification of energy management systems in Colombian industry

Desafíos y recomendaciones para la masificación de los sistemas de gestión energética en la industria colombiana

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Artículo de Revisión

Abstract— **Pollution and environmental deterioration are two problems that have been exacerbated in recent years, encouraged by the dramatic increase in the world's energy consumption, the burning of fossil fuels, and the lack of adequate management of natural resources. The global approach to this problem has been made from different perspectives, where the proposals related to the rational and efficient use of energy highlight. In this sense, this paper identifies the barriers and motivators related to the massification of programs that motivate Energy Efficiency in the Colombian industry, presenting possible proposals for the solution of challenges of the national context.**

Index Terms—**Energy Management Systems, Energy Efficiency, Industry, ISO 50001.**

Resumen—**La contaminación y el deterioro ambiental son dos problemas que se han agravado en los últimos años, alentados por el dramático aumento del consumo energético mundial, la quema de combustibles fósiles y la falta de una gestión adecuada de los recursos naturales. El abordaje global de esta problemática se ha realizado desde diferentes perspectivas, donde destacan las propuestas relacionadas con el uso racional y eficiente de la energía. En este sentido, este trabajo identifica las barreras y motivadores relacionados con la masificación de programas que motivan la Eficiencia Energética en la industria colombiana, presentando posibles propuestas para la solución de desafíos del contexto nacional.**

Palabras claves—**Sistemas de gestión energética, eficiencia energética, industria, ISO 50001.**

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I. Introduction

THE increase in the consumption of natural resources worldwide and the increasingly latent risk of the depletion of fossil resources is a constant that has lasted in recent decades, creating widespread concern in the world about the proper use of natural resources and Greenhouse Gases (GHG) emissions, recognizing all the harmful and irremediable long-term effects of not controlling these emissions and the intensive use of the fossil fuels [1], [2]. Hence, it is vital to search for methods to reduce energy consumption and GHG emissions and keep the energy price at reasonable levels [2] since projections show that, in the coming decades, demand will continuously increase due to the growing industry dependence on energy [3].

Electrical energy demand reduction is possible with the implementation of saving schemes, Energy Efficiency (EE) programs, and the diversification of the energy matrix through the massive inclusion of renewable distributed generation units that take advantage of the regional energy potentials, which are strategic starting points for the development of energy policies [4]. Here, EE programs can potentially lead to an intelligent, sustainable, and inclusive growth of society, as recognized by the European community [5]. Here, it is necessary to consider that the industry has an influential weight in the energy consumption of any nation, being one of the main contributors to GHG emissions, where the reduction of these stands out as a significant non-energy benefit in EE programs [3], [6], [7]. Also, it is relevant to highlight that in the industrial sector is possible to obtain encouraging results through programs that promote rational energy use and efficiency improvements, leading to help in mitigating emissions to the atmosphere and reducing the accelerated increase in electrical energy demand [8].

Therefore, it is necessary to identify the barriers that hinder the integration of energy management programs, as well as to determine the factors that motivate the implementation of industry-focused EE programs. These programs allow greater productive use of electricity and promote small-scale renewable energy projects, helping to reduce dependence on imported fossil fuels [4], [9].

Also, the current world energy transition has to be highlighted, where economic, technological, political, and cultural phenomena interact, promoting measures to encourage and contribute to mitigating the effects of climate change.

Energy transition has as fundamental pillars the increase in EE and the massification of renewable energy generation sources in order to reduce the energy sector carbon footprint; with EE measures being one of the best short-term alternatives that can have a significant impact in the industry through a reduction in operating costs and an increase in business competitiveness [10].

This paper reviews the alternatives that allow the massification of EE in the industry, focusing on Energy Management Systems (EnMS) and evaluating the challenges found in the Colombian paradigm. In addition, a series of recommendations are established that can make it possible to face the challenges identified in the national panorama; for this, the second section presents the importance of EnMS in the industry and introduces the motivations and barriers that exist when implementing alternatives in EE in the world. Then, the third section shows the panorama of EE in Colombia, the main limitations of the current context, and the economic implications of the Covid-19 pandemic in the industry. The fourth section proposes a series of recommendations to address the main challenges of the national industry related to the incorporation of EE programs. Finally, the conclusions and final comments are presented.

II. Energy management systems in the industry

Energy efficiency is not a new term for the world, this definition began to be used in 1970 due to the oil crisis, seeking that countries promote policies aimed at saving energy to avoid economic crisis associated with high fossil fuel prices [11], [12]. It is possible to understand the definition of EE from several perspectives depending on the author but, all agree on minimizing energy consumption without compromising the quality of the final product by eliminating losses and wastes in the processes [13]–[18]. Nevertheless, the concern about making energy savings remains due to the increase of the fossil fuels prices and the pollution associated with the GHG emissions; these are essential points for the renewal of interest in the massification of alternative energy resources through sustainable development [19], the search for alternatives for EnMS, and the performance of EE programs to contribute to the reduction of GHG emissions in the world [10], [11] since from the environmental point of view the reduction of energy consumption is a cornerstone in global GHG emissions mitigation [20].

In this sense, one of the measures that promote EE is the EnMS which are defined as the collection and transformation of concepts, approaches, and methodologies for allowing end-users to become active users, improving the rational use of energy and energy performance through constant monitoring and evaluation of its processes without reducing the production, the quality or the comfort levels [21]. These methodological structures allow organizations to establish guidelines that promote continuous improvement at all levels of the company, creating an interaction between processes allowing to set objectives and establishing clear goals, as well as providing the possibility of evaluating the effectiveness of actions taken in the EnMS [22], [23].

Nevertheless, it is convenient to consider the multiple factors that restrict the planning and implementation of EnMS, preventing them from being prolonged over time, these barriers hinder sustainable development and the competitiveness of companies. Therefore, recognizing the conditions and benefits of the implementation of the EnMS is crucial for the design of an adequate methodology adapted to a specific industry, since this will allow to establish from a multidisciplinary perspective the economic, technological and social phenomena that impact each organization [24]. The last will allow the selection of criteria for the replacement of factors that do not generate added value in the products or tools to enhance the benefits of the system [25].

From the economic point of view, the initial investment for projects associated with EE, and the long period of return on investment, are fundamental factors when making an investment decision within the industries. The preceding added to the ignorance presented by industries management related to the credits available from the government, and the scarcity of economic support generates a disinterest in banking entities and a perception of high risk in financial institutions due to the limited awareness of the benefits of the measures framed in EE, representing a great barrier for the massification of EnMS [12], [26]–[28].

Regarding Small and Medium Enterprises (SMEs), financial institutions have considerations when committing to this type of project due to the lack of guarantees and the transactional costs of generating a loan to these enterprises [28]. In this sense, risk aversion is one of the companies' central problems when implementing EE programs [26], [27]. Furthermore, the need to focus resources on priorities defined by the organization, such as production and quality diverts the gaze from projects associated with EE, generating resistance to changes due to the perception that any action framed in the EnMS is something complex and challenging [26].

On the other hand, EnMS and programs aimed to increase EE in the industry bring with it several non-energy benefits such as the reduction of maintenance in equipment [29], the production increase [6], the enhancement of the product quality [29], and the improvement of the efficiency in the use of raw materials [13]. These aspects, far from being negligible, are reflected in the increase of economic benefits within the company, becoming drivers for EE investors [30]; unfortunately, these non-energy benefits are usually overlooked, leading to the underestimation of the potential total financial profit of this kind of program [6].

The economic benefits of EnMS must be accompanied by management aimed at the use of resources, thus reducing waste and losses in each process. Management oriented towards resource efficiency helps reduce environmental impacts and costs in manufacturing systems; this involves having a more sustainable society. For this reason, the rise of energy prices, juridical environmental constraints, and incentives are fundamental elements to stimulate the industry, motivating companies to implement EE strategies [31].

At the managerial level, decisions are the starting element for any EnMS, since its successful implementation depends on the commitment of all levels of the organization, especially senior management. Without this commitment, it makes no sense to implement this kind of program since this would imply efforts in vain, loss of time, and unsatisfactory results [11]. On the other hand, the active participation of all levels of the organization will guarantee the success of the EE project [32]. Having strong leadership from the management plays a fundamental role with its employees by supporting their contributions, influencing their cooperation with the energy manager and the senior management of the organization [33].

Management should be made to understand that the implementation of EnMS in the industry allows organizations to improve the public image [29] and the projection of a broader potential in the market; since showing the public the measures implemented and the results generated by EE programs are aspects that can influence customers when making a purchase decision [34]. In this way, the advantages at the financial and organizational level are also perceived with great relevance to promote a better EE, this due to the marketing interests of entrepreneurs and managers of large industries [35].

In this way, productivity improvement is an essential motivator [6], [34]. In search of increasing business competitiveness, it is possible to understand it as lower use of energy per unit produced and can be presented as a time and/or resources saving due to automation processes or data collection [34]. Production can be a vehicle to reduce the waste of energy and resources at the same time [35] since by reducing the energy consumption necessary for the product manufacturing and increasing production levels, the industrial sector is benefited and is being encouraged to be competitive at national and international level [36]. Also, it creates new jobs, directly and indirectly, because new traders are generated that revolve around EE, where the effort is not focused only on manufacturing but also on research and development, service, and installation programs [37].

The ecological benefits that the implementation of EnMS brings are one of the greatest motivators for the deployment of EE programs [2], [19], [20], [34], [38]–[43]. Well, the literature indicates that these motivators can be even more attractive than the same economic benefits, since the organization is showing social responsibility and harmony with the sustainable development objectives that seek to reduce GHG, at the same time that this translates into energy savings [13], [29].

Taking into account the above, it is important that the regulations that arise respond to the reality of each country and the limited resources on the industry, in such a way that they can attract the top management of the companies to make strategic decisions based on the potential improvement, utilities and the perceived performance generated by an EnMS, where commitments and objectives are established for allowing the success of development and implementation of this EnMS programs [44].

The regulation must ensure that the state promotes innovation and competitiveness in the industry, prioritizing social purposes and promoting sustainable development through measurable and clear goals, and by setting performance standards that generate a real commitment from state policies to promote the industry through sustainable development, implementing a vision of shared value between government and industry with programs that encourage a more competitive and less polluting industry [36]. But, it is crucial to consider which this type of program does not last over time since although initial economic support is envisioned, in an extended time-horizon each company must appropriate its system and sustain it over time, maintaining the performance standard achieved and raising it in as much as possible [44].

Accordingly, it is necessary to establish a clear, coherent regulatory framework able to be sustainable over time, and it is essential to secure the way to monitor the measures, provide the industries with tools to implement the EnMS, and designate public entities to operate as control agents [45].

The industrial sector is incentivized by the government with general reductions in taxes, linking favorable tax treatment to energy-saving efforts [46], with subsidies or public funding to motivate the adoption of EE technologies [47]. Public EE policies are composed of mechanisms such as price regulation, management or legislation, and economic and fiscal incentives [48]. Non-fiscal incentives such as subsidies, preferential loans, and research and development funds potentially encourage investment in EE; these incentives will make EE programs more attractive for companies [46].

In this context, technological renovation is a crucial factor in the EE programs since the use of obsolete technologies is one of the principal causes of inefficiencies and high energy consumption in the industries, consequently, factories with reduced EE can improve substantially by introducing high energy-efficiency technologies, which allow the reduction of intensive energy consumption due to the losses associated with their processes, reducing the associated cost for each gross unit produced [13], [29], [49], [50]. Therefore, searching for the maximization of efficiency in machines and industrial processes contributes to the development of efficient and sustainable production [31].

Finally, the industries have technical limitations that can lead to an increase in losses and inefficiencies in the industry, a clear example of this is that due to the immersion of reagents in the network, it leads to a reduction in the power transport capacity active, to an increase in the losses in the network, to the deterioration of the voltage profile and with all this to the decrease in the quality of the service [51]. Another aspect to be highlighted at a technical level is that in practice it is common to oversize equipment, for example, the choice of motors with greater capacity than is really needed, this to satisfy the demand for additional loads and make a projection in the team time [52].

III. COLOMBIA AND THE MASSIFICATION OF ENERGY MANAGEMENT SYSTEMS IN THE FRAMEWORK OF THE COVID-19 PANDEMIC

The energy consumption registered by the industrial and commercial sectors at a global level is the cause of around 40% of GHG emissions; therefore, the decrease in this type of consumption is decisive for countries to meet their national commitments to reduce emissions to the atmosphere [38]. In the Colombian case, according to the characterization of the demand made in [42] and [53] for the year 2015, the industrial sector consumes around 29.8% of the energy at the national level, which is equivalent to 327,693 TJ of energy, this being the second sector with the highest consumption after the transport sector, which consumes approximately 40% of the country's total energy [53]. This massive consumption is comparable with the importance of this sector for the Gross Domestic Production (GDP), with the industrial sector showing a share of 11-14% of GDP between 1994 and 2014 [36]. The GDP belonging to the industrial sector is a determining variable in the national economy, which according to DANE, in 2015 was up to 21 USD billion [42]. However, for the year 2020 the national GDP presented a drop of 6.8% due to the effects generated by the Covid-19 pandemic, particularly the industry decreased by 11.1% for the third quarter of 2020, this contributes -1.4% to the annual variation [54].

In this context, the EE of industries plays a crucial role in social sustainability, economic performance, and environmental protection [3], because it leads to energy conservation. Hence, many programs and measures have been proposed to promote the improvement of EE in industrial sectors, which has been strengthened not only by the concern associated with climate change but also because the measures framed in the EE allow incentives for energy security, development, and economic competitiveness which are essential factors for the growth of any nation [36].

In this context, for organizations to reduce their energy consumption and to contribute to the solution of environmental problems, the ISO 50001 Standard was originated in 2011 which implementation can lead to a high impact on EE and climate change [55], within this standard, international experience of the best practices in implementation, maintenance, and operation of EnMS at all organizational levels have been collected [21]. This standard brings significant benefits to industries by supporting the establishment of processes and systems that encourage energy performance improvement, its use, and consumption, all this aimed at achieving cleaner production within the industrial sector [55]. In consequence, Colombia adopted this standard through the NTC-ISO 50001 at the end of 2011 to comply with the international recommendations outlined in the ISO standard [11].

In Colombia, through the University - Company - State strategy, there have been several studies and pilot projects that allow the country to have extensive experience in energy management [21], [56]. In this strategy, research has been the main actor through the EE benefits dissemination and with the development of route maps adapted to the current state of national energy consumption. Based on these ideas, the Colombian Network of Knowledge in Energy Efficiency - (RECIEE by its Spanish initials) was created in 2003 [11]. One of the main objectives of this network is the identification of a management model that allows the continuity and sustainability of the results of EE programs and strategies in the country, and the integration of energy management in industry, through the development of energy management projects and research lines with an impact on industry's productivity and competitiveness [57]. On the other hand, in 2007, the Comprehensive Energy Management model was developed, which originates the Comprehensive Energy Management System. Thanks to this background, RECIEE led the National Strategic Program on Comprehensive Energy Management Systems was planned and developed between 2010 and 2013, thanks to which 12 companies nationwide implemented sustainable EnMS [11]. Consequently, at the end of 2016, the Industrial Energy Efficiency program began in Colombia, which aimed to transform and promote the market for EE services and products for the industry through regulations and technical standards for capacities in EnMS and process optimization methods [58].

Al the national level, in the last five (5) years, one of the highlighted elements that promote the massification of alternatives in EE is the demand projections made by the Mining and Energy Planning Unit (UPME by its Spanish initials), in which an increase of energy of approximately 52% between 2016 and 2030 is projected [53]. Although national planning seeks the energy matrix diversification to meet the growing demand without increasing GHG emissions, EE should be considered a complementary path for reliability improvement, keeping constant or even reducing the level of GHG emissions and other pollutants [53]. The last will make it possible to cooperate with the commitment that the Colombian state currently has to reduce GHG emissions by 20%, which is one of the main reasons for strategies enhancement to preserve the environment and improve the EE of national industries [59]. In this sense, due to the energy transition and the extensive national trajectory related to EE, different regulatory incentives have been created, such as Law 1715 of 2014, which highlights because it defines efficient energy management as the set of actions aimed at ensuring energy supply through the implementation of EE measures and demand response [60]. Also, this Act makes it possible for those interested in invest in projects related to non-conventional energy sources and efficient energy management to access tax incentives set by this Law once the requirements and procedures established by the pertinent entities are fulfilled [61].

Despite the incentives that exist at the national level for these initiatives, it is necessary not to lose sight of the most relevant barriers that prevent the massification of EnMS in the Colombian industry. These can be grouped into organizational, cultural, economic, and regulatory aspects [62], [53], [63]. At the regulatory level, the participation of the local and national administration in the design of programs that take into account all business levels, from SMEs to large enterprises, is pertinent so that the programs do not fall short when implemented. However, from the financial sphere, it is essential to have the necessary resources and inputs [63], since, even with the will of the organization, if the resources are not available to build effective measures in EE, it will not be possible to have a development of these programs.

From the organizational point of view, strong leadership is essential for guiding the habits and customs of the members of the organization towards a culture of energy saving, this without forgetting that the support and encouragement of senior managers, in disposition and economically, is decisive for the performance of a correct exercise in EE [64], [32], [33]. Here, it is crucial to consider the stimuli that public entities offer to companies that implement EE programs, which has a significant influence on the process. Nevertheless, these motivators are not always visible or perceived as influential on decision-making for marked influence people within the organization. The last, together with the little belief of some individuals within companies regarding the benefits of these kinds of programs is one of the greatest limitations within the national context for the massification of EnMS in the industry [62], [53], [63]. In short, there is a need for greater dissemination of the benefits of these programs to increase the number of companies that dare to seek certification in energy management and thereby support these initiatives. Finally, it is crucial to highlight that the existing barriers in the country are also present at the international level in countries that seek to incorporate EE as a state policy [63].

Furthermore, an element to consider in the national panorama related to the EE is the results presented by the Useful Energy Balance (UEB) study, which compares the consumption of the current technologies used in the country with the electricity demand of the use of the best national or international technologies (Best Available Technologies - BAT). The results show that the useful energy in Colombia represents 31% of the final energy; also, inefficiency in consumption is around 67%, which costs the country between 6,600 and 11,000 million USD per year. From the point of view of efficiency in the industry, in this context, the final energy could be reduced between 71,000 TJ and 97,000 TJ, achieving savings up to 810 USD million and 1,400 USD million by measuring respectively national BAT and international BAT [10]. There is currently an unpromising horizon for Colombian industry because according to the national development plan, only 22% of companies are considered innovative, and the relationship between industry and university was 2.7% for the year 2016, the latter turns out to be an impediment to the development of qualified professionals with a pragmatic vision of the industry [65].

In this sense, it is worth highlighting the effect that Covid-19 has had on the national economy and industry. In Colombia, like the vast majority of countries in the world, it was necessary to implement restrictive and confinement measures [66]; thus, global mobility fell significantly, falling by as much as 50% in April 2020. These measures had a substantial impact on the companies operational activities, the mobility of people, the distribution of products, and the supply of goods and services. In economic terms, it is a crisis both in the supply and demand sectors with different characteristics and possible solutions [54].

As expected, an effect of the above-mentioned is that the region had a negative economic impact. In fact, the Economic Commission for Latin America and the Caribbean (ECLAC) presented its traditional Preliminary Balance in December of 2020 of the Economies of Latin America and the Caribbean, in which America's continent was the most affected region globally, to such an extent that the Covid-19 pandemic is considered the worst economic crisis in the last 120 years [67]. At the sectoral level, it must be said that, although the current situation has had a negative influence on all sectors of the economy, the intensity is different according to the sector, where the least affected have been mining, financial services, essential character services, and agriculture; however, the most affected ones have been construction, transport, manufacturing, and commerce [67].

Consequently, the difficulties in the industry that have been occurring in Colombia resulting from the Covid-19 pandemic should lead each sector of the economy to seek a way to reduce costs and increase their income; for this, savings and reducing of surpluses in production is a crucial factor. Considering this, from an economic, environmental, and sustainable point of view, EnMS and EE programs have aspects that can be used by the Colombian industry to potentiate and make effective the benefits of these programs; therefore, it is advisable to rely on frameworks such as Lean Manufacturing and regulations such as ISO 50001 since, although it is possible to have good results without a certified system, experience has shown that the most outstanding results belong to those systems with certification [40]. In a complementary way, an important aspect to consider is the relevance of the use of technology since the encouragement of BAT use would lead to the energy losses reduction, and therefore, a decrease in economic losses, the latter being a crucial aspect to attract investors and motivate top management in companies.

IV. Recommendations for the Implementation of Energy Efficiency Programs in Colombia

Based on the above, Table I shows the main challenges associated with the EE programs implementation in the Colombian industry and a series of recommendations and proposals that would help to overcome these challenges in the national context.

TABLE I
CHALLENGES WITHIN THE COLOMBIAN INDUSTRY FOR THE IMPLEMENTATION OF EE PROGRAMS

Sociocultural challenges	Sociocultural limitations are related to the irrational decisions, beliefs, prejudices, and behaviors of some members of the organizations that are against the methodology proposed for the EE improvement in the industry because they can be obstacles to the successful development of energy management programs [12]. Therefore, changing these precepts integrating an EE culture in all industry members constitutes a significant challenge for the industrial sector. Human capital is essential in development and innovation in the industry, becoming a key agent, which can translate its belonging sense into the realization of processes that allow innovation and the development of the organization [64]. Therefore, training and qualification of personnel are necessary to positively impact the organization's projects [68], leading to an energy-environmental culture that allows increasing competitiveness and reducing environmental impact in search of sustainable energy development [69].
Challenges of the country with the international community	At the international level, the Sustainable Development Goals (SDGs) are an initiative by the United Nations that seeks to identify the measures that intervene on environment preservation, economic growth, and advances in social equity [70]. Focusing efforts on promoting programs at an industrial level that allows for a more competitive, innovative, and committed industry to care for the environment; thus guaranteeing energy security and the development of the country [3], [36], [65] The fulfillment of the goals projected in the National Energy Plan (PEN) 2020-2050 is essential to achieve the SDGs, Colombia's commitment to reducing greenhouse gases, consolidating the energy transition for Colombia [10]. The vision of the National Energy Plan 2020-2050 points out that the industrial sector should strengthen innovation, training of human personnel, digitization of data, adoption of new technologies, and the replacement of coal generation by clean energy for its production processes [10].
Economic challenges	The main economic challenges of the industry related to EE are associated with the investment's long period of return, the scarcity of economic support, the lack of interest of the banking entities, and the perception of high risk in the financial institutions due to the limited awareness of the benefits of EE programs [12], [26]–[28]. In addition, the focus of resources on priorities defined by the organization as production quantity and quality diverts the gaze from EE projects generating resistance to change in the organization's employees, who can associate any action aimed at EE as something complicated and complex [26]. In this context, similar to the proposal for socio-cultural challenges, it is necessary to focus the vision of investors, industries, banks, and the state on the expected results of the implementation of EnMS and EE programs, making these project alternatives to not be abandon for others with a lower return period, thus encouraging those related to the implementation of EE programs which can improve productivity and create an energy-saving culture that can lead to a reduction in GHG emissions [38], [20]. Therefore, it is essential to develop strong awareness campaigns on the effects of industrial losses reduction in environmental conservation, aimed at the general public but especially at the country's financial sector. Entrepreneurs and the financial leadership of companies should also know the existing plans and incentives available to make investments in these projects more attractive despite the long payback period. However, for this to be effective, it is necessary to motivate the industry to invest in EE projects, either through incentives or through penalties imposed for those industries whose losses exceed a certain threshold, because Law 1715 and Law 697 have tried to implement this kind of methodology, but they have been insufficient within the national context.

Technical and technological challenges	It is pertinent to enforce what is stipulated in article 28 of Law 1715, related to the setting of specific sectoral objectives that allow the establishment of measures and instruments for the renewal of equipment for others with a higher energy performance [71]. The importance of regulation regarding the industry's actions that can improve technical parameters of the network is evident, this is the case of Resolution CREG 015 of 2018, which required industries, through penalties establishment, to pay attention to reactive power injection to the electrical system, allowing the improvement in the voltage profile, the correction of the power factor and therefore, the reduction of the system congestion [52], [72]. At the same time, it is also necessary to understand and highlight the impact that technological renewal would generate in industrial processes and the potential improvement associated with the equipment replacement by better energy performance appliances [29], [13], [49], [50]. At a technical level, the oversizing of equipment is a factor that affects the decrease in the power factor, increasing the use of reactive energy that circulates through electrical systems [52], [51]. Hence, it is convenient to carefully apply the two fundamental criteria for the equipment sizing according to the needs of the system [52]: (1) It is necessary to deeply know each process to establish strategies aimed at the efficient use of energy, and (2) Establish the amount of energy consumed by each of the equipment through decentralized metering.
Regulatory challenges	Law 1715 of 2014 regulates the integration of non-conventional renewable energies into the national electricity system establishing the criteria for the massification of these energy sources. The fifth chapter of this Law refers to efficient energy management promotion through the Indicative Action Plan for Energy Efficiency (PAI-PROURE by its Spanish initials), which enables the creation of planning and information instruments of a technical, legal, economic, and financial nature to allow the development of energy regulations and incentive the development of EE in the country [71]. The last allows the creation of a comprehensive regulatory framework aimed at identifying the forms of financing and budgetary needs for the promotion of efficient energy management, the establishment of clear goals in specific time frames, and the creation of methodologies that allow evaluating the performance of the industry in terms of EE. Then, it is necessary to establish, in the National Development Plan, clear sectorial goals, adapted to the reality of the country, for the improvement of energy performance that allows sustainable development, thus generating a real commitment from state policies for the massification of renewable and efficient energy generation [65]. In addition, in a complementary manner, the necessary financial means for the development of activities by RECIEE must be established, which allows generating new spaces for the continuously dissemination and exchange of knowledge on good operational practices, to allow industries to improve their energy performance, thus complying with the provisions of Law 1715 [71].
Organizational challenges	The main challenges at the organizational level are associated with the commitment of the organization's members to EE programs since the importance of senior management commitment during the EnMS implementation process should be highlighted [21]. The latter since the administrative leadership will be in charge of defining authorities guarantees so that the planning and execution processes have good endowments of resources, activities, and responsibilities that allow the effective operation in the planning and implementation of the system, thus leading to integrate the SGEn into the organizational culture [34], [49], [33], [27]. A proposed strategy is the appointment of a manager with technical knowledge of energy consumption, who will be in charge of the energy management within the company, and who participate in the administrative decisions of the company [73]. The last could guarantee the constant awareness of administrators and investors about the importance of executing EE actions, which will have a significant impact on the rest of the organization due to the vital role that management commitment plays in EE strategies. In addition, clear communication channels are necessary for allowing top management to stay informed about the status and risks of the EnMS [73].

V. CONCLUDING REMARKS

This paper reviewed the alternatives that allow the massification of EE in the industry, focusing on EnMS and evaluating the challenges found in the Colombian paradigm for proposing some recommendations that can make it possible to overcome the challenges identified in the national panorama.

To fulfill the country's commitments to the SDGs, and in turn promote the massification of the EnMS and EE programs in the country, a state policy is necessary for supporting industries, providing subsidies for the purchase of more efficient equipment, and tax incentives that support and encourage companies to be certified in regulations such as ISO 50001, ensuring that these incentives are not held only by large companies since although the industries with the highest energy consumption should be the more promoted to implement this type of programs due to their energy savings potential, it is also essential to motivate SMEs since it contributes to their growth, as well as, the impact of EE becomes widespread. Here, it is noteworthy that although the government has encouraged companies to implement energy management programs, the incentives that are currently present are not enough to motivate more companies to invest in these areas.

Strong awareness of the importance of saving and conscious consumption of energy is necessary for the successful implementation of EnMS because the lack of knowledge of the impacts of EE in the industry is still common in the national context. Therefore, to attack the problem hearth, education institutions should make these issues more visible, either by incorporating them into the syllabus or through annual conferences where energy agents develop campaigns for educational institutions that allow the young population to understand the importance of these issues. In a complementary way, the increase in economic benefits and educational aid by the government and individuals, for those who wish to study EE-related issues is an initiative that, in the long term, will lead to better research and widespread knowledge about the EE methodologies, thus leading to more attractive future for EE projects and EnMS.

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