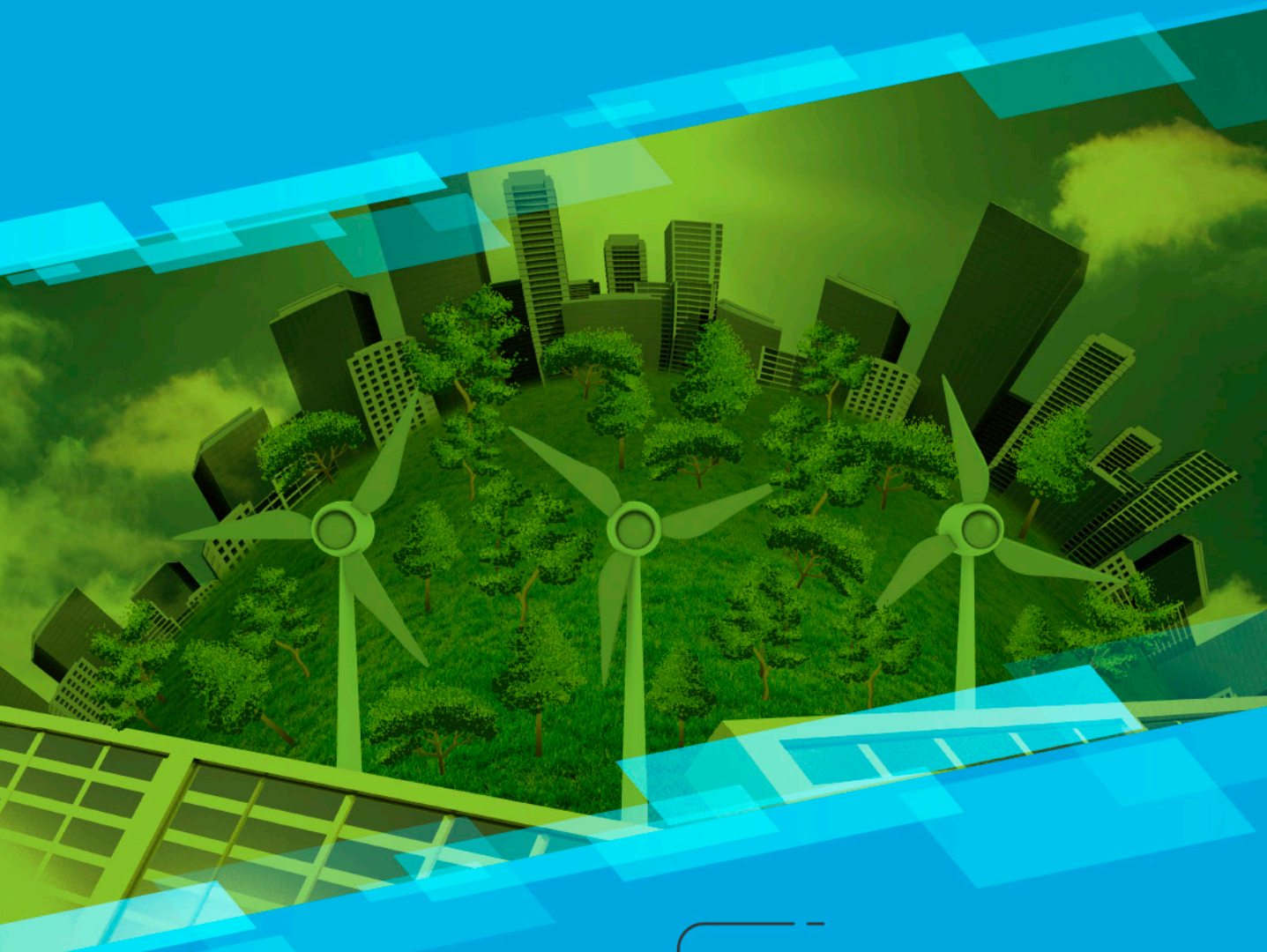
II International Congress on

BRESICT

Biorefineries and Renewable Energies Supported on ICT



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Piedecuesta, Santander, Colombia

February 17-20, 2020

Universidad Cooperativa de Colombia

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AWARDS

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Abstract

The II International Congress on Biorefineries and Renewable Energies Supported by ICTs (BRESICT) opened its doors from 17 to 20 February 2020 at the facilities of the Instituto Colombiano de Petróleo (ICP), at Piedecuesta, Santander, to actors from the academic and industrial public and private sectors. National and international guest speakers, students, entrepreneurs, professors, and managers met in order to transfer, develop, and identify solutions based on the capabilities and technologies developed by universities, industry or government that are applicable to the country's energy and global challenges. This version had a certified attendance of 150 visitors among attendees and speakers, from 13 countries, who had the opportunity to participate in two main activities held during the Congress: the academic and industrial papers presentation and the "Identification of collaboration opportunities for research and innovation projects" Workshop. During the co-creation workshops there were 64 attendees, including researchers, academics, and businessmen. Four research project proposals emerged: two from the renewable energy table and one from the respective tables in Biorefineries and Industry 4.0.

Keywords: alternative energy, bioenergy, biorefineries, ICT, renewable energy, sustainable development goals.

Resumen

El II Congreso Internacional de Biorrefinerías y Energías Renovables Soportadas en TIC (BRESICT) abrió sus puertas del 17 al 20 de febrero de 2020 en las instalaciones del Instituto Colombiano del Petróleo (ICP), en Piedecuesta, Santander, a actores del sector académico e industrial, público y privado. Se reunieron conferencistas invitados, tanto nacionales como internacionales, estudiantes, empresarios, profesores y directivos, con el fin de transferir, desarrollar e identificar soluciones basadas en las capacidades y tecnologías desarrolladas por universidades, industria o gobierno que sean aplicables a los retos y desafíos energéticos del país y globales. Esta versión tuvo una asistencia certificada de 150 visitantes entre asistentes y ponentes, provenientes de 13 países, que tuvieron la oportunidad de participar en las dos principales actividades realizadas durante el congreso: la presentación de ponencias académicas e industriales y el taller "Identificación de oportunidades de colaboración para proyectos de investigación e innovación". Durante los talleres de cocreación se contó con 64 asistentes, entre investigadores, académicos y empresarios; y surgieron cuatro propuestas de proyectos de investigación, dos por la mesa de energías renovables y una por las respectivas mesas en Biorrefinerías e Industria 4.0.

Palabras clave: energía alternativa, bioenergía, biorrefinerías, TIC, energías renovables, objetivos de desarrollo sostenible.

Contenido

Introduction

Europe, with its environmental policies, has set a path in search for an environmental-friendly development, taking advantage of the available resources in a responsible manner and maintaining a rhythm of progress that makes it an example for the rest of the world. On the other hand, the Government of Colombia recognises the potential resources it has throughout its territory to supply clean energy to the neediest communities in the country, especially the rural and non-interconnected zones (NIZ). Thus, this type of energy is mentioned in Law 1715 of 2014, which states that "the State will develop strategies for the use of renewable resources for sustainable economic development, the reduction of greenhouse gas emissions and security of energy supply". Colombia has a great potential in this type of energy: the resources available at the national level, such as high solar radiation, localised winds of medium high speeds (at 80 m height for the particular case of the state of La Guajira) and energy potentials of the order of 450,000 TJ per year in biomass waste, represent attractive alternatives compared to those of countries located in other latitudes of the planet. This, combined with the existence of validated technologies for the use of these resources, reduced cost trends, a broad dependence on water resources in terms of electricity generation associated with the risks of climate change, and relatively high end-user tariffs, means that in Colombia it makes sense to consider the use of these unexploited sources, especially the great potential for rural and the NIZ, as well as to promote the implementation of ICT that facilitate the development of innovative projects in the Colombian energy sector.

Universidad Cooperativa de Colombia (UCC), present in 18 cities, has access to a large part of the country's territory, making it a key player in the process of knowledge and technology transfer in this area. On the other hand, the European Cooperation in Science and Technology (COST) network is currently one of the broadest cooperation frameworks in the world, with a budget to carry out research and innovation projects in various thematic areas in which Universidad Cooperativa de Colombia is part of via the following actions:

CA17128 "Establishment of a pan-European network on sustainable lignin recovery" which has as its main objective to facilitate the transition from a complex and highly under-exploited secondary stream to a biorefinery product and a major industrial feedstock, a European network is established to unite and coordinate the many efforts being made in academia and to provide industry stakeholders, including SMEs, with relevant and up-to-date information on lignin.

CA17133 "Applying nature-based solutions to create a circular city with resources" with the objective of establishing a network to test the hypothesis that: "A circular flow system implementing NBS for nutrient and resource management within the urban biosphere will lead to a resilient, sustainable and healthy urban environment".

Finally, CA17105 "A pan-European Network for Marine Renewable Energy" whose main objective is to establish a collaborative approach, as it provides a strong networking platform that also creates the space for dialogue between all stakeholders in wave energy; its main goal is equal opportunities for research, collaboration and funding for all researchers and practitioners, regardless of age, gender and location.

Through the alliance generated between Universidad Cooperativa de Colombia and the COST Network, as well as with UK Researcher Links, the Network of Promoters of Sustainable Development Goals (SDG), European Technology and Innovation Platform for Ocean Energy (ETIP Ocean) and Oceans Energy / Offshore Wind, to carry out energy, water and air projects supported by smart systems, research and development of academic capabilities in these areas has been initiated. However, there is still a gap in the use and appropriation of these technologies not only in the academic sector, but also in the business and government sectors regarding the generation and transfer of knowledge on biorefineries, alternative, and renewable energies based on ICTs. Therefore, it seeks to identify and generate opportunities for partnerships and joint work between different actors in technological innovation.

BRESICT 2020 was possible thanks to the alliance between Universidad Cooperativa de Colombia and institutions such as Newton Fund, European Cooperation in Science and Technology (COST), ESSA EPM Group, Royal Academy of Engineering of the United Kingdom, European Union's Horizon 2020 Program, Ecopetrol, Fellows Colombia, EU-LAC Foundation, Revista *Negocios y Petróleo,* Asociación Nacional de Empresarios de Colombia (Andi), Dotaequip Ltda. Ecodiesel Colombia, Comisión Regional de Competitividad de Santander, and Cooperativa de Tecnólogos e Ingenieros de la Industria del Petróleo y Afines (TIP).

Target audiences

Academic researchers, industry and government related to renewable energy, biorefineries and icts.

Objectives

1. Transfer the knowledge acquired from national and international experts to researchers, as well as to people linked to the industrial energy field or anyone interested in the subject.
2. Develop co-creation workshops, business roundtables between academia, companies and international and national experts in order to generate alliances or exchange knowledge around specific projects.
3. Identify solutions based on the capabilities and technologies developed by universities, industry or government that are applicable to the country's and global energy challenges.

Chapter 1. Biorefineries

Keynote Speakers

Time to the coffee break: Can coffee waste materials be used in a circular economy?

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Keywords: coffee processing, chemical characterisation, cellulose, lignin, sugars, silverskin.

Introduction

The bioeconomy and the circular economy concepts are becoming increasingly important in the agricultural and industrial sectors. There is an increasing interest in obtaining traditional petrochemical based products from bio-based feedstocks and processes in order to attain a sustainable economy. The present research reports the use of biomass waste materials from coffee manufacturing in small biorefinery options.

Problem

Lignocellulosic biomass waste has a complex structure consisting of three major fractions: cellulose, hemicelluloses and lignin; and their relative abundances depend on the type of biomass feedstock (Huang et al., 2008). Depending on the quantity of all these major fractions and the individual compounds, the valorisation opportunities can vary. Therefore, the importance of the use of traditional and new characterisation methods of these kind of materials becomes relevant. In addition to the economy and feedstocks, social impact in some areas need to be considered in future biorefineries. In this sense, a domestic bio-based economy needs to be studied in these areas to foster innovation and to spur the modernisation of the agricultural sector.

Coffee processing is a good example with a production of 31.8 million € in exports and it is the fourth agricultural product marketed (Zarrinbakhsh et al., 2014). More than 2,300 million cups of coffee are consumed in the world every day and most of the coffee consumption takes place in industrialised countries, while 90% of coffee is produced in developing countries (Hughes et al., 2014), especially in rural and vulnerable areas.

Objective

Study the possibilities offered by waste coffee processing materials in small biorefinery options under a circular economy concept. This work is based on the identification of the waste materials in different areas, the identification of the best characterisation methods and the use of the chosen characterisation methods (traditional and novel) in two coffee waste materials. In addition, some possibilities of valorisation options can be given.

Methodology

Used coffee grounds and silverskin are characterised, being about 50% of the waste from the coffee processing (Janissen & Huynh, 2018). The analysis of ash, water content, extractives (ISO 14453:1997), cellulose, hemicellulose and lignin by Van Soes methods (Viel et al., 2018) and the analysis of individual sugar and other decomposition compounds by acid hydrolysis and HPLC (Llano et al., 2017) are studied.

Results

Coffee manufacturing is a complex process not only within developing countries but also in more industrialised ones. Depending on the stage, different waste materials can be used for valorisation options, from skin, pulp, mucilage, hull and silverskin from the coffee cherry to the used coffee ground. In this work, an identification of all of the waste materials in coffee processing under a circular economy perspective together with the possibilities in developed and more industrialised countries have been carried out. A general scheme has been proposed including all the processing steps. The second step was to study the characterisation methods to separate the different fractions for valorisation opportunities. In this case, two waste materials (silverskin and used coffee grounds) have been characterised. The results give more possibilities for cellulose-based products (paper, fibres, textiles or biofuels) and lignin (energy valorisation and additives). In addition, and in order to study the valorisation options from a sugar platform, a new methodology of hydrolysis and HPLC characterisation has been used to obtain the individual compounds in both residues. Glucose, galactose, arabinose and mannose are the main sugar compounds in both waste materials. However, in the case of silverskin, xylose is another possibility to be valorised into xylitol or biopolymers. The concentration of other decomposition compounds (acids and furans) is negligible in both residues.

Conclusion

Waste materials from coffee processing fulfil the requirements to be valorised using small biorefineries in rural and industrialised areas. Silverskin and used coffee grounds can be valorised into fuels and energy, cellulose-based products, and products from sugar fermentation. This work will be the basis of future studies in different areas (including vulnerable areas in Colombia) in order to use the obtained products as every-day products and energy. Main pre-treatments for separating the main fractions and future studies in which these options will be techno-economically evaluated by simulating the entire processes, using Aspen Plus® software, will be carried out.

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Valorisation of the organic fraction of municipal solid waste for the production of bio-based products

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Abstract

The transition from the current fossil-based economy into the bio-economy era necessitates the utilisation of crude renewable resources as sustainable feedstocks for the production of bio-based chemicals, polymers and materials. The sustainable production of such bio-based products requires the development of innovative biorefinery concepts. **Problem:** The organic fraction of municipal solid waste (OFMSW) could be valorised via biorefining for the production of value-added co-products (e.g. lipids, protein, pectin) and fermentation products using the hydrolysed carbohydrate fraction as carbon source. Succinic acid production is currently not cost-efficient and crude resources should be used as feedstocks. **Objective:** To develop an efficient and sustainable biorefinery for the valorisation of OFMSW and the production of succinic acid. **Methodology:** This study focuses initially on the separation of OFMSW into value-added co-products. OFMSW has been also utilized for the production of crude enzymes via solid state fermentation used for the hydrolysis of the remaining carbohydrate fraction. The sugar-rich hydrolysate is used for succinic acid production via fermentation by the bacterial strain *Actinobacillus succinogenes* and the engineered yeast *Yarrowia lipolytica* (kindly provided by Dr. Carol SK Lin from the City University of Hong Kong). A novel electrochemical membrane bioreactor (kindly provided by Professor Korneel Rabaey from Ghent University) has been used for the integrated production and *in situ* separation of succinic acid. The whole biorefinery concept including succinic acid production and separation has been simulated via process design using experimental results for the estimation of material and energy balances. The biorefinery concept is assessed via techno-economic evaluation and life cycle assessment (LCA). **Results:** Costing and LCA assessment showed that the use of the bacterial strain *A. succinogenes* results in lower succinic acid production cost and environmental impact than the engineered yeast *Y. lipolytica*. This is mainly attributed to the aeration requirements of the yeast strain. The integrated electrochemical membrane bioreactor system leads to improved succinic acid production efficiency than the conventional fermentation process. The biorefining of OFMSW leads to the production of value-added co-products. **Conclusion:** OFMSW is an abundant feedstock for biorefinery development. Improved succinic acid production efficiency could be achieved by the integrated bioelectrochemical bioreactor. **Originality:** Through this research,

integrated and sustainable refining of OFMSW and succinic acid Production could be achieved. **Limitations:** The process is currently under development and it has not been optimized yet.

Keywords: Organic fraction of municipal solid waste, Biorefinery, Succinic acid, Techno-economic evaluation, Life Cycle Assessment.

Acknowledgments

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Waste to wealth: an algal-based strategy for food waste valorisation

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Abstract

This abstract presents the bioconversion of food waste to value-added products by microalgae which can be a promising way to tackle the growing global problem of waste management. **Problem:** The unsustainable management of food waste by government creates many problems in environmental and economic issues. In addition, food waste consists many useful nutrients such as carbohydrate, lipid, protein for re-utilisation by bioconversion techniques. **Objective:** The objective of this research is to explore an efficient algal-based strategy for food waste valorisation by microalgal strain *Chlorella* sp. to produce biomass, lipid and lutein sequentially. **Methodology:** Efficient hydrolysis of food waste by commercial glucoamylase for microalgal cultivation. Shake flasks experiments for biomass, metabolites, physiological and transcriptional properties. Bioreactor validation for sequential fermentation of biomass, lipid and lutein with fed-batch strategy. **Results:** By utilizing the recovered carbon in 10 and 20 g L^{-1} hydrolysate, the algal biomass was up to 6.14 and 6.91 g L^{-1} in bench-top scale fermentation. In 20 g L^{-1} hydrolysate, the excessive glucose converted into lutein with a high lutein content of 62.95 mg L^{-1}. In addition, the recovered nitrogen played crucial roles in regulating the cellular carbon flow to lipid biosynthesis with a high lipid content of 2.46 g L^{-1} by 10 g L^{-1} hydrolysate. **Conclusion:** This study provides an innovative solution to food waste valorisation, demonstrating the potential of microalgae as a platform for converting food waste into high-value products (i.e. from waste to wealth). **Originality:** This project formulated an integrated and sustainable food waste management strategy for systematic investigation of microalgal value-added products for the first time. **Limitations:** The molecular mechanism of biobased products still need to be clarified.

Keywords: biomass, *Chlorella* sp., food waste hydrolysate, lipid, lutein.

Materials and structural considerations for thermal biomass processing

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Abstract

Thermal processing of biomass offers the potential for on-demand energy production from sustainable sources, independent of weather or time of day. This can be by direct combustion as a substitute for fossil fuels, through gasification to hydrogen/carbon monoxide or, under appropriate conditions, through pyrolysis. The latter generates gas feedstocks for either direct combustion, use in electrical power generation or onward processing into fuels for transport or petrochemicals, also producing valuable co-products.

Fossil fuels have spent millions of years homogenising (biomass has not). The input chemistry therefore contains far more complex molecular structures. At a chemical level, biomass processing is based on breaking the large input molecular structures into small molecules. Since the inputs are complex and often unpredictable due to variation in feedstock, the outputs may be similarly variable. This results in different damage mechanisms which require changes to be made in designing equipment.

For higher temperature processing, whether that be direct combustion or cracking for conversion to alternative feedstocks, the operating conditions are often incompatible with conventional materials and an alternative approach is needed.

This research discusses issues in material selection in biomass conversion plant, including the practical consequences of implementation, in respect of achieving required performance, avoiding premature failure and ongoing assessment through life using a holistic approach based on structural health monitoring. This includes the use of failure modes and effects analysis (FMEA) and options for condition monitoring through non-destructive methods, derived from both modelling and practical assessment.

Practical examples are discussed, including approaches to lifetime extension in biomass combustion plant, the use of FMEA in developing syn-crude production capabilities and the development of portable biomass gasification plant as an adjunct to the production of charcoal and biochar using a retort.

Keywords: Biomass, Charcoal Retort, Gasification, FMEA, Corrosion.

Sustainable ecosystem through renewable energies for Puerto Carreño, Vichada department, Colombia

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Abstract

The present paper is product of the research project "Sustainable ecosystem through renewable energies for Puerto Carreño, Vichada department, Colombia", carried out from March 2019 until December 2020 in the municipality of Puerto Carreño, located west in the department of Vichada, Colombia. **Problem:** The lack of access to continuous, high quality and sustainable energies in Puerto Carreño, associated to its situation with very difficult conditions for transportation from Bogotá and/or other cities in Colombia are a threat to economic and social development of the region. Even though there is very high potential for sustainable development, with many natural resources and high solar radiation, actual economy is pretty poor, and doesn't provide much possibilities for the inhabitants of the region. **Objective:** Formulate pilot plants and combine strategies for the efficient and sustainable economic and social development, taking into account the entrepreneurship potential of the region: honey, cashew nut, fishing, and tourism. **Methodology:** Sustainable energy production combined with the different economic sectors of the region implies understanding and characterising actual practices, creating pilot biodigestion and solar power plants, combined with economic development. Optimising these sectors with the communities will led through pilots, will give the route to sustainable development. Formation on renewable energies and sustainable economic development with all the actors on site would led to sustainable and long term changes. **Results:** The outcomes are optimized energy production in combination with economic sectors, pilot agricultural transformation and valorisation of 4 different value chains, and design of formation to overcome the lack of formed personal in the new economic context. **Conclusion:** This project seeks to generate a sustainable integrated change in the city of Puerto Carreño, to favour the sustainable economic development of the inhabitants of the region. **Originality:** Through this research, integrated and sustainable economic development strategies are formulated for the first time in the municipality of Puerto Carreño. **Limitations:** The development of the Vichada region is quite complicated due to its geographic position, with little access to terrestrial communication.

Keywords: sustainable development, renewable energies, biodigestion, solar power value chains, formation.

Valorisation of lignin towards chemicals, fuels and polymers

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Abstract

Lignin is the most abundant aromatic/phenolic polymer in nature and is one of the three main structural components of lignocellulosic biomass, along with hemicellulose and cellulose. Its primary building units is p-coumaryl, coniferyl, and sinapyl alcohols, linked mainly with β-O-4 ether or C-C bonds. Lignin is widely available as by-product from the pulp/ paper industry and the 2nd generation bioethanol production. Despite the high potential of lignin as a low cost (waste/side-product) raw material, it is still under-utilized compared to the carbohydrate fractions of biomass. This aromatic/phenolic polymer can be effectively utilized towards the production of aromatic (BTX) and phenolic monomers which can be further exploited as fuels, in the production of phenolic or epoxy resins, polycarbonates and polyurethanes and various other related applications. In this presentation, we will discuss the state of the art, as well as recent results of our group (Figure 1), regarding lignin valorisation processes that are currently being developed and exhibit high exploitation potential, with emphasis on fast pyrolysis and hydrogenolysis of lignin which are capable to provide bio-oils that contain valuable phenolic and/or aromatic (BTX) compounds (Rinaldi et al., 2019; Margellou & Triantafyllidis, 2019; Lazaridis et al., 2018; Charisteidis et al., 2019). Furthermore, the utilization of various types of lignins, with or without chemical functionalization, as additives or fillers in epoxy or phenol-formaldehyde resins will be also discussed.

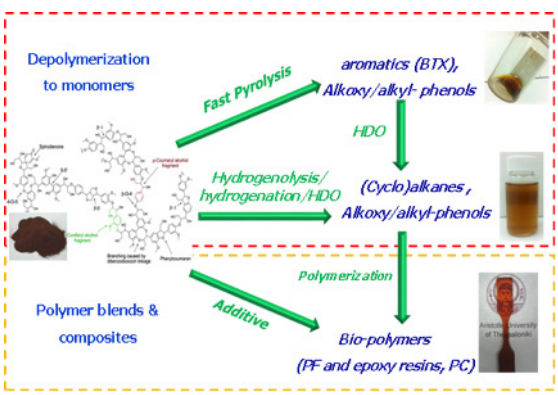

Figure 1. Integrated approach employed for lignin valorisation to fuels, chemicals and polymers. Source: own elaboration.

In brief, we have investigated the valorisation of different softwood and hardwood biomass derived lignins, as well as lignins obtained from agricultural waste biomass (olive and vine pruning, peach and olive kernels, etc). In addition to the

classical kraft, organosolv and enzymatic hydrolysis lignins, we have studied the "surface" lignin which can be selectively extracted under mild conditions with organic solvents (ethanol, acetone) from hydrothermally (in neat H_2O) pretreated biomass, aiming to enhanced the enzymatic hydrolysis of cellulose and at the same time to selectively recover hemicellulose (Nitsos et al., 2019; Nitsos et al., 2016). The structure of lignin and the abundance of the characteristic groups and chemical bonds were determined by advanced 2D HSQC NMR. It was verified that softwood lignins comprise mainly of coniferyl alcohol units, i.e., G units with one methoxy-group, while the hardwood lignins contain both G and S units, the latter having two methoxy groups.

For the depolymerization of lignin into phenolic and/or aromatic monomers, catalytic fast pyrolysis (CFP) and hydrogenolysis processes were applied. In the CFP we focused on the use of conventional and hierarchical zeolites with tuned acidic and textural properties, which can lead to enhanced bio-oil production with tailored composition, i.e. towards BTX aromatics and naphthalenes and/or alkyl-phenols, with low concentrations of heavier PAHs [3,4]. In the catalytic hydrogenolysis by metallic catalysts supported on micro/mesoporous carbons, the lignin derived bio-oils contain mainly alkoxy-phenols (>85%). The monomers yield is influenced by the experimental conditions (reaction temperatures, reaction time, catalyst mass, etc). Organosolv lignin showed higher reactivity and phenolic monomers yield, ca. 30-40%, compared to kraft lignin (5-15%).

With regard to the use of lignin, as polymer additive or filler, kraft and organosolv lignins were studied in glassy and rubbery epoxy composite systems. Utilization of lignin in the glassy polymer composite at low loadings (3%) resulted in improved mechanical properties. At higher (ca. 20-40 %) lignin loadings, significant improvement of stress and strain, along with stiffness and toughness, were observed for the rubbery composite systems.

In short, lignin can be converted to bio-oils rich in phenolic and/or aromatic monomers which can be further utilized for the production of fuels and polymers. The hydrogenolysis lignin oils (produced via simple solvolysis or by the use of appropriate catalysts) can be utilized as marine fuels while after hydrodeoxygenation (HDO) the lignin oil can be converted to hydrocarbon (alkanes and cycloalkanes) and can serve as transportation/aviation fuels. Finally, lignin can be successfully used as low-cost additive/filler in resins for the production of bio-composites.

Keywords: bio-polymers, chemicals, fuels, lignin, lignocellulosic biomass.

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Solar energy and water in the biorefinery concept

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Abstract

While the field of heterogeneous solar photocatalysis for water/air disinfection and mineralization of contaminants has been extensively investigated, a new research venue related to the selective valorisation of residues (especially the lignocellulose-based ones) has recently emerged as a promising and futuristic alternative to apply solar light for the fabrication of valuable chemicals and fuels in the concept of solar bio-refinery (Colmenares, 2019). The application of solar energy to carry out chemical syntheses is not a new concept. This idea was initially proposed by Ciamician (1912). Although the research development of solar photocatalysis has been significant, it is still too young for commercialization. However, some of them have demonstrated that solar photochemical production of selected fine chemicals, especially in regions where the Sun is abundant, may be environmentally friendly alternatives to existing conventional processes. Close related to the solar bio-refinery concept, water treatment and management is of special importance (Colmenares, 2019). Because the rapid depletion of clean water sources on our Earth, together with the unsustainable rate of population growth, the need to develop technologies for the recycling of wastewater is as relevant as ever. Additionally, the strict policies regulating the standards of wastewater pollution for industrial applications impose the need for effective decontamination methods. Available purification technologies, based essentially on physical separation of contaminants and biological degradation, fail to provide an efficient solution for the complete removal of toxic, no-biodegradable organic compounds. In this context, photocatalysis (as part of Advanced Oxidation Processes), using highly reactive oxygen species, demonstrated to be one of the most efficient processes for water detoxification (Andreozzi, 1999; Chong, 2010).

In the concept of the solar bio-refinery we can consider hydrogen as an important target. Hydrogen is commonly regarded as the most promising future fuel and potentially an ideal energy carrier due to its highest gravimetric energy and zero emission of carbon dioxide (Wang et al., 2019). Following these lines, photocatalytic hydrogen evolution (especially using solar energy) from water contaminated with organics offers a complementary and renewable way for solving the global energy crisis by means of simultaneous H_2 generation and wastewater remediation (Corredor et al., 2019). In order to enhance the efficiency of photocatalytic hydrogen generation, the application of sacrificial agents (organic compounds) in the photocatalytic system has been proposed (Colmenares et al. 2011). This process called photocatalytic wet reforming (it can be carried out under mild conditions and driven by sunlight) represents an attractive pathway for the removal of organic pollutants in wastewater with the simultaneous valorisation of these substances (Colmenares & Luque, 2014).

The aim of this lecture is to present the most recent state of the art and our scientific and technological progress in Warsaw on the development of novel solutions for water decontamination with the parallel production of solar chemicals in the frame of the concept of a solar bio-refinery (Colmenares, 2019). The principal focus of this lecture will be to discuss the pros and cons of a new approaches which consists of a perfect synergistic action of organic waste filtration-degradation in water with the simultaneous batch and continuous production of high-valued chemicals including here water "as a strategic material for a sustainable future". Two case studies will be presented:

Photocatalytic filtration-degradation in batch of organic-based pollutants from water: Modern composite filter materials were obtained via modification of commercially available polypropylene (PP) nonwovens with particles of nanorods zinc oxide (1D ZnO/PP) with high aspect ratio. This modification was conducted as a three-step process consisting of a plasma treatment (radio frequency plasma treatment in oxygen atmosphere allows for improvement of polypropylene liquid contact angle) of the polymer nonwovens, deposition of ZnO nuclei on fibers surface and low temperature hydrothermal uniformly growth of ZnO rods (1D). A remarkable photocatalytic initial specific activity for ZnO/PP was observed (3-fold higher than commercial ZnO) and high stability in aqueous phase phenol mineralization (Colmenares et al., 2015). This research is an important step forward in the preparation of photocatalytic active filters (the combination of the advantages from photocatalysis and filtration) for water purification.

Highly efficient nonwoven – nanoparticles hybrid systems for photocatalytic production of hydrogen: Motivated by recent progress in photocatalytic generation of hydrogen from organic solutions and water as well as our first successful synthesis of polypropylene (PP) nonwoven–NPs hybrid systems, it will be presented the design, fabrication and performances of such hybrid systems for the sustainable production of H_2 using homebuilt LED flow photo–reactor. The main goal of this research is to create highly efficient nonwoven–NPs hybrid systems for photocatalytic production of H_2 through the identification of highly active TiO_2–based NPs in visible light spectrum, without incorporation of noble elements, their subsequent synthesis, and uniform deposition on the PP nonwoven.

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Benign-by-design processes for sustainable biomass/waste valorisation

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Abstract

The design of benign and environmentally sound methodologies has been the driving force of scientists in recent years towards more sustainable methodologies. Attractive and innovative protocols that nowadays are even part of industrial ventures including biomass-derived porous carbonaceous materials, designer nanomaterials for catalytic applications and catalytic strategies for biomass/waste conversion into useful materials, chemicals and fuels have been recently developed in our group in recent years. These topics have extensively covered the preparation and design of (nano)materials, biocatalysts and photocatalysts and their utilisation in heterogeneously (bio)(photo)(electro)catalysed processes, flow chemistry as well as in biomass/waste valorisation practices (Shen, et. al; 2018; Rodríguez-Padrón, et. al., 2018; Filiciotto, et. al., 2017; Lai, et. al. 2016; Jodlowski, Yépez & Luque, 2016).

In this lecture, we aim to provide an overview of recent efforts from the scientific community in leading the future of global scientists from chemical engineers to (bio)chemists, environmentalists and materials scientists in benign-by-design methodologies for various types of catalyst systems and key applications in bio-, photo- and electrocatalysis.

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Enzyme-mediated production of prebiotic cello-oligosaccharides from forest biomass

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Abstract

The current study focuses on the production of cellobiose as a novel oligosaccharide with a prebiotic potential that originates from plant cell wall polysaccharides. These cello-oligosaccharides are produced by enzymatic hydrolysis processes using waste lignocellulosic biomass residues (birch and spruce) as substrates. To achieve this goal, we followed two different strategies, including the construction of tailor-made enzyme cocktails comprised of different processive cellulases and the modification of the performance of the commercially available enzyme mixture, Celluclast®. The potential of the hydrolysis products to support the growth of different *Lactobacilli* probiotic strains as a sole carbon source was demonstrated.

Keywords: cellobiose, enzyme hydrolysis, non-digestible oligosaccharides, lignocellulose, nanofiltration, prebiotics.

Introduction

The valorisation of biomass residues towards the production of value-added products is attracting increasing interest during the last years, not only because lignocellulose is a renewable source of sugars that can be transformed into a platform of chemicals for different applications, but also because it is an abundant waste stream, most of the times under-valorised. Non-digestible oligosaccharides (NDOs) represent a group of carbohydrates that are resistant to gastrointestinal digestion, therefore they are considered as prebiotic candidates. Such oligosaccharides can derive from the biomass cellulose fraction through a controlled enzymatic hydrolysis that eliminates the yield of monomers. Production of NDOs from lignocellulosic biomass residues (birch and spruce) includes a complete process starting from physicochemical pretreatment and fractionation in order to obtain a cellulose-rich solid pulp (Matsakas et al., 2018; Matsakas et al., 2019), followed by controlled enzymatic hydrolysis, product recovery and purification and, eventually, evaluation of prebiotic activity. In this work, several strategies for enzyme-mediated production of oligosaccharides were evaluated, including the design of tailor-made enzymatic cocktails that offer a

controlled polysaccharide cleavage and produce less monomers (Karnaouri et al., 2018; Karnaouri et al., 2019a), the modification of reaction conditions (e.g buffer exchange to abolish the end-product inhibition of enzymatic activity; Karnaouri et al., 2019b) and the fine-tuning of the performance of commercially available enzyme cocktails (e.g addition of β-glucosidase inhibitor; Tsuji et al., 2013).

Methodology

For the construction of customized cocktails, hydrolysis of organosolv pretreated forest residues (birch and spruce) was tested in the presence of three processive cellulases (EG5, CBH7, CBH6) and one accessory enzyme (LPMO). An experimental design was set up; evaluation of the results was performed with Design Expert 9.0.0 software using the most appropriate model that fitted the experimental data. The predicted enzyme combinations for optimal cellobiose production were verified experimentally. In parallel, a fine-tuning of the performance of the commercially available enzyme mixture Celluclast® was conducted towards the optimization of cellobiose production. The optimal enzyme combinations and reaction conditions in both cases were applied on scale-up reactions and the produced oligosaccharides were recovered and separated from glucose through nanofiltration. Screening of five different nanofiltration membranes was performed and the effect of different parameters was tested regarding the best separation of cellobiose/glucose. The prebiotic potential of the cellobiose-rich products was estimated by the ability to stimulate the growth of *Lactobacillus* strains (*L. gasseri* and *L. plantarum*).

Results and Discussion

The optimal enzyme combinations were comprised of 20% EG5, 43% CBH7, 22% *Tt*LPMO, 10% *Pa*Cbh6a and 5% EG7 in case of birch and 35% EG5, 45% CBH7, 10% *Tt*LPMO, 10% *Pa*Cbh6a and 5% EG7 in case of spruce, leading to 22.3% and 19.1% wt. cellulose conversion into cellobiose, respectively. Enzymatic hydrolysis was applied on scale-up reactions and the produced oligosaccharides (consisted of >90% cellobiose) were recovered and separated from glucose through nanofiltration with NF270 membrane (Dow Filmtec), at optimized temperature (50ºC) and pressure (10 bar) conditions, yielding a final product with cellobiose to glucose ratio of 21.1 (birch) and 20.2 (spruce). In case of enzyme mixture Celluclast®, the reaction engineering (pH, multi-stage hydrolysis with buffer exchange, addition of β-glucosidase inhibitor) yielded a cellobiose-rich product with a high cellobiose to glucose ratio (37.4) was achieved by utilizing organosolv-pretreated birch biomass. The hydrolysates were tested as fermentative substrates and were shown to be able to efficiently stimulate the growth of both *Lactobacilli* strains.

Conclusion

Our results demonstrate that controlled enzymatic hydrolysis, either by employing a mixture of processive cellulases or modifying the performance of commercially available enzyme cocktails, combined with product recovery and purification, can potentially support the sustainable production of food-grade oligosaccharides from forest biomass.

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Short presentation abstracts

Life cycle analysis for MSW disposal alternatives in Colombia: Definition of methodology and a case of study

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Abstract

Sanitary landfills remain the most common option worldwide to manage waste. In Colombia, final disposal of Municipal Solid Waste (MSW) in sanitary landfills is the dominant technological alternative. From the methodologies used for the evaluation of the environmental performance of MSW management scenarios, the most frequently used is the Life Cycle Analysis (LCA). Here we describe the process followed to select the methodology for the environmental evaluation of different technologies in Colombia, and discuss a case of study where it has been evidenced that moving from the traditional way of disposing off to biogas capture brings important environmental benefits. **Introduction:** A literature review was made to identify studies where LCA methodology for the management of MSW were used and consider final disposal in landfills, biogas collection, leachate collection and treatment. Within the possibilities some are well established, e.g. global warming potential (GWP), formation of photochemical oxidants (POF), ozone depletion potential (OD), terrestrial acidification potential (AP), aquatic eutrophication potential (EPT) and ionizing radiation (IR), and estimate the impacts associated with a good degree of certainty. Whereas others such as human toxicity (HT) and ecotoxicity (EH) have a high degree of uncertainty and little development for quantification and interpretation. **Problem:** Performing an accurate LCA requires contextualized information. There is a need in Colombia to evaluate the technical, environmental and economic performance to select the most viable technologies for the specific site options before its implementation. **Objective.** The objective of the research is to quantify the environmental impacts associated to different waste disposal strategies applied in Cali, as a tool to inform the decision makers. **Methodology:** The study was carried using Scopus data base during the years 2000 to 2018. Then, four scenarios of waste disposal for the city of Cali, Valle del Cauca, Colombia were modelled using LCA methodology in the software EASETECH. **Results:** Standardised results showed that environmental improvements were obtained when moving from traditional waste disposal technology to biogas capture and use. **Conclusion:** Through this research it was possible to determine the categories and quantify the impacts applicable to waste management in the Colombian context emphasizing the reduction of impacts when moving from the traditional way of disposing off residential waste to biogas capture and use. **Originality:** Through this research a

quantification of the environmental impacts of different scenarios for waste management in the city of Cali, Colombia was made, which constitutes one of the few works of this nature made in the Colombian context. **Limitations:** Information disperse which difficulted the assessment.

Keywords: environmental impact assessment, life cycle assessment, waste management.

Introduction

Sanitary landfills remain the most common option worldwide to manage waste. In Colombia, final disposal of msw in sanitary landfills remains the dominant technological alternative (DNP, 2016; Superservicios, 2018). Nevertheless, recent National Policy for the Integral Management of Solid Waste have included aspects of circular economy (Ministerio de Ambiente y Desarrollo Sostenible, 2019), which implementation is expected to bring benefits for the protection of human health, the environment and the preservation of natural resources. From the methodologies used for the evaluation of the environmental performance of msw management scenarios, the one most frequently used is the lca, a standardized methodology for studying environmental aspects and potential impacts during the life cycle of waste management (Boldrin et al., 2011; Icontec, 2006). Performing an accurate lca requires contextualized information. Given the multiple management options for msw, there is a need to evaluate the technical, environmental and economic performance to select the most viable technology for the specific site options. In this paper we describe the process followed to select the methodology for the environmental evaluation of different technologies in Colombia, and discuss a case of study as well as the main obtained.

Materials and Methods

The study area is a regional landfill located in the department of Valle del Cauca, Colombia, which serves to more than 18 municipalities, receives an average of 570 tons/day of waste with an active surface area of 19.8 ha to place near 1.3 million of m^3 of waste, and a further capacity of expansion of 57.55 ha. lca, a tool that allows the quantification of the environmental burden of different management alternatives, was used for the assessment of alternatives to manage msw in Colombia. A literature review was made to identify studies where lca methodology for the management of msw were used. The study was carried using Scopus data base through the years 2000 to 2018. Results are presented in Figure 1, where it can be seen the frequency of the impact categories studied. Modelling using EASETECH model version 2.3.6, a computer flexible model for the evaluation of the overall consumption of resources and environmental impacts generated by waste management systems (Ole Urup Anders, 2014), together with the Ecoinvent database. The scenarios modelled were: scenario zero: waste disposed considering technical criteria for the collection and treatment of leachate, however capture and management of biogas are not considered, scenario a) describes the current management of msw in Colombia, waste is disposed considering technical criteria for the collection and treatment of leachate with biogas capture and venting; scenario b) considers the management of msw through landfilling with infrastructure for the collection and treatment of leachate, biogas capture and burning, with no use of biogas for power generation; scenario c) considers the management of msw through a landfill with infrastructure for the collection and treatment of leachate with biogas capture and use for power generation. The functional unit defined was 1 tonne of fresh municipal solid waste disposed in the study area.

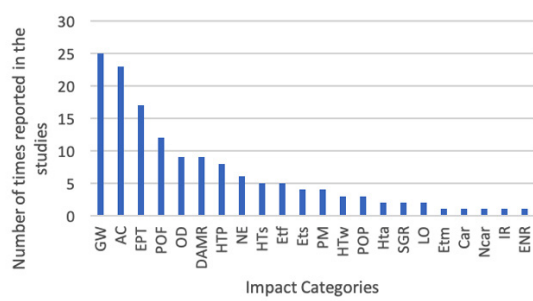
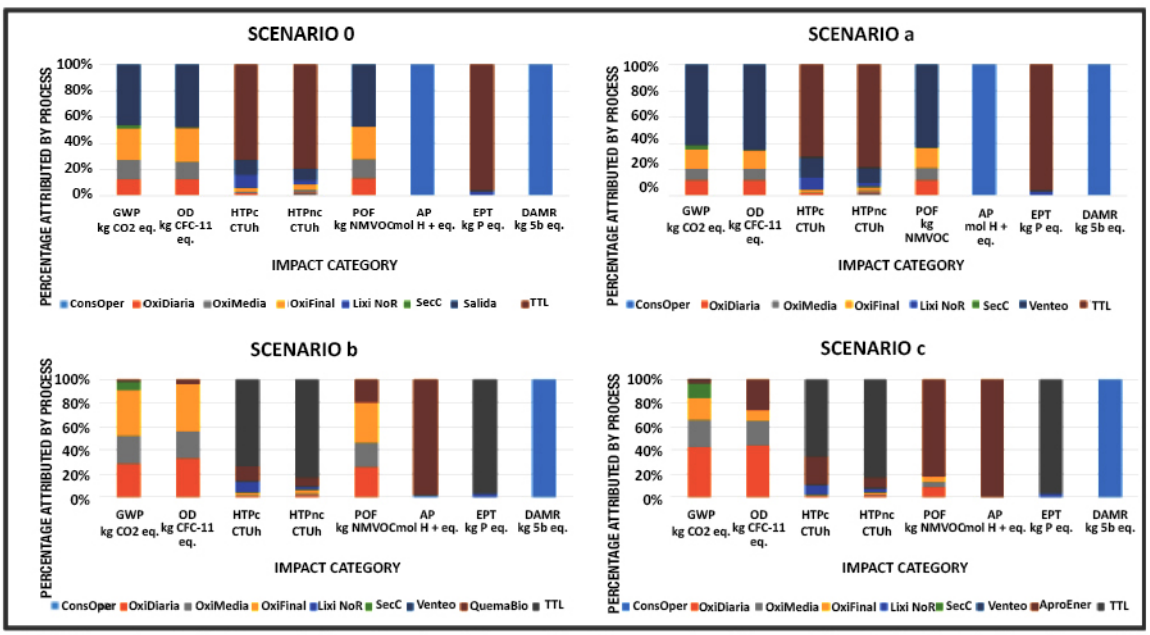


Figure 1. Impact categories frequency identified in lca studies. Source: own elaboration.

Results and Discussion

Figure 2 summarizes results obtained for each impact category in each scenario in terms of their impacts. For scenarios zero and a, biogas without output control is the process that most contributes to the impact categories gwp, od and pof. Leachate treatment is the process that contributes most to the HTPc, HTPnc and EPT categories; whilst the construction and operation of the landfill contribute to impacts related to the ap and damr categories. In scenarios b and c, methane oxidation by final coverage is the process that contributes most to the gwp, od and pof categories. Leachate treatment is the process that contributes most to HTPc, HTPnc and ept.



GWP, global warming potential, OD: ozone depletion, HTPc: carcinogenic human toxicity, HTPnc: non cancinogenic human toxicity, POF: photochemical oxidants, AP: terrestrial acidification, EPT: aquatic eutrophication, DAMR: abiotic resources depletion,ConsOper: construction and operation, OxiDiaria: daily oxidation, OxiMedia: oxidation due to middle coverage, OxiFinal: Oxidation due to final coverage, SecC: carbon sequestration, LixiNoR leachate no collected, Ventecx biogas venting, SalidaBiox biogas output, TTL: leachate treatment, QuemaBio: biogas burning. AproEner: energetic use.

Figure 2. Process contribution to each impact category. Source: own elaboration.

Conclusions

It was possible to determine that the categories of impact applicable to the Colombian context are related to those commonly reported in lca studies for msw management scenarios, thus allowing to be certain that the evaluation of environmental impact, considers the impacts identified and attributed to waste management. Impact categories such as climate change, acidification and eutrophication, represent a greater frequency in terms of reporting in lca studies. For this project a European method was used, thus demonstrating the commitment and progress that is made with this type of tools, such as lca. Achieving a harmony between companies and the state in the sense of environmental assessment, could represent an advance in issues of emission inventories, which allows to obtain robust and proprietary databases for the Colombian context.

Acknowledgements

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Numerical and experimental study of laminar burning velocity of syngas/methane mixtures using syngas obtained from biomass and coal gasification

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Abstract

We evaluated the effect of two different syngas compositions and syngas addition on the laminar burning velocity (S_L) of syngas-methane mixtures. The syngas obtained from biomass gasification has a composition of 20% H_2, 20% CO and 60% N_2. On the other hand, the syngas obtained from coal gasification has a composition of 40% H_2, 40% CO and 20% CO_2. Flames were generated using a contoured slot-type nozzle burner and the angle method was used to determine S_L. To calculate the flame angle, CH* chemiluminescence images were captured with and ICCD camera and processed using Matlab. Experimental results were compared against numerical simulations using the Gri-Mech 3.0 detailed mechanism. Good agreement between numerical and experimental results was obtained. It was observed that for all equivalence ratios, the addition of syngas obtained from biomass to methane strongly increases the laminar burning velocity compared with syngas obtained from coal gasification.

Keywords: biomass, coal gasification, methane, laminar burning velocity, syngas.

Introduction

Nowadays, there is a worldwide interest in developing alternative fuels, which is of great importance for countries and regions with reserves of biomass and coal. Synthetic gas (syngas, SG) obtained from the gasification of biomass and coal is considered to be one of the most promising alternative fuels in developed and developing countries (Arrieta, García, Yepes, Bedoya & Amell, 2019; Guo, Nie & Yu, 2019). However, depending on the type of reactor and the gasifying agent, syngas generally has lower heating values between 1.0 and ~2.6 kWh/m^3 and Wobbe index values between 1.5 and ~4 kWh/m^3, which are very low compared to the values for pure CH_4 (9.425 kWh/m^3 and 14.09 kWh/m^3, respectively).

A solution that has been proposed at a global level is mixing hydrocarbons with syngas to take advantage of the energy value produced by the hydrocarbons and the high reactivity provided by the H_2 as a syngas component (Lieuwen, Yang & Yetter, 2009). The characterization of this fuel mixture is of great importance in practical terms in order to evaluate its possible behaviour in

existing technologies, however, there is low information regarding to the combustion properties of this kind of fuels.

Laminar burning velocity (S_L) is one of the most important fuels and fuel mixtures property since it is essential for characterizing several combustion processes. Information on S_L is fundamental for the analysis of combustion phenomena such as flame structure and flame stability, and the validation of reaction mechanisms in the presence of diffusive transport at high temperatures (Burbano, Pareja & Amell, 2011a).

In the present study, we evaluated the effect of two different syngas compositions and syngas addition on the laminar burning velocity of syngas-methane mixtures. Here we focused our attention on syngas composition that can be obtained from biomass and coal gasification.

Materials and Methods

Figure 1 is a schematic diagram of the experimental configuration implemented in this study. The flames were generated in three contoured slot burners with different outlet geometries. The selection of the burner depends on the estimated burning velocity of the mixture, considering that the slot output speed is directly related to S_L. The contoured slot-type nozzles (13.8mm x 5mm, 21mm x 6.7mm and 29.8mm x 9.4mm) helps to reduce the effect of flame stretch and curvature in the direction of the burner axis. A contoured slot-type nozzle also allows to have laminar Reynolds numbers for all the equivalence ratios to be studied, as well as nearly uniform exit velocity profiles. Additionally, a cooling water circuit inside the burner keeps the mixtures at a constant temperature.

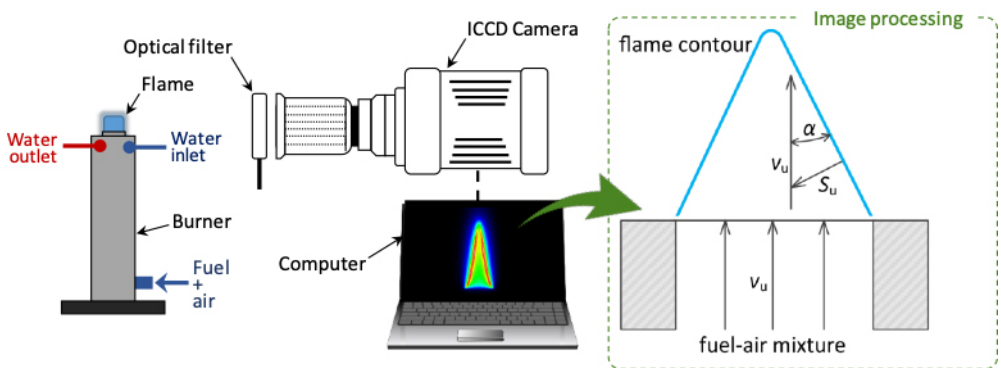

Figure 1. Schematic diagram of the experimental setup. Source: own elaboration.

Several lean and rich methane and syngas flames were generated in the burner described above. In the present study, we evaluated the effect of two different syngas compositions and syngas addition on the laminar burning velocity of syngas-methane mixtures (equivalence ratios between 0.8 and 1.4). The syngas obtained from coal gasification has a composition of 40% H_2, 40% CO and 20% CO_2 (syngas 1) and the syngas obtained from biomass gasification has a composition of 20% H_2, 20% CO and 60% N_2 (syngas 2). Each air-to-fuel ratio and exit velocity were ensured using rotameters that were specifically calibrated for each component gas, similar to those used in (Burbano et al., 2011a). The errors in the final composition were estimated to be lower than 2%.

The experiments were conducted using an ICCD camera equipped with a coloured filter centred at 430 nm, values of S_L were determined with the angle method and were compared with simulations performed with CHEMKIN PRO package using the reaction mechanism GRI-Mech 3.0. The digital photographs obtained by the ICCD camera are stored as a pixel array of 1024×1024. Then using a Matlab code a background image previously taken before experiments is subtracted and the flame is located where the maximum intensity is registered. The code detected the edges of the flame fronts, and thus the corresponding flame angles are calculated. The laminar burning velocity is related to the flame angle, α, according to equation 1.

$$S_L = V_u \sin(\alpha)$$

Where V_u is the mean velocity of the unburnt gases at the exit of the burner.

Results and Discussion

Figure 1 shows an example of flame profile obtained in the experiment for methane without addition of syngas at equivalence ratio of 1.0. The reaction zone is clearly visualized by means of an ICCD camera equipped with a colored filter centered at 430 nm and the post-processing technique is able to determine the angle of this profile to compute the flame velocity of this investigation.

The experimental and numerical results for laminar burning velocities using syngas obtained from coal gasification are shown in Figure 2. Equivalence ratios from 0.8 to 1.4 are located in x direction, and in y direction the laminar burning velocity in cm/s. As syngas contains hydrogen and the laminar burning velocity of this is very high, S_L is higher for mixtures with higher content of syngas. This increase can be explained by the addition of H_2 to the mixture due H_2 promotes formation of OH radicals increasing the concentration of H producing an increment of the reactivity of the mixture and consequently of laminar burning velocity (Cardona, Amell & Burbano, 2013). At the same time the addition of syngas generates that the peak of S_L moves to rich mixtures.

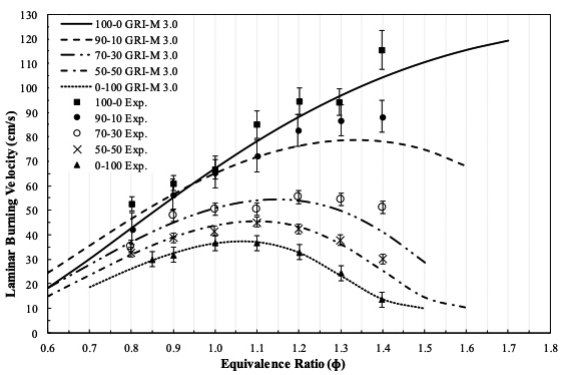

Figure 2. Experimental and numerical results for laminar burning velocities using syngas obtained from coal gasification. Source: own elaboration.

According with measurements the percent of increase in S_L peak from the mixture with 0% syngas to 50% syngas mixture is about 22 % which is in concordance with previous studies (Cardona et al., 2013; Burbano, Pareja & Amell, 2011b). And for this study S_L peak for the mixture with 90% syngas in content is 2.4 times S_L peak of pure methane.

Regarding with numerical results, Figure 2 shows good agreement between numerical and experimental data at lean conditions, however, GRI-Mech 3.0 underestimates S_L values for rich conditions especially near the maximum S_L value. This behaviour has been already registered by Natarajan et al (2005). For peak S_L, the maximum error between numerical and experimental results is 12%.

Figure 3 shows the experimental and numerical results for laminar burning velocities using syngas obtained from biomass gasification. For the syngas obtained from biomass gasification the addition of hydrogen to methane increase the laminar burning velocity considerably. The syngas 2 obtained from the biomass gasification has a minor content of hydrogen respect to the syngas 1 obtained from the coal gasification, therefore the percent of increase of the laminar burning velocity of syngas 2 for all equivalence ratios is less compared to syngas 1.

In fact, the percent of the increase in S_L peak from the mixture with 0% syngas 2 to 50% syngas 2 mixture is about 13 %, 9% less regarding syngas 1. S_L peak for the mixture with 90% syngas in content is 1.2 times S_L peak of pure methane, much less compared with syngas obtained from coal gasification.

Regarding with numerical results, Figure 3 shows a very good agreement between numerical and experimental data at higher H_2 contents and for all equivalence ratios. However, for 50% H_2 addition, numerical data does not fit experimental data very well mainly on rich mixtures. For peak S_L, the maximum error between numerical and experimental results is 9%.

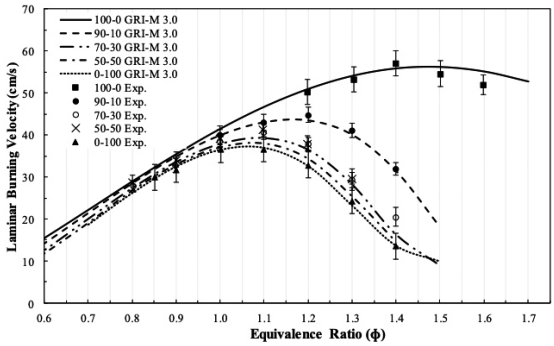

Figure 3. Experimental and numerical results for laminar burning velocities using syngas obtained from biomass gasification. Source: own elaboration.

Conclusions

Measurements of the laminar burning velocity of syngas/methane mixtures using chemiluminescence of CH radicals were made. Numerical calculations of S_L using GRI-Mech 3.0 were also performed to be compared with experimental results and a good agreement was found besides measurements agree with reported literature.

With the increase of S_L, for the syngas/methane mixture, the blow off tendency is expected to improve when compared to a flame of pure methane.

GRI-Mech 3.0 mechanism was in agreement with the experimental results. Numerically, small differences were observed between all mixtures for syngas obtained from coal gasification and syngas obtained from biomass gasification. The greatest deviations between experiment and calculations occurred at rich fuel-air ratios (ϕ > 1.1). However, future work should investigate additional mixtures to evaluate with certainty the effect of substituting syngas by methane.

The syngas 1 has a major laminar burning velocity with respect to the syngas 2 for all equivalence ratios; this behaviour is related to the hydrogen content, which increases the reactivity to the mixtures.

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Design of a prototype for energy harvest

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Keywords: alternating current, direct current, electromagnetic fields, radio frequencies, very high frequency.

Introduction

The energy harvest is considered as a process of capturing energy from natural sources that are accumulated and stored for later use. Bearing in mind that in the city of Neiva it is evident the amount of telecommunication antennas generating amounts of radiofrequency that could possibly be affecting the quality of life of its inhabitants. This problem is evidenced as an opportunity for its use within an energy harvesting system that allows collecting the amount of radiofrequency existing in the environment for its use.

Problem

In the city of Neiva there are 71 telecommunication antennas distributed in different communes, implemented without the application of decree 0162 of 2014. Research conducted by Tovar Pulido, Jara Mosquera & Díaz Perdomo (2015), of the antennas found, 83% fail to comply with the decree stipulated for its implementation, a situation that increases the risk to health due to the production of non-ionizing radio frequency electromagnetic fields (EMF-RF). At present, the electronic devices with which it interacts generate electromagnetic fields, being exposed to invisible contamination.

Another representative factor is cell phones that operate using Radio Frequency (RF) waves. These RF waves are different from the types of radiation (ionizing), such as X-Rays, gamma rays, ultraviolet light, which break the chemical bonds in DNA. RF waves at high levels can heat the tissues of the human body.

Objective

Design a prototype that allows energy harvesting at sites with the highest concentration of Radio Frequency (RF) waves in the city of Neiva.

Methodology

The research methodology for this process is qualitative. The energy harvest consists of the process of capturing small amounts of energy released by natural sources such as light, heat, vibrations, one of the objectives of energy harvesting is to improve the efficiency of the devices that are currently available, take advantage of the lost energy of electronic devices, capture these types of energy for accumulation and storage to have an energy source (Quilla, 2019).

One way to obtain constant energy in places where sunlight and mechanical vibrations are insufficient, is by collecting RF signals from various wireless communication systems. In recent years, being able to obtain clean energy through electromagnetic waves radiated by communications systems, in RF and microwave frequencies, has taken a big boost (Pavón, Ambrosio, Flores, Santiesteban, & Torrealba, 2016).

The main differential factor of energy collection by means of this method is that it is essentially free energy, as shown in Figure 1, RF-based energy harvest architecture and take advantage of the large number of antennas that the city of Neiva has. Figure 2 shows a map of Neiva with the location of the different RF antennas. The idea of energy harvesting through RF is to capture the energy of electromagnetic waves with the use of an antenna and convert it into direct current, so that it can be used to wirelessly charge different low-power devices such as the sensors.

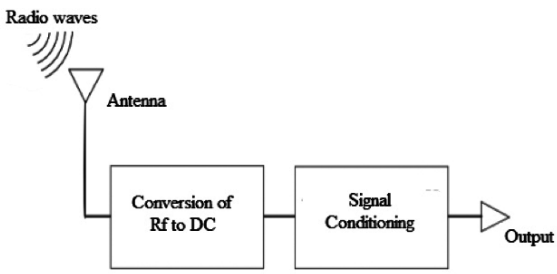

Figure 1. RF based energy harvest architecture. Source: own elaboration.

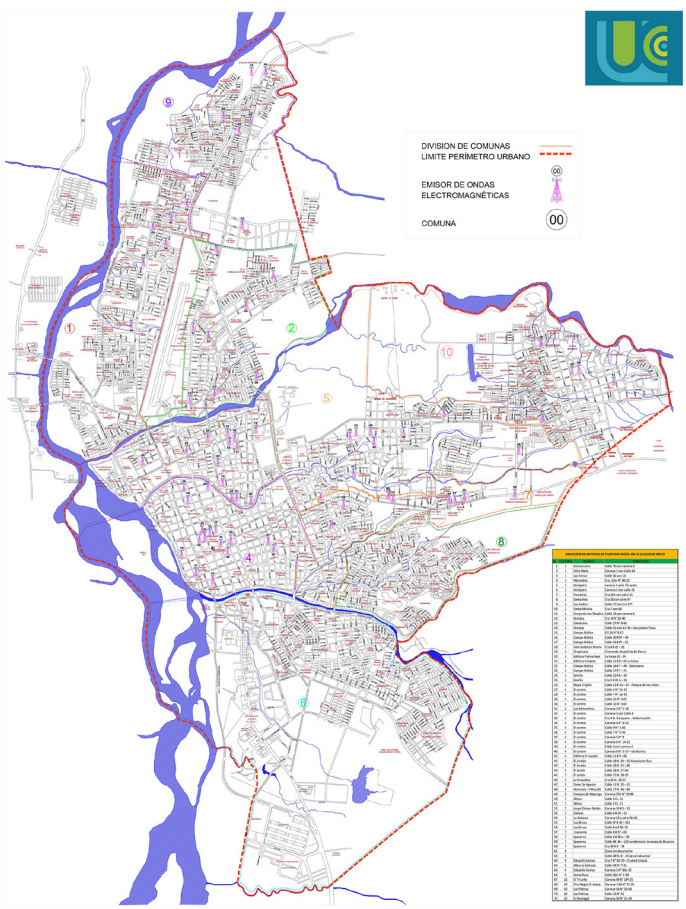

Figure 2. Map of Neiva with the location of the different RF antennas. Source: own elaboration.

There are devices on the market to carry out the energy harvest, a clear example are those offered by the Powercast company, specialized in this area, directly selling a kit with everything you need, which facilitates obtaining energy through the RF harvest.

Results

The expected result is a low-cost prototype that allows us to capture the RF and perform the energy harvest, for this, the following elements are needed:

*Antenna***:** It consists of receiving the electromagnetic waves of the air by means of an antenna and processing it until direct current is achieved. The RF are located in a range of 30 Hz to 300 GHz. Therefore, it is convenient to use an antenna that captures VHF (Very High Frequency) frequencies that occupies the range of these frequencies.

Capacitors: A capacitor, that is a passive component since it is not responsible for electrical excitation, but is used to connect active components and conserve energy. This allows you to support an electric field.

Diode: A diode, is a semiconductor device that acts essentially as a unidirectional switch for current. It allows the current to flow in one direction, but it does not allow the current to flow in the opposite direction. They are also known as rectifiers because they change alternating current (AC) to pulsating direct current (DC).

The operation of the device is based on the principle of the capture of electromagnetic waves through the antenna, said RF travels to the capacitors distributing the energy to the diodes, it is recommended that they be of germanium 1n34, the diodes convert the alternating current into direct current and deposit the voltage on the last capacitors for later use.

With the devices mentioned above you can build a circuit for the combine as shown in Figure 3 circuit architecture.

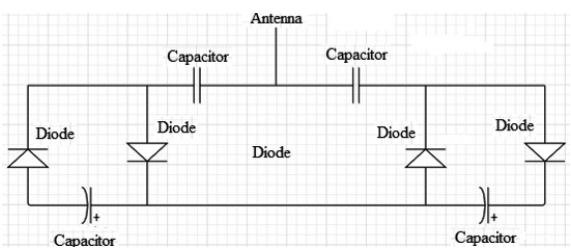

Figure 3. Circuit architecture. Source: own elaboration.

Conclusion

In the environment there are numerous RF electromagnetic signals, which have energy to be harvested and power low power devices. In addition, it benefits the process of generating clean energy.

Originality

It is considered to have the first community of researchers concerned with contributing to the generation of clean energy through energy harvesting in Colombia and especially in places where the radio frequencies emitted are evident.

Limitations

Ignorance in the generation of RF emitted by the devices and lack of appropriation of the community in its use.

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Validation of a dynamic model to represent thermal degradation of polymer binary mixes submitted through pyrolysis

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Abstract

This paper shows the validation process of a dynamic model proposed to represent the one-step thermal degradation reaction of individual components in polymer mixtures. It was used samples of Expanded Polystyrene, and Low-Density Polyethylene taken from common elements made of these materials for five thermogravimetric analysis tests. On the other hand, it was applied a procedure to obtain the parameters to model and to simulate the polymer mix thermal degradation process. The results of the simulation using the dynamic model proposed were compared to the thermograms of the five samples submitted to TGA tests. The simulation results showed a reasonable degree of approximation with a mean square error of less than 5%.

Keywords: polymer pyrolysis simulation, polymer thermal degradation, thermogravimetric analysis, dynamic model.

Introduction

Pyrolysis is an alternative to consider to treat waste not suitable for primary recycling. In this process, polymer chains are decomposed into another with smaller molecular weight. The resulting hydrocarbons can be reused as direct substitutes of fossil fuel or after they are submitted to some refining process (Abnisa & Wan Daud, 2014; Ahmad et al. 2015; Anuar Sharuddin et al. 2017; Chen et al. 2015; Miandad et al. 2017; Sharuddin et al. 2016; Wong et al. 2015).

The thermogravimetric analysis (TGA) or thermogravimetry is a technique that in which are studied the loss of mass of a plastic sample submitted to a regulated temperature program (García, Marcilla & Font,1995; Li, Gong & Stoliarov, 2015). That analysis is made in a thermobalance that contains technology and instrumentation to register the behaviour of the residual mass as a function of the temperature. The result is shown through a thermogram, which is a plot where the process behaviour can be interpreted. In TGA, it can have a complete and reliable register of the loss of mass, and the phase changes because there is the instrumentation of precision, and the sample size is small enough to the heat transfer can be uniform.

The main focus of this work is to validate a dynamic model proposed to represent thermal degradation. It is made a comparison between real data provided by TGA of binary mixes of plastic and the result of simulated thermal degradation obtained using a differential equation of the model for thermal degradation of the same plastics. A dynamic model for a specific plastic was developed in (Bellon Hernandez & Prieto, 2017), and this paper is a continuation extended for a binary mix. The polymers used in this study were Expanded Polystyrene (EPS) and Low-Density Polyethylene (HDPE). This paper is one of the products of an research project whose aim is to control the pyrolysis process of MPW. This stage corresponds to modelling and simulation of the thermal degradation of the plastic mixture.

Materials and Methods

The equation that expresses thermal degradation for each one of the polymers present in the mixture is:

$$\frac{dm_i}{dT} = A_i\left(m_i - m_{fi}\right)e^{-\frac{1}{2}\left(\frac{T-T_{fxi}}{\sigma_i}\right)^2} \quad (1)$$

All the terms in (1) are well explained in the paper that is part of this work (Bellon Hernandez & Prieto, 2017). Based on the results of the TGA for EPS and LDPE separately and as a mixture was obtained several parameters to a particular equation. These equations served as a started point to make a simulation on the Matlab Simulink environment. The data from thermograms for each sample were compared with the simulated results.

Results

Figure 1 shows the comparison between thermogram from TGA of a sample of LDPE plastic and the result of simulating the thermal degradation with the same mass and heating rate.

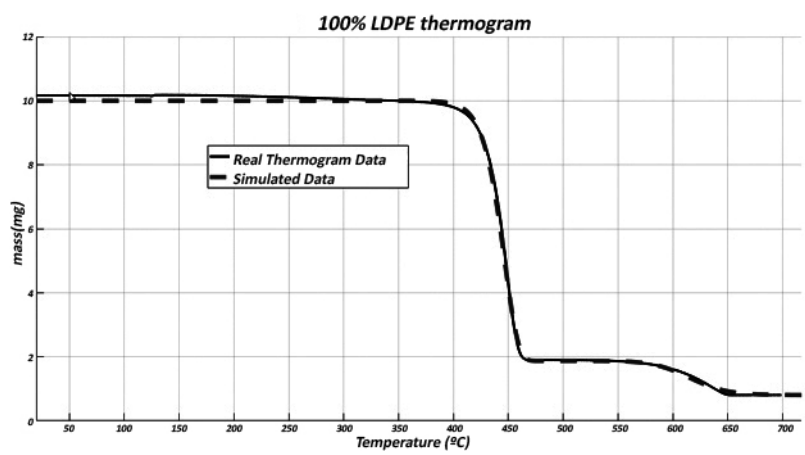

Figure 1. One of the results of comparing real data with those given by simulation. Source: own elaboration.

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It was executed 5 TGA for 5 samples of plastic: 100% of LDPE, 100% of EPS, 75% LDPE + 25% of EPS, 50% of LDPE + 50% of EPS, and 25% of LDPE + 75% of EPS. In each case, the result of the simulation was well adjusted to the thermograms obtained from the real TGA.

Conclusions

The thermal degradation process of LDPE and EPS mixtures can be represented as the sum of the individual one-step degradation reactions modelled through the general equation (1). The results of the simulation well approximate the loss of mass of the real samples submitted to TGA tests in all the temperature range of the process. Consequently, it is not necessary to segment the process into sub-ranges to look for parameters in each one of them.

The usefulness of this model is that it presents a good approximation in all the temperature range in which the process works. For control applications, it is advisable to have a model that can be used as a reference in all the points of the process. In this way, predictions about thermal degradation and mass loss can be extended over a broader time window. In order to make a reliable prediction, it is also necessary to have a precise characterization of the raw material.

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Pilot-scale assessment of biohydrogen and volatile fatty acids production via dark fermentation of residual biomass

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Abstract

This paper determines the hydrogen and volatile fatty acids (VFA) production from a dark fermentation (DF) process in a pilot plant, using residual biomass available in Colombia. The biomass used as substrates: pig manure (PM), coffee mucilage (CFM), and cocoa mucilage (CCM). Based on the physicochemical characterization of the substrates and the inoculum, the experiment was carried out using an organic load of 10g VS, S/X ratio of 1:1 and a C/N ratio of 35. The pilot plant was operated under mesophilic conditions (35°C), a pH of 5.5, and a working volume at 80% of the reactor capacity, corresponding to 4L. The cumulative bio-hydrogen production (CHP) was 3674,021 mL H_2, corresponding to 91.85 mL H_2/g VS, and the amount of VFA was 4952 mg COD/L. The removal of VS was 84.4%; this, together with the production of VFA, allows suggesting secondary processes associated with biorefinery schemes.

Keywords: bio-hydrogen, dark fermentation, pilot plant, volatile fatty acids.

Introduction

Biofuels can be obtained through biochemical processes, such as dark fermentation and anaerobic digestion, using residual biomass as the primary source for hydrogen and methane production. Countries like Colombia can benefit from this process, since part of the national territory is destined to agribusiness, representing 2% of gross domestic product (Perfetti et al., 2017). Currently, Colombia has enough residual biomass coming from agriculture and livestock sectors. Some residues, such as PM, CFM, and CCM, have a potential for the production of biohydrogen, biomethane, and value-added products (Hernández et al., 2018). Also, residual biomass such as cocoa and coffee mucilage are not being used in Colombian industry, despite being rich in sugars and carbohydrates, and susceptible of being employed in fermentation processes (Hernández et al., 2018).

In this study, bio-hydrogen production was evaluated in pilot plant batch reactors starting from a mixture of CFM, CCM, PM, and inoculum. As an additional consideration, physicochemical parameters of the effluents of the dark fermentation process are reported, considering that they have secondary metabolites and other products that can be isolated and evaluated, which promotes the economic viability of the process for the estimation of biorefineries schemes.

Materials and Methods

Previous studies over PM, CFM and CCM biohydrogen potential (Rangel et al., 2020) were used to determinate the following operative conditions: organic load 10g VS, S/X ratio 1:1, mesophilic condition (35°C), C/N ratio 35, pH 5.5 and stirring speed of 80 rpm. The experiments were based on the physicochemical characterization of the substrates.

Substrates and inoculum

The CCM was collected from a medium-scale traditional farm placed in Carmen de Chucurí, Santander. The CFM was collected during the mechanical demucilaging process at a private farm placed in Las Herreras, Teruel, Huila. The PM was obtained from Agriculture Research Center Marengo (C.A.M) of the Universidad Nacional de Colombia located in Mosquera, Cundinamarca. The substrates were frozen at -4°C to avoid biological degradation after de assays.

Analytical Methods

The characterization of the substrates and the effluent were follow APHA and ASTM methods. The quantification of the volume of biohydrogen produced was performed by RITTER flowmeters (MiligasCounter - RIGAMO software), which allows the total gas measurement in real-time.

Results

The physicochemical characterization of the substrates was carried out as a basis for the calculation of the volume of substrates and inoculum to be added in the reactor. Table 1 shows the results of the characterization.

Table 1. Physicochemical characterization of substrates and inoculum.

	PM	CCM	CFM	Inoculum
TKN (%w)	2.07±0.15	0.56±0.20	0.058±0.050	N/A
TS (%w)	29±0.3	19.7±0.5	2.1±0.87	5.6±0.56
VS (%w)	22.92±0.34	19.19±0.43	1.82±0.75	4.94±0.38

Source: own elaboration.

The pilot-scale performance was evaluated in terms of H_2 and VFA production. After a batch operation of 11 days, the CHP was 3674.02 mL, corresponding to 91.85 ml H_2/g VS. Figure 1 shows the cumulative hydrogen production after the fermentation time, a system stabilization is distinguished, as the standard deviation decreases with the days (9 to 6 percent), due to microorganisms growing efficiency at the consumption of the substrates.

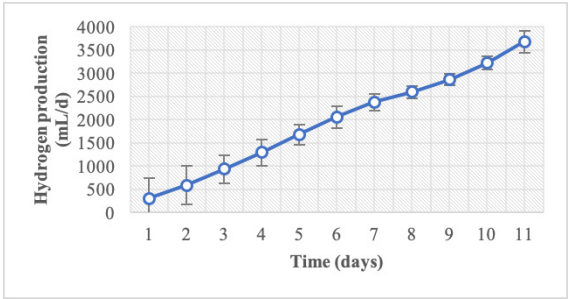

Figure 1. Cumulative hydrogen production after the 11 days of fermentation. Source: own elaboration.

Regarding the VFA production, it is seen a positive progression over the production until day 10, raising above 4900mg COD/L, where it decreases to 4400 mg COD/L (see Figure 2). The target also presented a decrease in VFA production, which is related to the beginning of the methanogenesis phase.

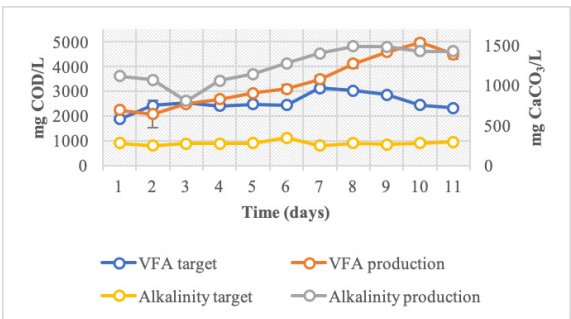

Figure 2. Volatile Fatty Acids production during the fermentation time. Source: own elaboration.

Discussion

As shown in Figure 1, after day 8, the target starts its methanogenic stage, it has no substrates, and the amount of carbohydrates is lower. The methane molecule has a higher mass than hydrogen and reflects an increase in biogas production. Therefore, at the end of the 11 days, the blank is more unstable and was intervened to maintain the pH at 5.5, using a higher amount of acid reagents.

Furthermore, Lin et al (2011) reported a bio-hydrogen production rate of 15.59 $m^3/m^3/d$ and a yield of 1.04 mol H_2/mol saccharose in a reactor with a working volume of 0.4 m^3, a stirring speed between 10-15 rpm, a temperature of 35°C, and an organic loading rate of 240 kg COD/m^3d, performing with saccharose as substrate. In this study, under the same thermophilic conditions and a smaller reactor, bio-hydrogen production remains positive with an increase in the last three days, recording a total production of 3674,021 mL H_2 after eleven days of fermentation. Also, from day 5, the relation of the data is close and is reflected in a standard deviation between 9% and 6%.

Vatsala et al (2008) reported a VFA production of 226 kg for a 100 m^3 reactor, given to soluble products such as acetate and butyrate. Besides, a total production of VFA between 10198 to 24418 mg COD/L, composed mainly of butyrate and acetate, with 44.4 - 53.2% and 21.3 - 26.4%, respectively (Lin et al., 2011). Lin et al (2010) applied a working volume of 400 L at a temperature of 35°C, reaching VFA production of 3102 mg COD/L.

Conclusions

When working with an organic load of 10gVS, S/X 1:1, C/N of 35, and the experimental conditions mentioned in the methodology, the cumulative production of hydrogen at the pilot-scale, was 4367ml H_2, corresponding to a yield of 109,175ml H_2/g vs. Likewise, this load presented significant progress for VFA production (4952mg COD/L); this presents an opportunity to carry out approaches to biorefinery processes, which allows the recovery of VFA, giving added value to the process, together with the fact of the use of agro-industrial waste through dark fermentation.

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Acid depolymerization of cell wall polysaccharides from Ulvan-rich extracts of green seaweeds

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Introduction

There is an emerging interest for marine biomass resources due to its unique and complex structures which serve as renewable sources for chemicals and polymers into a wide variety of applications. Seaweed polysaccharides (fucoidan, carrageenan, alginate, agar-agar, ulvan, etc) are bioactive compounds with therapeutic applications (i.e. antiviral activity, immuno-inflammatory or antitumoral among others). Ulvan is a structural sulfated polysaccharide from the cell walls of *Ulva spp* green seaweed *(Chlorophyta)* that contains mainly two types of disaccharides, ulvanobiuronic 3-sulfate type A and ulvanobiouronic 3-sulfate type B; containing L-rhamnose, D-glucose and D-xylose as sugars and D-glucuronic and L-iduronic as uronic acids (Tako et al., 2015) and represents about 8-29% of *Ulva spp* total dry weight. Ulvan can form thermoreversible gels, exfoliated complexes with clays, and its demonstrated biological properties are valuable form agricultural, food and pharmaceutical applications (Cunha & Grenha, 2016). However, there is not a clear consensus regarding adequate ulvan composition or analytical procedures. Therefore, the exact chemical structure and composition as well as the molecular weight of ulvan is not well-known (Pankiewicz et al., 2016). These parameters directly affect the biological activity and the physic-chemical properties of the different ulvans isolated from *Ulva spp* seaweed cell-wall which is crucial for meeting the required specifications of each final application (tissue engineering, skin care, pre-biotics, etc) of the different potential markets (cosmetics, nutraceutics, pharmaceutics). In order to study the chemical composition of ulvan, different depolymerization methods can be used. Most widely used in the literature for ulvan-rich extracts depolymerization is methanolysis (Costa et al., 2012; Pezoa-Conte et al., 2015). Nevertheless, in a previous study, authors studied three different methods for depolymerization of Ulvan-rich extracts from *Ulva rigida* (methanolysis, mild acid hydrolysis -hydrochloric acid- and strong acid hydrolysis- sulfuric acid) and the highest sugar conversion was observed under mild acid hydrolysis (Macías et al., 2019). For this reason, the main goal of this research is to study the acid depolymerization of the cell-wall polysaccharides of *Ulva rigida* with HCL under different conditions and the quantitative analysis of the neutral and acidic monomers.

Materials and Methods

Ulva rigida provided by Investalga Ahti S. L. company was three times washed with ultrapure water, oven-dried and milled. Then, extraction of the sulfated-polysaccharides was done by hot water extraction. After that, ulvan-rich extracts were separated from the spent green seaweed, filtered, centrifuged (30 min, 5000 rpm) and supernatant was oven-dried at 105ºC until constant weight.

HCL at three different concentrations (0.5 M, 1 M, 2 M) and three different temperatures (80ºC, 100ºC and 120ºC) were used in glass test tube digester. Depolymerization time was also studied. A total of 17 times ranging from 1 min to 24 h were carried out in triplicated. 10 mg of the dried extracts were weighted and mixed in a vortex shaker with 2 mL of HCL solution. All experiments were done in triplicate. Once the experiment is finished, 3 mL of ultrapure water and 200 µL of the pyridine were added at each tube to stop the reaction. Then sample vials of 1.5 mL are prepared using syringe filters of 0.22 µm.

Quantification of the depolymerized ulvan-rich extracts and the *Ulva rigida* was carried out by HPLC-IR with the column Shodex SH 1011 (300x8 mm, 6µm) under the method conditions found in the literature (Llano, Quijorna, Andrés & Coz, 2017). MWD was determined by HPLC-SEC-DAD using the column CHO-9231 Polysep-GFC-P 6000 (300x7.8mm). Sulfates were determined by using the sodium rhodizonate colorimetric method. Ash after 12 h at 575ºC and 900ºC in a muffle furnace were also measured.

Results

The chemical characterization of the cell-wall compounds of the *U.rigida* green seaweed was done. Cell-wall polysaccharides (CWPs) constituted between 38-54% w/w of the dry Ulva sp. The major CWPs fraction constituting 18-29% w/w of the green seaweeds is ulvan. Other CWPs are insoluble cellulose, glucuronan and xyloglucan. Molecular Weight Distribution of the extracts was also determining giving values of $3{\cdot}10^6$ Da which is similar from ulvan extracts provided in the literature ranging from $2.8{\cdot}10^5$ Da up to $1.6{\cdot}10^6$ Da (Champenois, 2009).

In order to study the chemical composition of ulvan-rich extracts, samples were depolymerized with HCl at three acid concentrations (0.5 M, 1 M and 2 M) and three temperatures (80ºC, 100ºC and 120ºC). Graph bars of all conditions assayed are shown in Figure 1, together with a plot graph of the best neutral and acid sugars conversion.

Maximum sugar conversion of Ulvan-rich extracts was achieved after 6 h of depolymerization via acid hydrolysis with HCl 2 M at 100ºC Hot water extraction method resulted in high yield of 54.0% and ulvan extraction efficiency of 96.6%.

Conclusions

Depolymerization of ulvan-rich extracts obtained after hot water extraction of *U.rigida* green seaweed was carried out by using HCL at different concentrations and temperatures. Neutral and acid sugars formation and degradation from 1 min to 24 h was determined to find the maximum conversion of the cell-wall polysaccharides extracted from the *U.rigida*. The highest sugars concentration (57.2%) was observed after 6 h of acid hydrolysis with 2 M HCl at 100ºC. Sugar conversion by acid hydrolysis was higher in comparison with methanolysis of the same *U.rigida* extracts where maximum sugars concentration of 34.7 % w/w was reached after 2 h of methanolysis (Macías et al., 2019).

Acknowledgements

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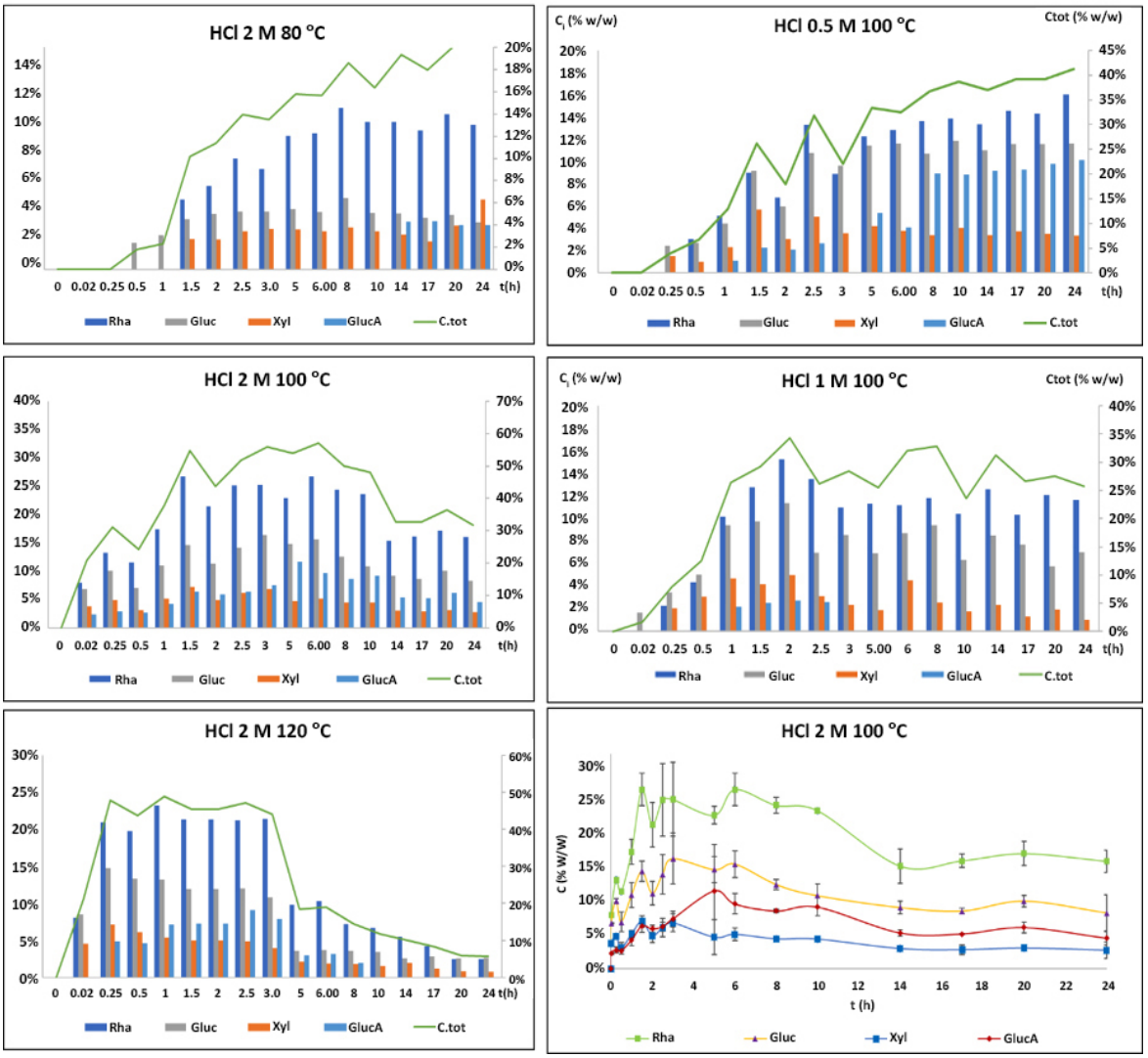

Figure 1. Schematic structure of the family of polysaccharides presented in Ulva sp. Source: own elaboration.

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Chapter 2. Renewable Energy, Water and Air

Keynote Speakers

Development and adaptation of the technology of air biotreatment in trickle-bed bioreactor to automotive painting industry

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Abstract

The automotive painting industry is a source of environmental pollution caused by Volatile Organic Compounds (VOCs) present in the discharged ventilation air. In order to respond to the demand for suitable engineering solutions, Ekoinwentyka Ltd. developed and adapted the technology of Compact Trickle Bed Bioreactor (CTBB) that had previously been applied in wastewater treatment plants. CTBB operating principle builds upon co-current downflow of the gas phase (polluted air) and liquid phase (solution of mineral salts) through a packed bed where active microorganisms are immobilized in the biofilm on the surfaces of packing elements. In the present paper, technology adaptation from pilot scale to full scale CTBB and its application in a painting shop are discussed. The size of bioreactor in pilot scale was 0.32 m in diameter and 1.50 m total height. The pilot scale CTBB is shown in figure 1.

It was packed with polypropylene Ralu Rings (15×15 mm) forming a bed 0.62 m high, which was inoculated with a consortium of microorganisms dominated by *Pseudomonas fluorescens* bacteria. During several months, an experimental programme was conducted to determine optimum parameters of the bioprocess, such as gas and liquid flow rates, and physiological parameters of biofilm formation and growth. Inlet and outlet VOC concentrations in the air were measured by means of gas PID and FID detectors. The flow rate of air drawn from the ventilation system of the painting shop was changed between 1.0 and 10.0 m^3/h, inlet concentration of VOCs usually ranged from 10 to 200 ppm and the flow rate of liquid phase was maintained in the range 1.0 to 3.0 m^3/h. By measuring VOC concentration in purified air, the efficiency of VOC biodegradation was found to range between 85 and 99%.

Figure 1. Photograph of a working pilot scale bioreactor. Source: own elaboration.

Air biotreatment system proved robust as the microorganisms were able to survive short-lived jumps of VOC concentration at CTBB inlet to 1800-2000 ppm. On the basis of pilot-scale experiments, full-scale CTBB was developed 2.8 m in diameter and 10 m total height. During test operation of the bioreactor in the ventilation system of the painting shop as shown in figure 2, gas flow rate fluctuated between 100 and 6000 m^3/h, and liquid flow rate - between 20 and 90 m^3/h. Test results confirmed VOC biodegradation at the level of 85-99% and demonstrated system ability to neutralize the effects of excessive foaming or unwanted pH fluctuation in the liquid, thus proving the success of CTBB technology upscaling and adaptation to the conditions of automotive painting industry.

Figure 2. Working CTBB during tests of bio-purification of air in real conditions of Enduser. Source: own elaboration

Aquatic renewable energy review and capacity building for energy and water production in Colombia

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Abstract

Aquatera has developed a comprehensive analysis of aquatic technology based solutions and capacity building in Colombia in partnership with Universidad Cooperativa de Colombia (UCC) supported by the UK Royal Engineering Academy and consortiums with the European companies Oceans of Energy and Elemental water Makers. **Problem:** Colombia is facing great challenges on the provision of safe, clean and affordable energy in accordance to actual climate change paradigm for millions of people that live in coastal urban areas and communities. The Aquatic technologies development represent an opportunity to deliver green technology based solutions as well as strengthening a new local industry based on knowledge. **Objective:** To provide UK lessons learned on the enablement of the aquatic renewable energy industry through supporting local capacity building in Colombia to assess own development of wave, tidal, floating wind, floating solar and river hydrokinetic technologies solutions for improving urban and community resilience towards climate change. **Methodology:** Deep analysis around resource characterization, regulatory framework, R&D, community needs and economic features focusing knowledge transfer through guidelines and workshops organized with the academia, public institutions and community in Colombia. **Results:** Outline opportunities, constrains and different steps that government, industry and the R&D community may wish to consider to enable and support the development of aquatic renewable energy projects. **Conclusion:** The studies have focus on supporting capacity building of a local development based on technology solutions and knowledge to improve access to high quality and reliable energy and water services under a climate change paradigm meeting the Sustainable Development Goals set by the United Nations. Colombia gathers all conditions to develop energy and water solutions for communities near the sea coast or rivers. In many cases this solutions may be more suitable than other technologies due to deployment and resource features. There is a special opportunity to develop solutions based on aquatic technologies for communities that are isolated, with no power grid connection or without access to clean water for human consumption, since it allows the use of local natural resources to provide basic needs that are not covered in the communities. **Originality**: Aquatic Renewable Energy technologies are an industry under constant innovation which

offers a new area of development based on secure and clean technology solutions for social development under the current world climate change conditions. **Limitations**: There is a lack of funding availability and specific politics set out to push for an Aquatic Renewable industry in Colombia.

Keywords: aquatic renewable energy in Colombia, capacity building, clean technologies, marine renewables, marine renewable energy in Latin America, NCRE.

Acknowledgments

Special acknowledgments to the Newton Fund of the British Embassy, the UK Royal Academy of Engineering and the Dutch Voor Water Partners which supported the development of projects developed for Colombia.

Geospace distribution of the pink shrimp *Penaeus notialis* (decapoda: penaeidae), in relation to environmental parameters in the Colombian Caribbean

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Abstract

The industrial shallow-water shrimp fishery in the Colombian Caribbean is an economic activity that began from the 1970s and had its biggest boom between 1985 and 1995. The subsequent increase in fishing effort led rapidly to overfishing and decrease in yields (kilograms/work). In addition to the overfishing, the fall in sales prices and the increase in operating costs, mainly due to the high price of marine diesel, which constitutes 84% of the total costs, led to the departure of many vessels. In the last 10 years, no more than 10 vessels remain in the activity and currently only 3 vessels remain in the fishery.

In order to be able to know the geospatial distribution of pink shrimp (*Penaeus notialis*) abundance and its relationship to the depth and distance of the coast in the Colombian Caribbean, a fishing exploration cruise was carried out for 25 days in September 2013, in which 64 fishing trawls were carried out throughout the Colombian Caribbean. As results it was determined, through geostratatic methods, that the highest biomass values were found in the southern part of the Colombian Caribbean, with a small aggregation in Punta Gallinas, and a large aggregation from Cartagena to the Gulf of Urabá. The average biomass for *P. notialis* in the north was almost half (55.48 kg/km^2) than biomass found in the southern area (87.87 kg/km^2). The total biomass in the north was 207,718.07 kg (CV 21.33) and in the southern area was 1,674,862.19 kg (CV x 11.47). Using the cumulative frequency methods, it was determined that the relationship between biomass of *P. notialis*, depth (m) and distance from the coast (mn) presented significant associations ($p < 0.01$). The highest biomass were associated with depth ranges between 31.33 and 45.23 m (maximum preference between 44.53 and 45.23 m), and the distance to the coast between 4.77 and 7.38 mn (maximum preference between 6.25 to 6.36 mn).

The ratio of the highest total length values for females and males showed preferences with depths between 31.33 and 42.93 m (maximum preference between 36.93 to 38.33 m) and distance to the coast between 6.25 to 8.46 mn (maximum preference between 6.74 to 7.12 mn).

Currently the shrimp resource presents a recovery of its abundances, but given the high costs of fossil fuels (marine diesel), it does not allow the activity today to be profitable, so it is necessary to search for the use of more energy-efficient vessels and if possible, the use of low-cost alternative energy.

Constructive alignment of sustainable resource developments with voice of 'Colombian coastal communities' with modern QFD

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Keywords: constructive alignment, modern QFD, sustainable energy, system of systems, water desalination.

Introduction

This paper describes the approach used in a new programme to develop sustainable resource system for use by coastal communities in Colombia. It also briefly describes how it is planned to develop a supporting community education programme for this system.

Problem

Due to their remote locations, many Colombian coastal communities face difficulties in accessing reliable, affordable electricity and clean water. These challenges undermine both local enterprise, educational development, and cause significant health dangers. As well as these challenges, sustainable resource developments need to be carefully addressed with local beliefs and mental models about land and resources to ensure engagement and uptake of developments by those communities.

Objective

To address these challenges, a new initiative led by UCC aims to develop a marine and solar renewable energy system integrated with a water purification system, i.e. a system-of-systems program designed to ensure engagement and uptake by the communities. In parallel, a 'whole-community' education programme will be developed to ensure communities understand system operation, maintenance and development.

Methodology

It is planned to apply methods to integrate both community and enterprise goals and stakeholder needs into the design and development of the sustainable resource system using methods that originated in 1960s Japan. These methods,

namely *hoshin kanri* or policy deployment, and quality function deployment (QFD), have been modernised to become more agile and are described in ISO 16355 (2015). They will be modified to ensure that, beyond capturing and integrating typical stakeholder goals and needs, community mental models and belief systems are also incorporated as illustrated in figure 1. This provides further critical context to support analysis and extraction of 'needs' which will drive the development of the solution characteristics and requirements.

The methods will also be integrated with constructive alignment methods (Biggs, 1996) that align the design of educational programmes to the desired learning outcomes and needs of the students to develop the supporting education programme.

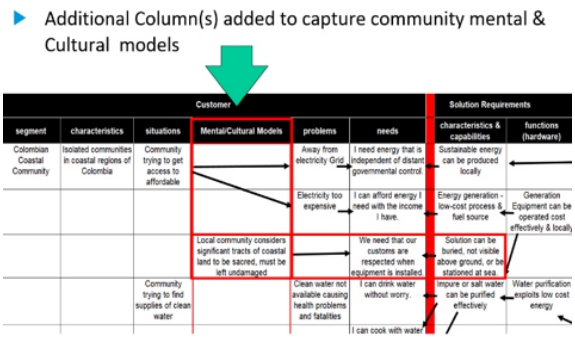

Figure 1. showing a modified 'Customer Voice Table'. Source: own elaboration.

Results

Initial research to understand community perceptions and responses to previous sustainable energy system developments have been conducted by Colmenares et al (2020). In addition, initial concepts have been developed for enhancing modern QFD methods to capture and integrate these aspects of specific community 'mental models and beliefs', and are being finalised along with integration with the constructive alignment approach to educational course design and development.

Conclusion

The collaborative, multi-project programme, is in initial phases and is already capturing and analysing information about attitudes of communities to sustainable energy developments. The identification of approaches and methods for understanding how stakeholder needs and priorities can be systematically embedded into detail system and educational designs is also well underway.

Originality

The overall programme aims to integrate development of education and technological systems that will underpin sustainable, community based capabilities and enterprise, is in itself a novel approach. This paper supports the overall project aim, extends the use of modern QFD methods and integrates these with the constructive alignment approach. This is a further original approach to ensure both the technological development of sustainable resource systems and community engagement and capabilities are developed simultaneously for the long-term, sustainable-deployment for the target communities.

Limitations

The programme is in initial phases so the deployment of the selected methods and approach has yet to be completed. Previous experience amongst the collaborators with the underpinning methods proposed gives considerable confidence to the likely benefits of this approach.

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Short presentation abstracts

Evaluation of the change of the electric matrix in Colombia: replacement of thermoelectric plants by non-conventional energy sources

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Abstract

Given the global concern about the effects of climate change, different international agreements have been carried out with the aim of reducing Greenhouse Gas Emissions. In this regard, when ratifying the Paris Agreement of 2015, Colombia pledged to reduce the emission of these gases 20% in 2030. This document evaluates the possibility of reducing the emissions generated by the country's thermoelectric plants by replacing them with technologies based on Non-Conventional Energy Renewable Sources within the National Interconnected System and some environmental implications that this would entail. An analysis of the technologies available in the Colombian territory was carried out and the emission factor area and land use that could be affected with the implementation of the technologies were compared, as well as the report on the emission reduction target agreed in Paris. It was found, among other aspects, that technologies with greater development in the country that can be implemented to perform the proposed replacement, would be wind turbines and solar panels, with which it would have a reduction in emissions equivalent to 17 and 19% of the goal set. The low implementation in Colombia of technologies based on Non-Conventional Energy Renewable Sources makes it difficult to obtain data and precision of the results.

Keywords: emission factor, greenhouse gases, non-conventional energy renewable sources, Paris Agreement, thermoelectric plants.

Introduction

The use of technologies based on Non-Conventional Renewable Energy Sources (NCRES) for the generation of electricity has been one of the strategies implemented worldwide to reduce Greenhouse Gas Emissions (GHG) produced mainly by the consumption of fossil fuels (Rodríguez et al., 2009). This article evaluates, from environmental engineering, the change in the electricity matrix in Colombia for the fossil fuel sources scenario by non-conventional energy sources, for which it is intended to establish the emission factor of the thermoelectric plants, to determine which technologies could replace them and to compare some effects of this change. This is due to the fact that the inclusion of these types of sources has gained strength with Law 1715 of 2014 in Colombia, which promotes the development and use of NCRES based technologies inside and outside the National Interconnected System (SIN by its acronym in Spanish), which is why there is a need to provide information that contributes to decision-making when proposing alternatives that meet the energy demand of the electricity sector, and to contribute to what has already been signed in the development of the global technological trend of Implement NCRES.

Methods

To know the equivalent CO2 emission factor of the technology to be replaced, the SIN power generation data were consulted between 2005-2017 (period of time in which the last events of El Niño were held in the country) to establish in which year the largest participation of thermoelectric plants was held and thus the emission factor was calculated (value that was used in the comparison, as will be seen later) through the "Tool to calculate the emission factor for an electricity system" method, a tool established by the United Nations Framework Convention on Climate Change (UNFCCC). Next, the approximate area of the thermoelectric plants that were used in the calculation of the maximum emission factor was established using Google Earth software.

To determine which technologies based on NCRES could replace technologies based on fossil fuel sources, a bibliographic review was carried out to find out what are the technologies that use unconventional sources of energy for the generation of electricity available in Colombia, considering if its technological concept is developed and if the political, historical and social context favours its implementation in the country. Once these technologies were determined, their emission factor was consulted in the literature taking as reference the technical characteristics of the Celsia Solar Yumbo farm, installed in the Valle del Cauca and the Jepírachi Wind Park installed in La Guajira.

To compare the effects of technological substitution; the emission factors consulted for the solar panel, the wind turbine and the one calculated for the thermoelectric plants were compared, and the contribution to reduce GHG emissions was determined as agreed in Paris in 2015. On the other hand, the approximate area necessary to implement the NCRES that supply the electricity generation of the year 2016 offered by the thermoelectric plants was determined, taking as reference the occupied area and the electricity generated by the wind farm and the solar farm already mentioned. Similarly, the possible location of these technologies in the country was established, crossing the digitized areas with the ArcGIS 10.5 software of the range of greatest wind and solar potential in Colombia, established in the Atlas Climatológico, de Viento y Radiación Solar de Colombia, carried out by Institute of Hydrology, Meteorology and Environmental Studies (IDEAM, acronym in Spanish), with the land uses present in the national land cover map 2010-2014 of the Rural Agricultural Planning Unit (UPRA, acronym in Spanish) carried out under the Corin Land Cover (CLC) methodology at a level 3 of detail, in order to establish the land uses that could be used for the implementation of these new technologies.

Results

CO2 equivalent emission factor of the technology to be replaced: It was found that, between 2005-2017 according to the latest El Niño phenomena recorded in the country, thermoelectric plants made a greater contribution in 2014, 2015 and 2016 with 29.6%, 31% and 28% respectively (XM S.A., 2017), due to the decrease in water in reservoirs. The year 2016 was taken as a reference for future calculations when presenting the highest emission factor, as shown in Table 1, although in 2015 the greatest amount of emissions to the atmosphere was recorded because

more was generated electricity with this technology. Regarding the area of thermoelectric plants in the country, it was determined that they occupy approximately 891.1 ha.

Table 1. High cost emission factors (No Low Cost / Must run) of the years with the highest thermal participation in the SIN.

Variables	Unity	2014	2015	2016
High-cost Thermoelectric Power Generation (No Low Cost / Must run) *	MWh	18.406.900	20.600.199	17.795.986
High-cost issuance (No Low Cost/Must run) *	tCO_2	12.137.201	13.840.880	13.148.709
Emission factor	**tCO_2/MWh**	**0,659**	**0,672**	**0,739**

Source: Own elaboration. Generated from data obtained from UPME et al. (2017). * The thermal plants considered low cost were not taken into account in the calculation.

Technologies based on unconventional energy sources that could replace thermoelectric plants: It was established that the solar panel and wind turbine technologies are those that present the complete innovation cycle in Colombia to make the comparison that is recorded below. Although the technologies that use biomass also comply with this cycle, they were not analysed because they contribute to the direct emission of CO2 during their operation and, on the other hand, they are mainly applicable to productive processes that seek to take advantage of agricultural waste.

Comparison of the effects generated by technological substitution: It was found that the land cover where it is possible to implement the unconventional technologies evaluated and that correspond to the areas with the greatest potential in Colombia, correspond to shrub (34.5%), bare and degraded lands (22.7%) and continuous urban fabric (5.6%) for solar panels and dense forest (22.17%); shrub (12.92%) and coastal swamps (10.95%) for wind turbines, percentages according to the total area in the country that has the greatest potential for each case. Table 2 lists the different parameters analysed for the comparison of the effects generated with the technological replacement of thermoelectric plants by NCRES, which are analysed in the next section.

Table 2. Parameters analysed for the replacement of thermoelectric plants in Colombia.

Parameter	Thermoelectric Plant	Solar Panel	Wind Turbine
Occupied area (ha)	891,1	19.413,81	1.808,03
Emission factor (gCO_2-eq/MWh)	739	60 - 73,2[1]	8,65[2]
Contribution to the Paris Agreement (%)	---	17,7 - 18	19,4

Source: Own elaboration. Generated from data obtained from Hong et al. (2016), Xu et al. (2018).

Discussion

As presented in Table 2, the area parameter allows mentioning that an area 2.03 times larger would be occupied with wind turbines and solar panels would require 21.79 times the area used by the country's thermoelectric plants. The difference is evident between the emission factor of the solar panel and the wind turbine with respect to that of the thermoelectric plants, because for each KWh of electricity generated with this conventional technology 739g $CO_{2\text{-eq}}$ are emitted, according to the factor calculations of emission made for the year 2016. This implies that by replacing the energy generated by the thermoelectric plants for said year, by energy generated by solar panels, they would stop emitting between 665 and 679g $CO_{2\text{-eq}}$/KWh, which represents a reduction between 90 and approximately 92%, while with wind turbines the reduction in emissions would be 730,35 $gCO_{2\text{-eq}}$/KWh, that is to say approximately

99%; these reductions are presented when considering the stages of greatest GHG emission for both thermoelectric plants and for solar panels and wind turbines.

Emission reduction with respect to the Paris Agreement: Analysing the previous results according to the commitment to reduce 20% of greenhouse gas emissions agreed in Paris, and considering that the country plans to generate a total of 335 million tons of $CO_{2\text{-eq}}$ by 2030 (García et al. 2015), it would be necessary to stop issuing a total of 67 million tons of $CO_{2\text{-eq}}$. In this sense, by replacing the generation that the thermoelectric plants had in 2016 by solar panels, it is estimated that they would be reduced approximately between 11,834,330.69 and 12,083,474.5 $tCO_{2\text{-eq}}$ per year from the moment it is carried out its implementation in the country. In the case of wind turbines, it is estimated that approximately 12,997,298.4 tons of $CO_{2\text{-eq}}$ would be emitted each year. That is, in 2030 the contribution to the Paris Agreement, in the case of solar panels, would be between 17.7 and 18%, approximately; while with wind turbines, the contribution to this commitment would be approximately 19.4%.

Conclusions

It was found that the non-conventional technologies with which the replacement of thermoelectric plants in the country could be carried out are solar panels and wind turbines. It would require approximately an area 2.03 times larger than that of thermoelectric plants in the case of wind turbines and solar panels would require 21.79 times this area. An emission factor of 0.739ton $CO_{2\text{-eq}}$ was determined in 2016 for each MWh generated with thermoelectric plants (No Low Cost), occupying an area of 891.1 hectares. The technological substitution proposed for the generation of electricity in the country would reduce the emission of GHG between approximately 17.7 and 18% using solar panels and 19% with wind turbines, according to the established target of 67 million tons of CO2-eq in the Paris Agreement.

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Mini-grids with distributed energy generation and frequency control: Six years of operational experience of a pilot project in Switzerland

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Abstract

A company developed a concept with a distributed mini-grid where different Voltage Source Inverters (VSI) and Current Source Inverters (CSI) where synchronized and controlled together. The system is based on a central inverter which provides voltage and frequency for the island grid (central VSI). Around this common point is the mini-grid: there are distributed inverter/chargers in all the different houses acting as current sources (distributed CSI). The operation of a pilot project in Switzerland for more than 6 years has validated the concept and provided a robust and stable solution over this time. Different operating modes and types of mini-grid users have been identified. A set of energy management rules has been developed for ensuring the successful operation of the mini-grid. The concept has been extended so other equipment could be integrated, such as grid-tied inverters, controlled deferrable loads, and smart meters for controlling loads. In addition, this project provided feedback for future research to improve the control and operation of similar systems.

Introduction

A community regroups 32 small buildings, historically used when livestock were at summer pasture, and currently used as summer cottages. These houses generally have electricity with individual solar systems: each house has its own solar PV generator, battery and inverter. Looking at the whole system, there is a lot of unused solar energy production and the global efficiency is very low. In a project to improve the electrification of this small community, the independent solar PV systems were linked together in a network of individual systems, with the goal of sharing advantages but not disadvantages, a specific energy management strategy is implemented in each individual inverter to decide when it shares energy or not with the other users. The novelty of this concept is based on combining individual systems, each with its own investment and interest, to share the common benefits together.

Concept description

The system is based on a central inverter which provides reference voltage and frequency for the mini-grid, a voltage source inverter (VSI). A low voltage (LV) single phase distribution line is connected to every house creating the mini-grid. The distributed inverters connected to this line act as current source inverters (distributed CSI), they synchronize with the mini-grid (central VSI) and feed or consume current from it, without modifying the voltage or frequency.

Energy Use Optimisation Respecting the Infrastructure Investments. Every user purchased their own private system (distributed CSI). By connecting to the mini-grid, every user maintains ownership of their system, including its benefits and responsibilities, but they can optimise their energy utilisation, allowing to increase the private investment (enlarge the private user installation) or to increase the common infrastructure (central installation).

Sharing Energy to Improve Global Efficiency. The optimisation of the energy use is achieved by: a) Maximizing the use of excess energy (feeding into the mini-grid the excess, if allowed), and b) Extending the energy resources exceeding the battery capacity and local power (taking energy from the mini-grid if allowed).

Adapted to Every User. The energy optimisation with three energy situations could be adapted depending on every user, application or demand: a) Consumer users, benefiting from the energy in the mini-grid (if possible) to consume directly or store for future use (if they have storage), b) Productive users, feeding the excess energy not self-consumed to the mini-grid. These users could have a system with or without battery, and c) Fully interactive with the mini-grid users, consuming their own energy plus energy from the mini-grid and feeding their energy excess to the mini-grid when their battery is full.

Increasing Global Self-Consumption - Reducing Battery Cycling. The goal is that every user maximizes its self-consumption reducing the battery cycling, but the excess or deficit of energy is shared in the mini-grid to optimise the global energy utilisation. The strategy is "Share the benefits, not the problems". The users energy needs are satisfied at least as well with the mini-grid as with an autonomous system.

The challenges

The project was conceived as a pilot project for demonstrating the feasibility of the technical solution. In addition to the technical challenges, the project faced other challenges coming from the project context.

A. Lack of Dedicated Communication Bus. Sharing energy requires a control strategy among the producers. Installing a dedicated communication bus would have added costs, complexity, and a higher probability of failure. In this project there is no dedicated communication bus between the centralized controller and each system. The solution uses a frequency control strategy where no separate communication is required.

B. Energy Availability Self-determined by the Users. Each user is independent and can decide at every moment how do they interact with the mini-grid.

C. Business/Management Model. While there is no established business model, there is a clearly defined energy management model defined as follows. The central unit was installed for the common benefit of the users, who contribute to its cost and maintenance. The energy exchange is not monetized according to an economic model.

The solution

The central VSI is the grid forming unit establishing the voltage, frequency and other grid variables. This is the common infrastructure shared by the community. The distributed CSIs are the user's private systems, they are synchronized with the mini-grid established by the central VSI and they are interactive with the grid in function of the frequency and the status of their batteries.

The central VSI sets the mini-grid frequency and slightly modifies it around 50Hz (or standard) to communicate with the distributed CSI. The frequency is a very robust information carrier, not influenced by the quality or distance of the distribution line. The voltage is set at the standard, the frequency varies between -4 and +8% of the standard frequency.

The central inverter sets the frequency according to its battery state, for example: a) f=50Hz, reference frequency, b) f>50Hz, central batteries are full/close to full near 54 Hz; a lot of energy available, and c) f<50Hz, central batteries are not full/close to empty near 48Hz; low energy status.

The distributed CSI can determine the approximate central VSI battery voltage from the measured frequency and compare it to their own battery voltage, thus determining if the distributed CSI has more or less energy than the central VSI. The energy management rules determine the behaviour of the distributed CSIs. Decisions are decentralized: each distributed CSI applies the rules for itself without knowing what the others are doing and without communication among the distributed CSI. The energy management rules were established such that the global system should work in a coherent way.

A. Type of Users/Actors. According to the project requirements and considering the previous energy management rules, the following mini-grid actors are defined according to the next figure.

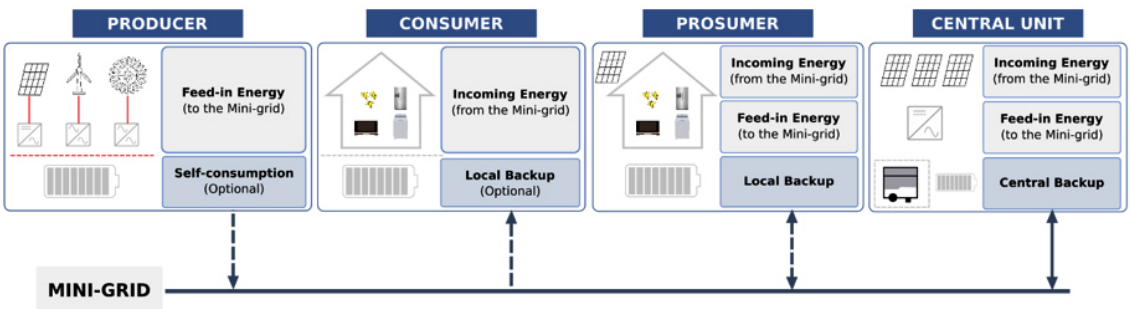

Figure 1. Type of Users/Actors. Source: own elaboration.

B. Interactive Frequency Control. The mini-grid function allowing to perform the interactive frequency control for the mini-grid.

1) The Central Inverter (VSI). The central VSI sets the frequency according to its battery voltage. The frequency of the mini-grid distribution line can be interpreted as the state of energy of the global system. The central battery voltage increases during the battery charge cycle. The frequency increases gradually starting at 50Hz and following the battery voltage until reaching 54Hz when the battery is fully charged. As the frequency increases, the distributed CSIs gradually reduce how much they feed into the mini-grid until reaching 54Hz, when there is no feeding into the mini-grid

The central battery voltage decreases as the battery is being discharged. The frequency decreases gradually starting at 50Hz and following the battery voltage until reaching 48Hz when the battery voltage reaches the low voltage disconnection value. As the frequency decreases, the distributed csis gradually reduce their consumption from the mini-grid until reaching 48Hz, when there is no consumption from the mini-grid.

2) The Distributed Inverters (CSIs). Reading the mini-grid frequency, the distributed CSI compares its battery level against the central battery level. This comparison determines the rules applied to the energy exchange in real time.

The behaviour of the system is represented in the figure 2, showing the state of the central VSI versus the state of the distributed CSI. This is represented with the frequency given by the central VSI and an equivalent frequency of the distributed CSI (representing the battery level after the frequency comparison). Each zone determine a rule to apply.

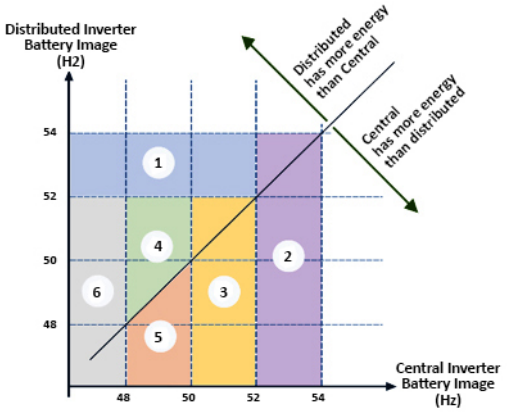

Figure 2. Energy Management Rules. Source: own elaboration.

Zone 1: The distributed battery is fully charged. The central battery is not fully charged. The distributed CSI will feed all the energy excess into the mini-grid. This energy will charge the central battery and/or be used by other users.

Zone 2: The central battery level is close to 100%. Feeding into the mini-grid by the distributed CSIs is limited.

Zone 3: The central battery level is high. The distributed CSI can use power from the mini-grid to supply its loads and to charge its battery up to the central battery level. In this zone the distributed CSI can take as much energy as needed from the mini-grid.

Zone 4: The central battery and the distributed battery are both at medium level, but the central battery level is lower than the distributed battery. The distributed CSI can use power from the mini-grid to supply its loads but not to charge its battery. The energy taken from the mini-grid is limited to the user quota. When the quota is reached the distributed CSI will operate autonomously, using energy from its battery.

Zone 5: The central battery and the distributed battery are both at medium level, but the central battery level is higher than the distributed. The distributed CSI can use power from the mini-grid to supply its loads and to charge its battery up to the central battery level. The energy taken from the mini-grid is limited to the user quota. When the quota is reached the distributed CSI will operate autonomously, using energy from its battery.

Zone 6: Battery security zone. The central battery is fully discharged, the distributed users disconnect from the mini-grid and keep operating autonomously (off-grid). This situation will not be reached when the exchange rules are correctly applied.

Conclusions

The mini-grid with interactive frequency control solution has been successfully implemented and the most important advantages from this solution compared to the situation before the mini-grid was created are:

The mini-grid solution allows to go beyond the traditional centralized system power by adding more distributed power on the mini-grid at any time, and benefit from the larger-scale of the project (logistics, transport costs and lobby for regulations, among others)

The solution is reliable and robust, in case of a problem in the central unit, the rest of the users are independent and able to keep their energy consumption with their own system. In case of a problem in one of the user's system, the rest of the users and the mini-grid keep operating at full capacity.

The high flexibility in the configuration and adaptability to future demand leave ample room for upgrades in the system, either at the central and private levels. Each user can increase their system in three variables: energy production (solar), energy storage (battery) and power (inverter).

The fact that there is no dedicated communication bus implies no data management and no centralized supervisor or intelligence to manage the system. The distribution line through the frequency is the carrier of the information resulting in a very robust and straight forward solution.

The solution is compatible with many different types of users, adapting the strategy for all user needs. Along with the project life, different strategies have been adjusted for the users, keeping the user autonomy and energy independency always as the key elements.

Teaching and learning styles for the design and application of curricular strategies in engineering towards a community-challenge based learning

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Abstract

This paper identifies the teaching and learning styles for the design and application of engineering curricular strategies towards a community-challenge based learning. **Problem:** Teaching and learning about renewable energies should be introduced in universities as a necessary tool for the development of critical thinking about the excessive use of energy sources, based on an effective solution starting from communities real problems. **Objective:** identify the teaching and learning styles for the design and application of engineering curricular strategies towards a community-challenge based learning. **Methodology:** The present study used a descriptive quantitative approach with a transversal design. Five professors and 24 engineering students from the Santa Marta, Medellín and Ibagué UCC campus were assessed through Honey and Alonso Questionnaire (CHAEA) to measure the learning styles (LS). On the other hand, for the teaching styles (TS) assessment, the Scale on Teaching Styles (ESEE) was used. **Results:** Taking into account the data analysed, it was found that the most prevalent learning styles among the selected students were: reflectors and activists. On what concerns about teaching styles, teachers with cooperative style were the most predominant. That evidences that the current study teachers stimulate teamwork. **Conclusion:** This paper aims to estimate the relationship between teaching and learning styles, community-challenge based learning and curricular strategies within the Universidad Cooperativa de Colombia that has a training based competency model. **Originality:** The most relevant value of this work is found in the usefulness of the data collected in order to propose actions aimed to improve teaching and learning processes for the designing and application of active learning-based engineering curricular strategies. **Limitations:** The search for future scientific databases should be expanded.

Keywords: curricular strategies, engineering, learning styles, renewable energies, community-challenges.

Introduction

Education has been considered as a process that contributes to both intellectual growth, as well as adaptation and development of social life, which is immersed by nature in the development of the human being (Burkhanova, Vaganova, Kutepov, Smirnova & Chelnokova, 2020). In turn, education plays a significant place in the development of a sustainable society, is a powerful agent of social change, raises awareness about new developments, provides training to professionals and researchers who will improve the next generation of high-tech systems and devices that will impact the development of renewable energies worldwide (Jennings, 2009; Lucas, Pinnington & Cabeza, 2018). From these social changes, many universities in the world are working to adapt to them, seeking a more flexible approach, and thus obtaining better results (Johnson, Adams-Becker, Estrada & Freeman, 2014). In this sense, people perceive and acquire knowledge in different ways, have ideas and think differently, which is why it is necessary to develop preferences towards certain cognitive, pedagogical and social strategies that contribute to give meaning to the new information acquired (Fraile-Calle, 2011; Kalkani, Boussiakou & Boussiakou, 2004). Therefore, individual features determine the variety of characteristics as subjects teach and learn, such differences can be psychological (motivation, attention, emotion, perception), sociological (empathy, isolation, collaboration, social interaction), environmental (family), school, church) and intellectual (creativity, ability to analyse, insight; Castañeda & López, 1992; Newton, 2015; Rodrigues & Mogarro, 2019). In addition, it is a key engineering competence to have the ability to solve problems in the field, accompanied by constant training. Requirements that progressively more associations, governments or even the graduates themselves consider necessary (Hassan & Puteh, 2017). Furthermore, active learning is a teaching approach that allows students to learn through critical thinking development of skills and problem solving, throughout the search for solutions to real life problems.

Materials and Methods

The present study used a descriptive quantitative approach with a transversal design (Hernández, Fernández & Baptista, 2010). Information concerning the teaching and learning styles was gathered from five professors and 24 engineering students from Santa Marta, Medellín and Ibagué UCC Campus. Honey and Alonso Questionnaire (CHAEA) was used to measure the learning styles (LS). It is an instrument consisting of 80 statements presented in the form of questions, 20 correspond to each of the learning styles: activists, reflectors, theorists and pragmatists. The rating system indicates that you must respond dichotomously: agree or disagree. In turn, the affirmative answers are added and the total score is obtained for each style and compared with the respective scales (Escurra, 2011). This instrument has been widely used to measure ls (Rodríguez, 2006), showing acceptable reliability, as well as adequate measurement stability over time (Juárez-Lugo, 2014). On the other hand, for the evaluation of the teaching styles (TS), the Scale on Teaching Styles (ESEE) was used, which consists of 31 statements followed by an estimation scale of four response alternatives that ranges from the total agreement "always" to the total disagree "never" including two intermediate stages "frequently" and "rarely." The instrument shows a total reliability of the Cronbach's Alfa scale of 0.886, which reflects an adequate internal consistency (Peiteado, Castedo & Juste, 2013).

Results

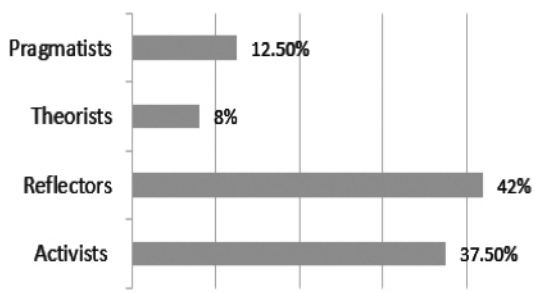

Figure 1. Learning styles. Source: own elaboration

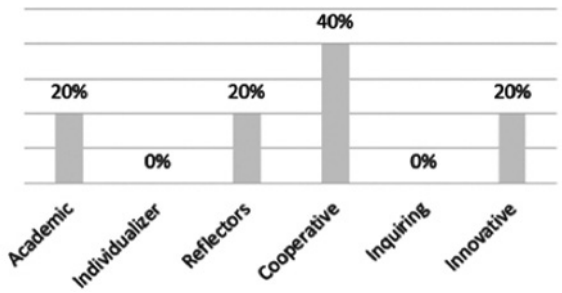

Figure 2. Teaching styles. Source: own elaboration

Taking into account the data analysed, it was found that the most prevalent learning styles among the selected students were: reflectors and activists (figure 1). That is to say that the assessed students were creative, methodical and comprehensive people. On what concerns about teaching styles (figure 2), teachers with cooperative style were the most predominant. That evidences that the current study teachers stimulate teamwork.

Discussion

Learning and teaching styles refer to the personal variables related between intelligence and personality, expressed in the different ways of approaching, planning and responding to learning demands (Camarero, del Buey & Herrero, 2000; Zatarain-Cabada & Barrón-Estrada, 2011). These styles are relatively stable, but can be transformed, serving as a tool for teachers in order to understand how their students learn and, in this way, modify or reinforce their own teaching style, which will have an effect on improving the learning process of student and therefore in greater academic success (Fernández, 2011; Maric, Penger, Todorovic, Djurica & Pintar, 2015). Thus, engineering is a dynamic discipline that requires people to work in other disciplines. Engineers have to adapt to new challenges day by day. Technical knowledge is needed, such as communication, leadership and interpersonal skills (Ruvini & Hamada, 2016). In consequence, active learning is a teaching approach that allows students to learn through the development of critical thinking and problem-solving skills, by searching for solutions to real-life problems. Transferring the teacher's total control of knowledge to a greater emphasis on the self-directed students' research (Du, Ebead, Sabah, Ma & Naji, 2019; Hasna, 2008; Moliner et al., 2018).

Conclusions

Finally, this paper is the first to estimate the relationship between LS and TS, community-challenge based learning and curricular strategies in a Colombian private university that has a training-based competency model. Therefore, this work's main value is found in the usefulness of the data gathered in order to propose actions aimed to improve the teaching and learning processes for the design and application of community-challenge based learning engineering curricular strategies.

Acknowledgements

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Evaluation of the tip speed ratio and power coefficient using a numerical study of a lift-based spherical turbine for in-pipe installation

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Abstract

The present article focuses on the numerical analysis of power generated and the Tip Speed Ratio (TSR) by a lift-based spherical turbine for in-pipe installation. The need and worry of mankind for electrical energy consumption, water-saving and distribution have increased over the years, and the current solutions for these needs have led to problematics such as in-pipe pressure regulation, which is wastefully mitigated. Consequently, the objective of this research is to evaluate the relationship between the mechanical power generated by the turbine and the Tip Speed Ratio (TSR) using Computational Fluid Dynamics (CFD) simulation as a start-up to begin a future characterization upon this kind of turbines. Moreover, a lift-based spherical turbine has been modeled along with a symmetrical airfoil NACA 0020 and simulated in ANSYS CFX. It was found that the maximum power coefficient value lies at a rotational speed of 33,4 rpm. This research aims to contribute with the characterization of lift-based spherical turbines for in-pipe installation for small-size diameter conducts, where a more thorough investigation is to be done.

Keywords: CFD simulation, in-pipe turbine, micro-hydropower, spherical turbine.

Introduction

Electrical generation and water-saving have become over the years an important object of investigation as well as a major concern for mankind. As a consequence, the global investment in micro- and pico-electrical generation has increased because it is a free-emission energy source, sustainable and environmentally friendly. Although the drinking water industry in industrialized regions is one of the most energy-intensive hydraulic-wise sectors, the majority of its energy is consumed inefficiently (Carravetta et al., 2018). The above mentioned inefficiency is evident in the excess of pressure which is generated within the pipeline by gravity disposition designs and storage systems.

Then, pressure-reducing valves (PRVs) are installed in the pipelines to control the pressure variation, leading to a wasteful dissipation of energy (Morani, Carravetta, Del Giudice, McNabola, & Fecarotta, 2018). Therefore, nowadays various investigations have started to evaluate the feasibility, power harnessing possibilities, and reduction in pressure capability of axial and vertical hydrokinetic turbines, due to the continuous discharge offering to generate electricity around the year, 24 hours per day (Ramos, Mello, & De, 2010) and as an example, applications can be witnessed in the study cases of a spherical turbine for in-pipe installation of Lucid Energy company (Lucid Energy, Portland, 2016).

Besides, this research is motivated by the fact that there is a lack of investigation on the characterization of small-size in-pipe spherical turbines. Therefore, the scope of this article is to contribute to the academic literature on the lift-based spherical turbines for in-pipe installation, as well as considering the physical conditions of the pipelines of the Medellín city distribution system for a possible local application.

The main objective of this research is to evaluate the relationship between the mechanical power generated by the turbine and the Tip Speed Ratio (TSR) using CFD simulation as a start-up to begin an investigation upon this kind of turbines.

Methods

Geometry modelling

A similar spherical turbine was studied by (Oladosu & Koya, 2018), in which the initial turbine model was designed for a 100 mm pipe diameter. Based on this model, and the recommendations of the Lucid Energy patent (Schlaback, 2011), an upscaled turbine model was reproduced in ANSYS SpaceClaim for a 150 mm diameter pipe. This diameter along with an average fluid velocity of 2,5 m/s were chosen after a previous investigation on the distribution pipelines of EPM (Company responsible for the aqueduct in Medellín).

As for the geometrical details: first, a symmetrical airfoil NACA 0020 profile of the lift-based spherical turbine was modeled with 200 bidimensional generated points with a chord length of 17,22 mm, and then imported into the CAD (Computational Aided Design) software, which also it conserves its airfoil shape all along the longitude of the turbine blades; second, the spherical turbine is composed by 4 curved blades that follow a 180° arc from start to end, with an inclination of 27,05° with respect to the vertical axis, and the distance between the pipe wall and the blades at an equatorial level is 7,52 mm. Also, a hub cap was created at the top and bottom of the turbine with a 90,73 mm diameter, mainly to facilitate the mesh generation and to avoid fluid flow getting in recirculation when passing through the turbine. The turbine has an equatorial diameter of 134,95 mm, a shaft diameter of 6 mm and a height of 119,28 mm. Following, two fluid domains were created: the first one is the stationary domain, which is the pipe of 150 mm in diameter; the second one is the rotational domain, which is constituted by a sphere of 146 mm in diameter (rotational interface) that contains the spherical turbine. Figure 1 shows the main dimensions of the turbine at a), and at b) a 3D representation of the CAD design.

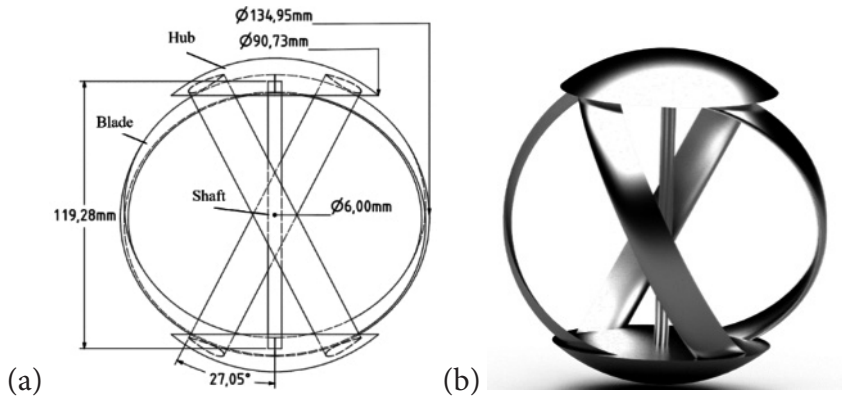

Figure 1. Design of the turbine. a) General dimensions; b) 3D design Source: own elaboration.

Simulation setup

The numerical simulation was carried out in ANSYS CFX. A steady simulation and frozen rotor approach were assumed adopting the SST (Shear Stress Transport) turbulent model, as other authors did with satisfactory results (Fleisinger, Vesenjak & Hriberšek, 2014). The volume domains were then discretized with a generated tetrahedral mesh, where the rotational domain was refined with a sphere of influence algorithm. The generated mesh has 593.314 elements and 112.491 nodes; a maximum skewness value of 0,813 in 34 elements; and a maximum aspect ratio of 12,6 in 2 elements. Following, three types of boundary conditions were defined: inlet flow velocity of 2,5 m/s, outlet static pressure at 0 atm, and a rotational domain set with various angular velocities starting from 1 rad/s. Furthermore, the rotational domain was placed at 1 and 3 hydraulic diameters from the inlet and outlet respectively. Figure 2 presents the assembly of the two volumetric domains along with the fluid flow direction at a), and a cross-sectional visualization of the discretized mesh at b).

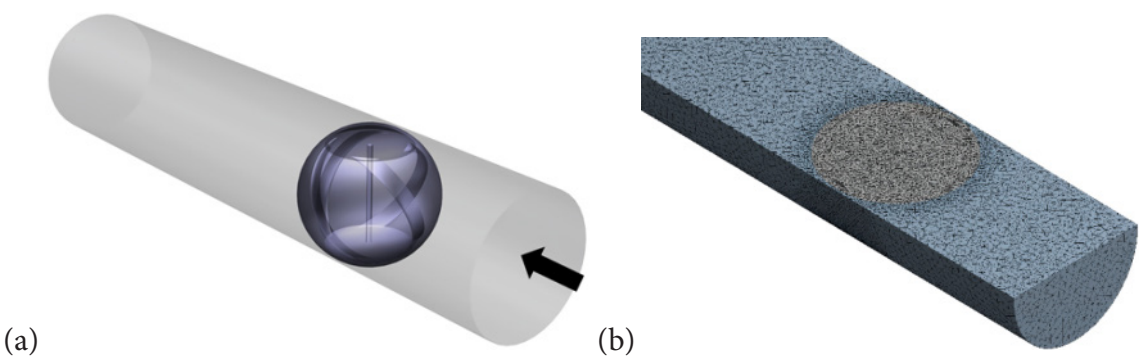

Figure 2. Volume domains. a) Rotational and stationary domain; b) Discretized mesh. Source: own elaboration.

Results

The Tip Speed Ratio λ is a ratio of the tangential velocity of the blade tips to the free stream velocity of the fluid. This parameter is paramount for turbine design because of its direct relation with the rotational velocity and the power extraction capability of the rotor. Then, the TSR is defined as:

$$\lambda = \frac{\omega r}{U_\infty}$$

Where λ is the Tip Speed Ratio, ω is the turbine angular velocity [rad/s], r is the turbine radius [m], and U_∞ is the free stream velocity [m/s].

Following, the power coefficient C_p is the percentage of power extracted by the turbine, and it is presented as a non-dimensional value for scaling and comparative purposes. The power coefficient is defined as follows:

$$C_p = \frac{\omega T}{\frac{1}{2}\rho {U_\infty}^3 A}$$

Where T is the torque [Nm], ω is the angular velocity [rad/s], ρ is the density of water [kg/m^3], and A is the swept area of the turbine blades [m^2], which for this turbine is πr^2.

Thus, figure 3 presents the relationship between the Tip Speed Ratio and the power coefficient for a constant free stream velocity of 2,5 m/s.

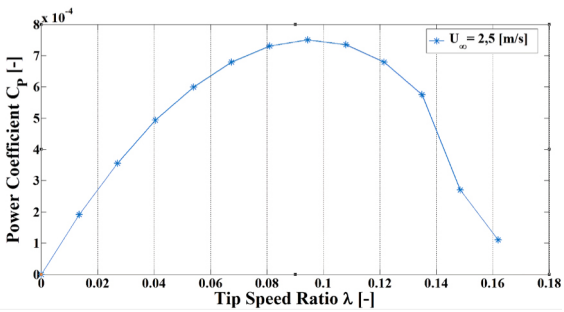

Figure 3. Tip Speed Ratio plotted against Power coefficient. Source: own elaboration.

Discussion

According to the results, a theoretical maximum C_p for a constant free stream flow velocity U_∞ of 2,5 m/s lies at a TSR of 0,09, held at a rotational speed of 33,4 rpm, which in turn yielded a mechanical power of 0,0836 W produced by a torque of 0,0239 Nm. The TSR and C_p relationship has been compared to an experimental investigation of (Bachant & Wosnik, 2011) on a similar spherical turbine, where an alike behaviour of these values where found. Additionally, C_p and TSR low values are believed to be so because of the refinement of the mesh, leading to possible loss of data during the simulation, especially at the rotating region. Moreover, the study has encountered some limitations, such as the impossibility to create a sizing method for the discretized mesh at the proximity of the rotational region as well as an inflation layer around the blades, due to its quality parameters degeneration when these methods were applied. Lastly, a more refined mesh of the zones of interest is recommended for future work upon this study.

Conclusions

A characterized behaviour of the TSR and C_p values were numerically obtained and behaviorally verified with other similar works for this specific lift-based spherical turbine for in-pipe installation. This result is then considered as progress on the characterization of this kind of turbines.

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Community-perception-based framework to design water-energy solutions: Case study from a Caribbean coast community in Colombia

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Abstract

The off-grid communities in Colombia are characterised by the diversity of their geography, socio-cultural contexts and structures of system. Despite their potential, the opportunities for access to energy and, therefore, other conditions to develop the education, productivity, health, technological projects and recreation are highly limited. Under those conditions, the implementation of projects with energy solutions based on renewable sources, would bridge the gaps of isolation and social marginalisation that have detained the future of these communities for years.

Projects with this aim, require the input of external actors to communities; but above all the complacency of its people to go towards the transition, from life styles in which energy has not played an important role to experiences could determine the transformations of their realities.

Achieving the confluence of interests among stakeholders involves dialogue and deepening the diverse ways of worldviews and the ethical perspectives regarding the use of natural renewable energy sources. It is also necessary to identify perceptions of confidence and risk of renewable energy projects. To design energy solutions according to the above, as well as highly sustainable, the framework "Community, water-Renewable Energies, Diversity" (CARED) is being developed, for which the first advance in its implementation is presented. The process has been carried out in Wayuu indigeneous community "La Paz" located nearby Manaure in La Guajira state in the northeast of Colombia.

Keywords: Community acceptance, renewable energies, diversity, social-environmental psychology, off-grid zones.

Introduction

The design of energy solutions aimed at communities far from urban centres, impoverished in economic terms, but with the richness of their socio-cultural constructs, worldviews, ways of establishing a relationship with nature; poses the challenge of understanding diversity in the fullest. That is, in the recognition that "diversity in the experience of the world is inexhaustible and therefore" (de Sousa Santos, 2017, p. 75) one could not intervene in these communities, with universal methods or solutions.

The intention of generating energy solutions for communities is governed by imperatives such as justice, equity, universal rights; however, its development and applicability depend on the particular human relationships between stakeholders; confidence in the process of discovering the outlines of the region's own problems and possibilities; the ability of the developers of energy solutions to build self-confidence in communities and transfer the knowledge for the empowerment of people in order to achieve stability the solutions created.

In this sense, this article sets out a framework proposal called "Community, water-Renewable Energies, Diversity" (CARED), in order to design of energy solutions for the Media Guajira area, municipality of Manaure, village of La Paz. This region is occupied by the Wayuu indigenous people, who retain their worldview and customs.

Firstly, it details the process carried out, so far, to structure the CARED framework and the content of the instruments for the production of information, oriented from the perspective of action-participation research.

Subsequently, progress is made in the implementation of this framework, which corresponds to the first visit to the community, to establish contacts with key information sources, generate initial conditions, not only for community demand of water and energy, but for empathy and trust, and raise a second visit for the exercise of surveying socio-cultural, productive, educational aspects, among others.

It is concluded that an approach to provide water-energy solutions that can be coupled with the rhythms, knowledge, internal dynamics of the communities, offers a better prognosis in the face of the relationship between stakeholders, feasibility and sustainability in the implementation of solutions created with community participation.

Methodology

The framework CARED is been developed from the perspective of action-participation research, which refers "to methodological conduct involving union between theory and practice, reflection, planning, action, education, transformation, individual and communal well-being, and social values" (Paredes-Chi & Castillo-Burguete, 2018). This is the following process: Figure 1.

Results

This framework has been implemented as follows:

Survey construction

Systematic mapping of public domain information

The first step was to obtain information and knowledge about the implementation of energy solutions, based on renewable energies of different types and in several countries and cultures. All of this information has fed the CARED framework.

Categories definition

The categories for the organisation, understanding, and relation of information in each community, according to the studies analysed and the experience of the team, correspond to the following aspects: sociodemographic, housing conditions, worldviews, social-cultural cognition, nature benefits among others.

Items construction

Based on mapping information, the experience of research peers in terms of community diagnosis, renewable and non-renewable energies, project development, education, among others, have been raised and developed each category that has been defined as necessary. The questions were formulated on open and closed-ended types.

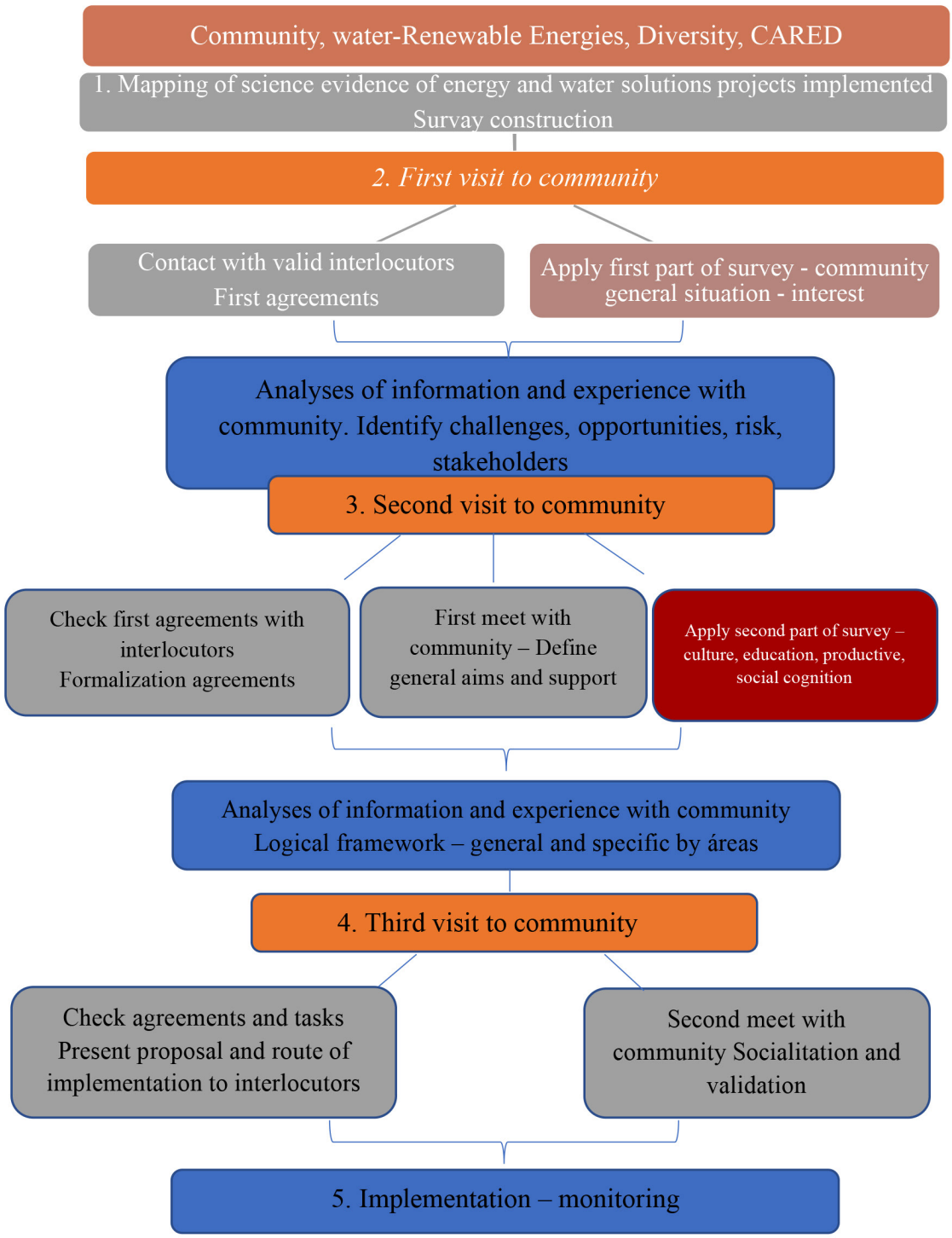

Figure 1. Framework "community, water-renewable energies, diversity" CARED. Source: own elaboration.

Methodology triangulation

Methodological triangulation by the researcher involves the theoretical and technical gaze of more than one researcher about a topic to work on. It is considered to occur when: "1) each researcher has a prominent role in the study; 2) the experience of each researcher is different; 3) the disciplinary bias of each researcher is evident in the study" (Arias, 2000, p. 5).

Implementation

A team of researchers in engineering and psychology of the UCC moved to La Paz, Manaure area, in order to develop the first steps of CARED framework.

First visit to the community

The arriving in La Guajira state allows observing the contrast between areas of enormous natural beauty with very important mineral resources such as coal and salt, a variety of thermal floors. The Media y Alta Guajira is the area with the greatest energy potential, with solar radiation levels of up to 6.5 kWh /m 2 in the summer season (Carvajal, 2018). However, it is also one of the areas of the country where the inhabitants have the greatest difficulty in meeting their most basic needs (Aaron, Solano, Choles & Cuesta, 2018). "The widest are La Alta Guajira with the Wayuu ethnic. It includes the municipalities of Maicao, Manaure, and Uribia" (Hoyos, 2016). The first visit to the community took place in the area of Media Guajira, municipality of Manaure. Those who attended the visit belong to the La Paz Ethno-Educational Center, which is located in the village of the same name. La Paz is one of the 9 villages in rural Manaure. According the educational project of the school, 90% of the children that attend are Wayuu Indians.

As part of the CREAD framework, the first visit to La Guajira has allowed seeing, at first hand, the difficult community conditions for access to water, which suffer its inhabitants and more intensely those who live in the highlands as is the case of La Paz, in the municipality of Manaure.

> For over a decade the Colombian the state of La Guajira has been suffering widespread malnutrition and premature death largely due to poor access to clean water for its poorest, most marginalized communities. The Wayuu indigenous group, the largest indigenous group in Colombia with over 200,000 members, have disproportionately suffered the consequences of this tragedy. (Avilés, 2019, p. 1750)

The minimum amount of water accessed by the community comes from jag-eyes (ditches) and groundwater wells that are located long distances from the family's room spots. Another part of the water is collected in rainy seasons or carried in tanks. The desalination plant is not in operation. Thus, the population can only use limited amounts of water to prepare food, bathe and irrigate crops (Daza, Serna & Carabalí, 2018).

On the other hand, limited access to electricity deepens the difficulties of overcoming the adverse conditions experienced by the communities of La Alta Guajira, in this case, La Paz, Manaure. The inhabitants of these territories must, periodically, purchase *diesel* tanks that are high cost, high pollution, limited efficiency, in order to minimally meet their electric energy needs (Rodríguez, Valencia, Rodríguez & Martínez, 2015).

Stressing the importance of access to electricity, focused on poverty reduction and the achievement of the Millennium Development Goals (MDGs) (Pinedo, 2010), much of this problem could be diminished if indigenous people had electricity. The water supply could be improved through the use of water pumps, the economy of communities would benefit by the conservation of their food, as well as the possibility of adding value to their artisanal and agricultural products. Hospitals could increase care coverage, education would improve in coverage and quality (for access to ICTs), among others (Ojeda, Candelo & Silva, 2016).

Carrying out the process of recognizing the territory from a perspective of community participation, is one of the critical moments of the implementation of projects with populations of all kinds, but significantly relevant when it comes to populations historically marginalized, isolated and socioculturally diverse. The method and technique for the construction and implementation of the diagnostic process can lay the groundwork for good further development of the project. It's a time when the developers of the project are also being tested with the community. It is the space-time to demonstrate honesty, clarity, genuine interest in support, capacity, and confidence in achieving the proposed goals.

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Opportunities for cross-fertilisation between the shipbuilding industry and the emergent offshore wind energy sector in Colombia: an overview of floating platform technologies

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Abstract

Introduction: This paper provides a review and analysis of cross-fertilization opportunities between the shipbuilding industry in Colombia and the Offshore Wind Energy (OWE) sector. **Problem:** In Colombia, there is an offshore wind resource available, so it is necessary to analyse the potential areas where national shipbuilding industries could take advantage of their knowledge and experience for the development of OWE projects. **Objective:** To identify the main aspects involved in the design and construction of floating platforms for Offshore Wind Turbines (OWTs) and to examine the restrictions and capabilities of the Colombian shipbuilding industry for their implementation. **Methodology:** A review of the technical aspects related to Floating Offshore Wind Turbines (FOWTs) and the integration of shipyards at a global level with the OWE value chain was carried out; subsequently, cross-fertilization opportunities between the shipbuilding industry in Colombia and the OWE sector were presented. **Results:** There are multiple areas in which the shipbuilding industry in Colombia could participate in the value chain of the floating offshore wind energy sector in Colombia, taking advantage of the knowledge and experience in topics such as shipbuilding, marine engineering, steelmaking, and construction techniques. **Conclusion:** The Colombian shipbuilding industry could enter new R&D areas derived from OWE projects, while its first-move would be in the design and construction of vessels for the installation, operation and maintenance of FOWTs. **Originality:** Through this investigation, the correlation between the Colombian shipbuilding industry and the emerging OWE market is identified. **Limitations:** At an international level, FOWTs are under development and testing. In the national context, currently there is not an established OWE sector.

Keywords: Floating Offshore Wind Turbines, Offshore Wind Energy, shipbuilding, shipyard capabilities.

Introduction

Nowadays, the Offshore Wind Energy (OWE) sector is experiencing increasingly rapid progress in the international arena. Among the currently available large-scale solutions to harvest energy from renewable sources, the Offshore Wind Turbines (OWTs) have responded to some of the challenges faced by earthbound applications, such as the land limitations for new deployments and the congestion of electrical transmission lines (IRENA, 2019).

As the OWT technology develops, it continues its transition to deeper waters where the conventional fixed-bottom foundations are not technically and economically feasible (Musial et al., 2019; WindEurope, 2017). This transition is enabled by the use of floating platforms, designed and constructed to provide a safe and reliable foundation for OWTs to be installed far away from the coast.

In a local context, although the wind energy generation is not yet widespread in Colombia, some previous reports indicate that there are available onshore and offshore wind resources along its Caribbean Sea coast, with a promising potential near to La Guajira region (Castillo et al., 2015; Rueda-Bayona et al., 2019). On the other hand, the Colombian government has started to promote the implementation of non-conventional energy sources through specific legislation (e.g. Law 1715 of 2014) and the awarding of five wind energy generation projects during the last energy market auction held in 2019 (Dinero, 2019). Therefore, it is necessary to explore the possibilities to take advantage of the offshore wind resource, starting with the design and adaptation of the existing technology to the Colombian conditions, in order to form an emergent Offshore Wind Energy Sector in this country.

Having this perspective in mind, the authors analyse the prospective areas where the national shipbuilding and maritime-related industries can leverage their knowledge and experience for the development of OWE projects involving floating platforms in Colombia. For this purpose, this paper presents an initial review of the technical aspects related to Floating Offshore Wind Turbines (FOWTs). Then, the integration of shipyards to the value chain of the OWE is explored. Finally, some opportunities for cross-fertilisation between the shipbuilding industry in Colombia and the OWE sector are discussed.

Review of floating offshore wind turbines (FOWTs)

The implementation of the first large-scale projects of OWE started in 1990 in Europe, specifically in the waters of the North Sea (Musial et al., 2006). Nowadays, some studies show the global cumulative installed capacity of OWE is within the range of 20 GW and 25 GW (IRENA, 2018; 2019; Musial et al., 2019).

There is a widespread agreement that one of the main drivers for the offshore wind industry is the requirement of accessing new areas with higher wind potentials (WindEurope, 2017). These can be found further from the coast, where water depths are usually greater than the limits for economically-feasible projects using the conventional fixed-bottom technologies (Musial et al., 2019). For this reason, in recent years there has been an increased interest in the design and development of floating systems for OWTs aimed to operate in deep waters (more than 60 m).

One of the main challenges for the implementation of FOWTs is related with the design and construction of the floating foundations. Figure 1 illustrates the most common floating structure solutions for OWTs: barge, semi-submersible, spar-buoy, and tension leg platform (TLP).

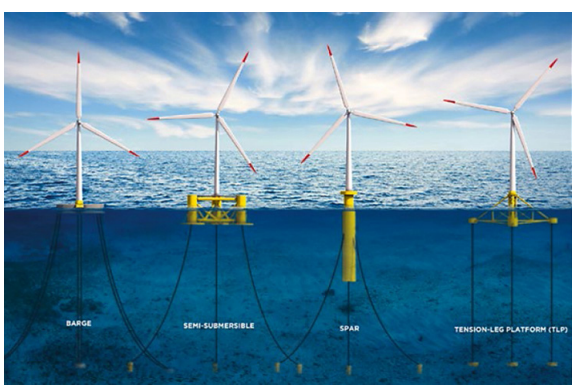

Figure. 1. Types of floating platforms for owts. Source: WindEurope (2017).

Potential synergies between the shipbuilding industry and the floating OWE sector

Due to their related technical background, ship design offices and shipyards have valuable know-how in cross-cutting areas for the FOWTs projects. These include, but are not limited to, naval and marine engineering, steelwork, outfit manufacturing, and corrosion management. In other words, the design and manufacturing of FOWTs requires traditional shipyard skills in large quantities, as well as the installation, maintenance, and further decommissioning of the turbines (Barry & Kamen, 2009). Hence, the different actors in the shipbuilding industry (e.g. shipyards, marine equipment manufacturers and suppliers, classification societies, marine and naval professionals) have a broad range of opportunities along the value chain of the FOWTs projects, as represented in Figure 2.

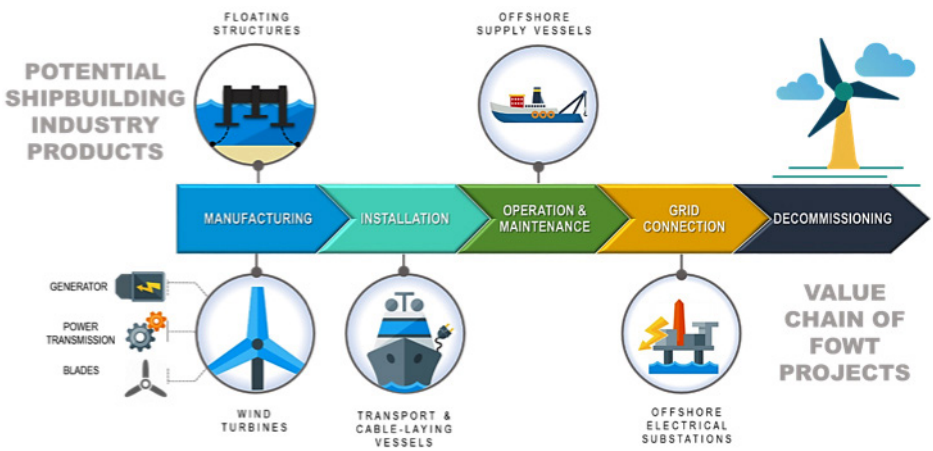

Figure 2. Opportunities for the shipbuilding industry in the value chain of FOWTs projects. Source: adapted from IRENA (2018).

Discussion: cross-fertilisation between the shipbuilding industry and the emergent FOW energy sector in the Colombian context

Bearing in mind the potential synergies between the shipbuilding industry and the floating OWE sector, it is possible to carry out a "cross-fertilisation" process where the existing knowledge, infrastructure, and methods of the shipbuilding industry can be integrated or adjusted to solve the specific requirements of the FOW energy sector, leading to diverse types of innovation. On the opposite way, the challenges posed by the FOWTs projects stimulate either the development of new capabilities in the shipbuilding and maritime industries, or the adaptation of the existing ones to be used differently.

Considering the current scientific and technological capabilities of the Colombian shipbuilding industry and the some of the R&D areas required for the potential implementation of FOW energy solutions in Colombia, the authors have identified prospects for cross-fertilisation between these two sectors. These interactions between the capabilities of the Colombian shipbuilding industry and the needs or requirements of the FOW energy sector are represented in Figure 3.

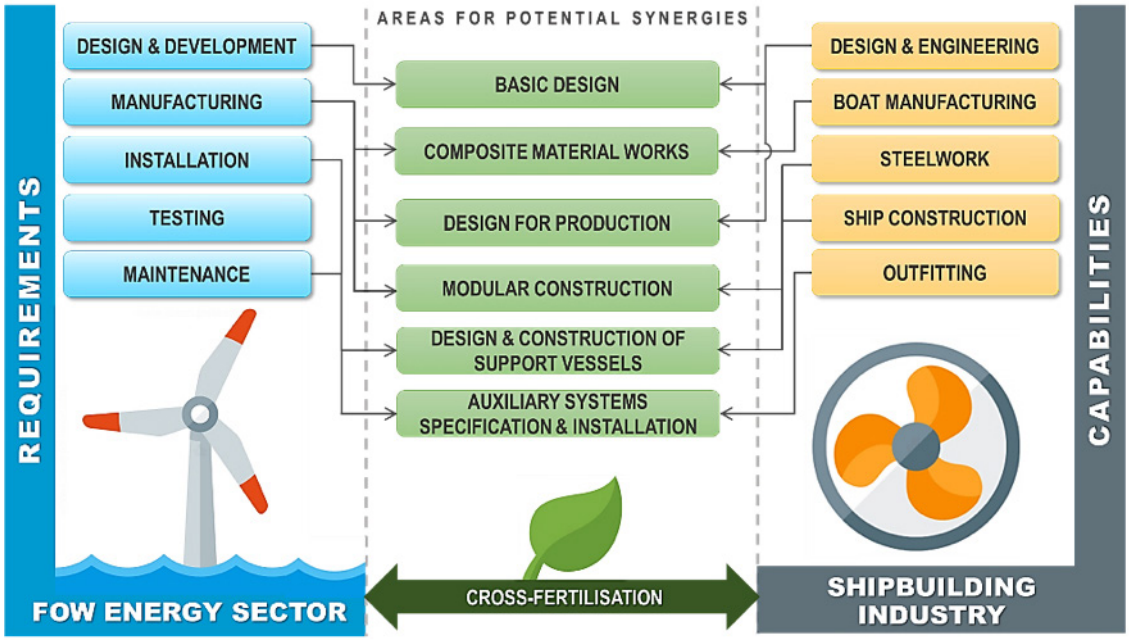

Figure 3. Areas for cross-fertilisation between the shipbuilding industry and the FOW energy sector in Colombia. Source: own elaboration.

Concluding remarks

Indisputably, the Floating Offshore Wind Energy sector shares a common technical background with the shipbuilding industry, with the potential to take advantage of a legacy of knowledge and experience in subjects as naval architecture, marine engineering, steelwork, and construction techniques for floating platforms. On the opposite way, the shipbuilding industry can strengthen its current capabilities by its participation in new areas of R&D derived from the OWE projects, gaining additional understanding of the interaction of the wind with a floating structure, which could lead to further optimisation of existing ship designs.

Although there are multiple areas where the shipbuilding industry in Colombia could participate in the value chain of the Floating Offshore Wind Energy sector in Colombia, it is foreseeable that the first steps in this industry would be related to the design and construction of vessels for the installation and operation/maintenance of the FOWTS, given the relationship of these activities with its core business.

Also, it is important to highlight the relevance of having technological partners to support the diverse processes throughout the value chain of the FOWTS. The triple helix model of innovation (i.e. academia, government, and industry) has been widely adopted in previous FOWTS developments worldwide. Therefore, is it recommendable to strengthen the synergies between these three actors in the Colombian context. A clear regulatory framework will also contribute to consolidate these synergies in the FOWT value chain, looking to achieve innovation through cross-fertilisation of the knowledge and experience of the different stakeholders.

Acknowledgements

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expressed in the paper are that of the authors and do not necessarily represent the views and opinions of COTECMAR or any of the members of the consortium for the development of the above-mentioned project.

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Micro hydroelectric with sustainable trout

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Abstract

The present work is part of micro generation. An attraction of this model (Micro hydroelectric with sustainable trout) is that it generates multiple benefits of economic viability and food safety with the least negative impact on the environment, planification that selected and developed easy acquisition structures and construction for vulnerable rural populations, being able to provide electricity from a small collection of water, which is a solution to the problems of fish farming. **Introduction:** This project is a product of the "Micro Hydroelectric with Sustainable Truchera" research, carried out during 2017 and 2019 in the municipality of Sevilla, located in the north of the department of Valle del Cauca. **Problem**: The lack of access to electricity in the rural sector of Sevilla, Valle del Cauca, likewise, also presents a high mortality in the trout crop population. **Objectives**: 1) Establish and carry out a diagnosis of ecological structures for the efficient use of water in the optimal production of fish farming. 2) Dispose and supply electricity to non-interconnected areas as an energy solution for rural communities. **Methodology:** A structural adaptation will be implemented geographically to apply sustainable environmental strategies, focused on the appropriate use of the water resource, in order to allow an easy implementation of a mini hydroelectric power plant (benefiting the population of Sevilla) and simultaneously guarantee the care of the ecosystem. **Results**: With the proposed model to solve the energy problems in the rural sector of Sevilla, it is expected to be implemented as a solution to the high mortality of the rainbow trout population (*Oncorhynchus mykiss*), improving their cultivation, and thus generating economic benefits and food security through clean and sustainable production complying with all environmental requirements. **Conclusion:** This project seeks to generate an electrical solution in non-interconnected areas, as well as to be able to provide a good production in fish farming in an optimal way, in order to favour the economic and social sustainability of the inhabitants of the rural sector of Sevilla. **Originality**: Through this research, the solutions to generate electricity are formulated for the first time and at the same time, the solution of the lack of oxygen in fish farming in the sustainable design and architecture of water resources management. **Limitations**: The budget is limited and there are certain difficulties in accessing this place, due to transport and mobility issues.

Keywords: eco, fish farming, micro hydroelectric, non-interconnected areas, *Oncorhynchus mykiss*, planning, rainbow trout, renewable energy, rural sustainability.

Introduction

In the fifteenth century, Leonardo Davinci designed techniques for harnessing energy, such as hydroelectric power. The further development of this technology is due to the British civil engineer Jonh Smeaton FRS (1724-1792) who first built large hydraulic wheels. In 1882, the world's first commercial hydroelectric power plant with capacity to light 250 lamps was launched in Appleton (Wisconsin, United States). It was the first technological step to use water as a source of energy.

This project is justified by its attendance to some sustainable development goals, like:

Materials and Methods

We need to first apply a description of the geographical system to size the water resource to our plans of 8 physical structures at different distances. As a result, we reach the correct implementation. This determines how much materials we will need, in this case: 90m of 8-inch tube, 12 clamps for 8-inch tube, 26m mesh gabion, two tanks of 500Lt each, 4 guaduas, 8 roof tiles, 3 metal structures, 1 generator, 2 pulleys, 2 pulley bands, pallet wheel , electronic transformer, electronic regulator, electronic voltmeter, ammeter, fuse, 50m 12 gauge copper wire, 100kl, 10m 1 inch tube, 10kl of fine grass, 40m plastic.

For the method of this project the following points were taken into account:

Fish farming: Collection of information on the characteristics of water and the height above sea level, a species of fish is defined that adapts in the sector; in this case it is the rainbow trout that gave us the guidelines for the design of the architecture of the structures of the project.

The geographical position and water resource: Having the main resource as water availability and the feasibility factor in inclination availability as the slope of the flow dropped by gravity for the adequacy of the project and connection distance factor as significant savings.

Viable space: In this way have a geographical perception of space to adapt and budget time and investment articulated with the environment so as not to modify the environment or pollute.

Design and Installation: Micro hydroelectric with sustainable trout is constituted for its best possible performance, to be able to supplement community needs that are those that give the design pattern with respect to the size and characteristics of vision. Basic projects of rural electrification with network extension can be carried out with joint populations where people live close to each other.

Ensure success: This inclusive activity, the installation must be done with the participation of the community and its commitment to work. In this way, the project can ensure residents' contact with all components and processes of construction and operation of the micro hydroelectric with sustainable trout. Only then will a true and effective technological and productive transfer be achieved for its sustainability.

Results

Results of this project that contains 8 structural models that work together.

Bocatoma: This model of easy construction with innovation of a continuous filtering stops solid waste, such as logs, large leaves, stones and a percentage 90% of the sand, etc.

doi: https://doi.org/10.16925/ecam.03

Sanded System: This model shows that the final percentage of solid waste that leaks from the hydrant has been evacuated, in this way these data give us confidence that stones or objects do not pass since the pipe can damage the pressure pipe and the healthiness of the trout.

Pressure pipe: A formula was used to determine the flow taking into account the density of the water and the temperature, because if the temperature changes, the trout would be in danger, this pipe is formed in two sessions. In the session A we have two pipes in parallel that supply the dewatering system with a length 34m and a 9m drop height gave us a flow 261,233854 L/s + 261,233854 L/s= 522.467708 L/s; where 103,752147 L/s remain in the continuous sandblasting operation. In session B, we had to supply the machine house with a length 50m and a height 30m of fall gave us a flow 418,715561 L/s.

Machine room: we used *guadua* as renewable material, tool and irreplaceable raw material. We set it as an example for sustainable architecture, excellent for the construction of our machine room, it is easy to acquire and the idea of its use is to protect this entire system of machinery from the rain and the outside environment.

Motor structure: Formula solution

$n1 \cdot d1 = n2 \cdot d2 = n3 \cdot d3$

$n1 \cdot d1 = n2 \cdot d2$ **110** ***rpm*** $\cdot 36cm = n2 \cdot 10cm$

$n2 = (110 \cdot 36)/10 = 3.960/10 = 396rpm$

$n2 = (110 \cdot 36)/10 = 3.960/10 = 396rpm \cdot 46cm = n4 \cdot 10cm$

$n4 = (396 \cdot 46)/10 = 18.216/10 =$ **1822*rpm***

In the formula of the motor structure, we can see that we only need 110rpm of input and it becomes what the generator asks us for its operation that is 1800rpm.

Trout Tank:

$800cm \times 500cm \times 150cm = 60.000.000cm^3$

$$60.000.000cm^3 * \left(\frac{1m}{100cm}\right)^3 = 60m^3$$

1 pond of 60m ^ 3 to grow trout, with which they can produce approximately 12 kilos per cubic meter, that is, more or less 47 commercial size trout

$$\frac{60m^3}{x}\frac{1m^3}{47} = 2.820$$ Trout is our production.

Overflow pipe: In the trout tank it has the overflow pipe where with a filter, it drains approximately 70% of the water, and these overflow pipes lead clean water to the river.

Stool collection tank: In this tank one works continuously, it has the collection pipe of the feces in the trout tank, approximately 30% of the water of the bottom of the trout tank, since the water of the depth is the one that has all these solids. The waste, which is stored in the collecting tank, can be reused as a very good fertilizer rich in nitrogen and other minor elements, an efficient process, since the water returns clean to the river.

Discussion

Currently, the negative problems in the poor availability of water, droughts and heat waves, environmental aspects such as eutrophication or acidification are detected, are incidents when selecting activities or technologies to find sustainability for the future. We want with this project be a measure that contributes to the sustainable development of the vulnerable sector.

Conclusions

We want this project to be a measure that contributes to the sustainable development of vulnerable sectors such as the rural sector, which creates sustainable solutions for the use of natural resources and careful management, as well as the preservation of ecosystems and water sources.

Experimental Analysis on Refrigeration Designs for Photovoltaic Panels

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Abstract

Experimental results in PV photovoltaic collection modules are presented. Through experimental testing of refrigeration systems, the energy efficiency of photovoltaic panels was increased operationally in open circuit voltage. The investigation covered four silicon panels, two mono and two poly crystalline; by means of electrical and thermal analysis with three different cooling systems, the potential difference decreases with increasing surface temperature; in the tests of the refrigeration systems, the decrease in temperature in mono- and poly-crystalline panels generated an increase in voltage of 3.52 and 2.71 volts respectively. In turn, the initial temperature of the panels was decreased from 61.1°C and 57°C, to an average of 35°C. Universidad Cooperativa de Colombia and the ESLINGA research group aims at meeting the Sustainable Development Goals (SDG), particularly, goal 4 (Quality Education) to 7 (Affordable and Clean Energy).

Keywords: energy efficiency, heat sinks, photovoltaic panel, radiation, voltage, temperature.

Introduction

The problem of this applied research is based on how to increase its power, its open circuit output voltage, each manufacturer provides a temperature range to generate the greatest amount of energy, known as the maximum power point. For the development of the project it was necessary to design systems that allow cooling of the photovoltaic panels, bringing them closer to greater energy efficiency and testing them in an experimental way.

Background

Geothermal energy. Guerrero Fernández (2013) studied the cooling of photovoltaic panels by using surface geothermal energy using a plate-tube exchanger, up to 25% of higher energy production can be obtained on average.

Cooling by a water tank after the panel. Krauter & Ochs (2004) implemented a system called the TEPVIS based on a water tank located on the back of a panel. The temperature reached by the cells was improved without using any energy for cooling, partially absorbing and dissipating heat.

Air duct. In Singapore, researchers (Teo et al., 2012) carried out tests using an air system which was installed on a roof of the University of Singapore for these tests. The temperature of the photovoltaic module is proportional to the solar irradiation and inversely proportional to the power, with the active cooling system the temperature increases an average of 1.4°C for every 100 W/m2 of increase in irradiation, but the module that It did not have the system, it presents an increase in its temperature of 1.8°C per 100 W/m2.

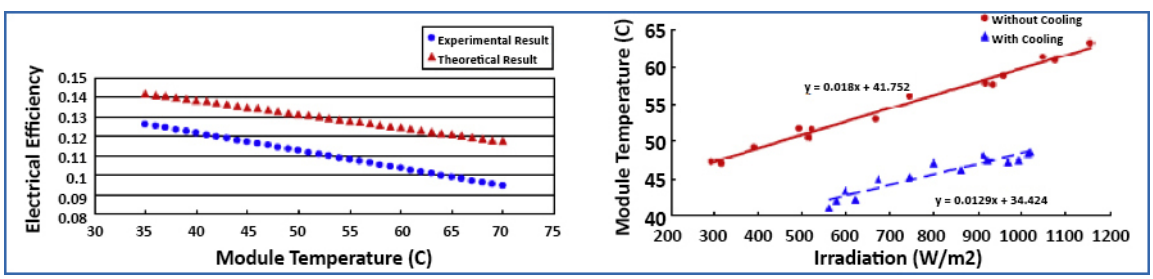


Figure 1. An active cooling system for photovoltaic modules. Source: Teo, H. G., Lee, P.S. & Hawlade, R. M. (2012). An active cooling system for photovoltaic modules. *Applied Energy,* 90(1), 309-315.

Framework

Open circuit voltage. In a solar cell the maximum voltage is known as (Voc), which occurs in an open circuit and in the same way occurs at zero current. For an open circuit, the maximum voltage depends on the current generated by the light and by the amount of polarization that it generates in the solar cells.

$$V_{\infty} = \frac{nkT}{q} \ln\left(\frac{J_l}{J_s} + 1\right) \quad (1)$$

Note that Voc depends logarithmically on the current density generated by the light *Jl* and on the inverse of the saturation current density *Js.* As, *Jl* varies little, while *Js* can do it in several orders of magnitude, then the value of Voc is conditioned by the values of *Js.* The *Js* depends strongly on the recombination mechanisms of the electron-hollow pairs before participating in the conduction current. The fewer carriers recombine, the lower will be *Js* and the greater will be Voc. As *Js* depends on the temperature, when it increases the value of *Js* increases and Voc decreases; while the greater the energy gap, the greater is Voc (Hosenberg & Bowden, 2018).

Efficiency of a Photovoltaic Panel. The efficiency of a solar cell is determined as the fraction of the incident

energy which is converted into electricity and is defined as in eq. (2) the efficiency of a photovoltaic panel is demonstrated Being Pin the incident solar energy. In eq. (3) the maximum power of a panel is shown. In Eq. (4) it is evidenced of the energy efficiency of a solar cell.

$$n = \frac{Pmax}{Pin} \quad (2)$$

$$Pmax = V_{oc} I_{sc} FF \quad (3)$$

$$n = \frac{V_{oc}\, I_{SC} FF}{Pin} \quad (4)$$

Materials and Methods

Selection of refrigeration systems was based on literature review. Achieving designs of refrigeration systems: starting from a conceptual stage establishing the operating criteria, and the detailed design was elaborated considering three types of convection heat transfer phenomena.

The first of them by convection using a refrigerant fluid which was sprayed on the surface of the modules as shown in figure (2A). Technical aspects of software were considered, the programming of the system is done through the Arduino program, the which through parameterizing the temperature limits to activate the cooling system.

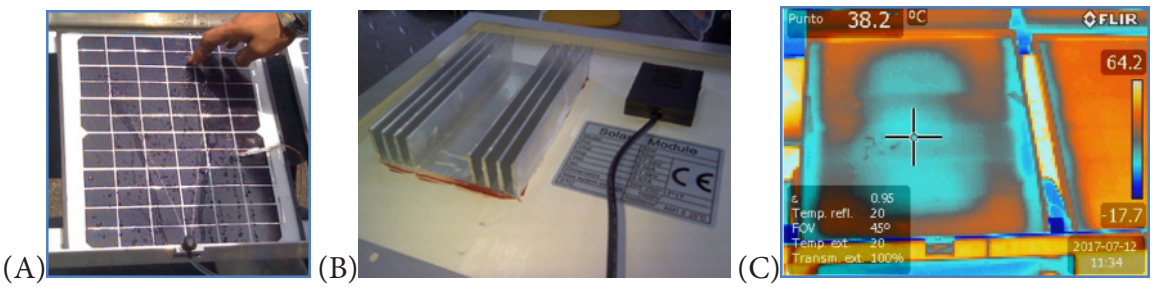


Figure 2. Cooling Systems. Source: own elaboration.

The second one, shown in figure (2B), is based on a convection system with heat dissipating fins on the back of the panels with conductive silicone.

The third system is a type of forced convection, by means of a fan the air is propelled towards the previously installed fins, surface temperature ranges were already known, the Arduino DAQ was used, this allowed to control the intensity and cooling times (2C).

Experimental tests on the panels: Through an assembly of the three systems. The tests carried out are recorded. The variables: ambient temperature, humidity of the environment, voltage and the surface temperature of one of the panels. The data presented in this article were taken over 2 months for 2 hours, with 5-minute intervals. To obtain the efficiency, it was necessary to have a value of the incident radiation on the panels at the time the tests were performed, requested in the city of Cali for the months of June and July from the meteorological station of the Universidad Antonio Nariño.

Results

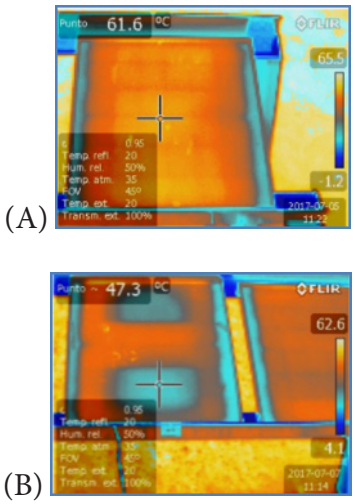
The analyses regarding the thermal and electrical behaviour of the solar modules is the convection cooling system with dissipating fins. The difference in the efficiency increase of this system compared to the third system that also uses fins is minimal, it can even be inferred that the convection cooling system between a fluid and a solid and the forced fin convection cooling system they need an additional study of energy efficiency to verify that the production that is gained by cooling the panels does not generate losses with the use of these.

Table 1. Comparison of voltage, temperature and efficiency between the two types of panels for the second cooling system

Panel Type	Voltage	Efficiency	Temperature
POLICRISTALINO	+1,754V	+1,29%	-10,08°C
MONOCRISTALINO	+2,11V	+1,92%	-11,896°C

Source: own elaboration.

Figure 3. Thermal Photo monocrystalline with fins (A) vs. without cooling system (B)



Source: own elaboration.

The first system had a better distributed cooling for the entire surface, based on the efficiency of the panels based on their surface temperature. Monocrystalline panels would increase their efficiency by 2% and Poly-crystalline panels by 1, 41%.

Discussion

In order to take full advantage of the heat transfer in the convection cooling system by means of heat dissipating fins, it is recommended that the fins be installed on the back of the solar panels on their entire surface.

In order to determine the position of the solar panels through the theory, the most recommended degree of inclination that the PV panels should have in order to maximize the radiation from sunlight which is 15° is indicated. This value is based on the studies carried out by renewable energy companies which state that as the location of the PV installation moves away from the equator, the solar modules must be tilted in order to receive more irradiation.

Conclusions

It is possible to generate an average voltage increase of 2,814 volts for Mono-crystalline panels and an average increase of 2,218 volts for Poly-crystalline modules; with maximum voltage of 3.52 volts and 2.71 volts respectively.

With an initial temperature of 61.1°C for the Monocrystalline panels, it decreased on average of 16.61°C; with an initial maximum temperature of 57.8°C for the Poly-crystalline panels it decreased 14.68°C, even on hotter days a minimum temperature was achieved in the panels between 32°C and 34°C

Mono-crystalline PV Panels have a greater absorption of solar radiation and therefore a significant increase in temperature. However, just as it gains temperature, it is more affected by it, because when it gets too hot, the voltage drop it presents is much greater compared to the Poly-crystalline panel. But there is a temperature limit and therefore it is not fruitful to continue with the decrease in the temperature of the cell surfaces since the voltage had reached its maximum value.

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Optimal protection relay coordination for power distribution networks with photovoltaic generation penetration, case study: Dominican Republic distribution network

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Abstract

The integration of photovoltaic power generation systems has taken a great boom in the Dominican Republic and in Latin America in recent years, due to its characteristics, such as: easy installation, low maintenance cost, modular installation, free energy source and minimal pollution, but its inclusion in the distribution networks causes energy flows to change and therefore the topologies of the energy distribution networks change at a time when photovoltaic generation is generated and, therefore, the coordination of protections is lost. In this article we present a procedure to modify this coordination of the relays of over the currents of the switches, recloser and fuses of a distribution network typical of the Dominican Republic. Through simulation methods, we were able to verify that the trip times of the protections can change, generating new protection schemes and, through optimization methods, meta-heuristic optimal coordination adjustments required to have an adequate protection system that were obtained for this methodology is applied in the Reverse time protection relays. Introduction: This research is titled "Optimal Protection Relay Coordination for Power Distribution Networks with Photovoltaic Generation Penetration, case study: Dominican Republic Distribution Network" (2019) in the municipality of Rincon province of La Vega, located in the southwest of the island of Santo Domingo. *Problem*. Many of the technologies used in the protection systems of the MV networks used in the Dominican Republic are based on studies and research carried out abroad, so many times there are problems of adaptation and operation. We carry out an investigation regarding the adaptation of these technologies to the conditions in the Dominican Republic. *Objective*. This research aims to optimize the time multiplier configuration (TMS) and the trip time of the relay for the integrated distribution network through the default value of the current starting configuration. Adjustments of the trip times of the relays are made by the particle swarm optimization algorithm and thus avoid the loss of protection due to the presence and generation of photovoltaic in the medium voltage network. **Methodology**: The methodology established in this investigation is to analyse a distribution network, simulating faults in several scenarios and determining the protection relay characteristics by optimization method and adjusting the curves

in case of loss of coordination that could incur relay changes. **Results**: After the adjustments of the start times of the relays and fuses, the protection system is enabled for conditions in which there is no photovoltaic and avil generation to change the topology of part of the backup protection. **Conclusion**: The protection of the distribution networks must be optimized when there is inclusion of photovoltaic generation of part of the protection relays such as branch fuses. **Originality**: Through this research, integrated and sustainable strategies for analysing the behaviour of distribution networks in the Dominican Republic are formulated for the first time. **Limitations**: The lack of information provided by the municipality and access to sampling points.

Keywords: fuse, protection, relay, time fails.

Introduction

All protection systems play a very important role for the reliability of the distribution system also the protection system in time lag. The delay time is determined according to the required selectivity and this process is known as the setting of inverse tripping times of protection relays.

Materials and Methods

This investigation presents a procedure for an effective coordination of the protection systems of the energy distribution networks, thus avoiding possible failures of the protection systems that have an impact on the quality of the energy service offered in the Dominican Republic.

Protection Relay. By varying the level of solar radiation during different times of the day, the level of penetration of photovoltaic power generation systems changes. The penetration levels of photovoltaic systems in a feeder are defined as:

$$\text{Penetration Level} = \frac{\sum_{m=1}^{n} P_{\text{PV}_m}}{\sum_{j=1}^{d} P_{\text{Load}_j}} \times 100, \qquad (1)$$

Where ${}^{p}PV_{m}$ and ^{p}loadj represent power injection and demand power respectively. In the distribution feeders, the current flows from the main transformers of the network to the consumers. The coordination depends on the direction of the energy flows and the penetration of the photovoltaic generators in said distribution network objective function

$$F_{Min} = \sum_{i=1}^{N} T_i \qquad (2)$$

$$T_i = \frac{\beta}{\left(\frac{I_{sc}}{I_p}\right)^{\alpha} - 1} TMS \qquad (3)$$

The protection system must isolate a fault in the shortest possible time and maintain the area of the network upstream of the operated switch with the energy service. The main objective of the coordination of the protection system where: α, β are retransmission coefficients, Isc is the current short circuit current

Optimization Algorithm. Swarm optimization of particles was presented by Kennedy and Eberhart (1995). This algorithm is inspired by the social activities of birds. Each individual particle is the best search solution in a search space by having the best previous position of the neighbours and the best position of their own.

Methodology

First, an optimal power flow run must be performed on the network in the Digsilent 15.1 program with parameters from that network, then, fault data is recorded on all nodes. This gives an overview of the network topology without the presence of photovoltaic generation.

Simulation. For this study, the distribution network that feeds the town of Rincón in the Dominican Republic was selected. It is known as the Rincón circuit of 4.2 MW with length of 19 km and is powered by a 14 MVA, 69/12.4 kv transformer, which also supplies circuits II and III to the Rincón substation with a capacity of 4 mw each, these have distribution transformers which have powers ranging from 15 kva single phase to 150kva three phase all connected to 12.5 kv.

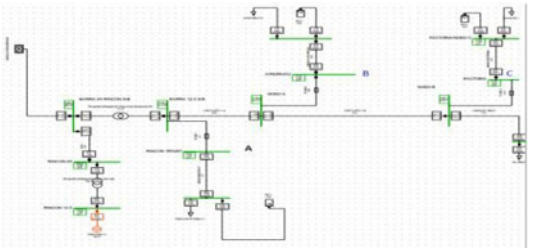

Figure 1. Distribution network circuit 1 corner with the Dominican Republic. Source: own elaboration.

Results

Table 2. Relationship cases for simulation purposes.

		TMS				FUSES		
Item	Type	R1	R2	R3	R4	FU1	FU2	FU3
1	ooo	0.01	0.31	0.01	0.31	5.566	5.416	8.073
2	ooo	0.01	0.31	0.01	0.31	5.566	5.416	8.073
3	ioo	0.01	0.3100002	0.01	0.3100003	4.232	5.845	7.671
4	oio	0.01	0.3100002	0.01	0.3100003	4.597	5.384	6.918
5	ooi	0.01	0.3100001	0.01	0.3100001	5.083	6.036	7.795
6	oii	0.01	0.31	0.01	0.31	2.548	4.095	5.264
7	iii	0.01	0.3100002	0.01	0.3100002	3.357	3.996	5.218

Source: own elaboration.

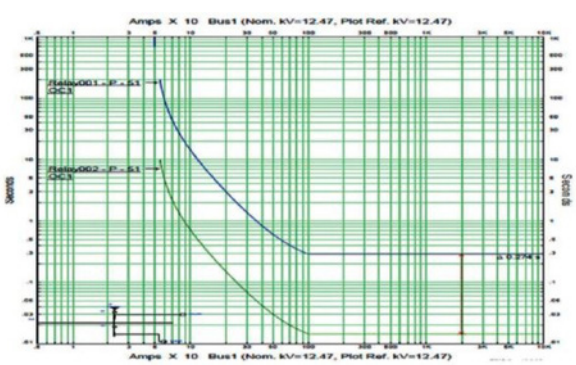

Figure 3. Optimal time varies cases. Source: own elaboration.

In the present graph you can see the incidence of changes in the tripping curve of relay R1 connected to the 12.5kv line. Fault 011 presents a delay time of 2,548 sec for fuse FU1 for the section that feeds the corner town, representing a reduction of 54.22% with respect to the adjustment of faults without photovoltaic generation, this deviation is considerable because photovoltaic plants 2 and 3 represent upstream power flows in the substation, thus varying the topology of the protections.

Table 2 indicates those of the operating times of relays R1 and R3 that are at the corner substation bar output and in section of circuit 1B respectively. relay R2 is the backup of relay R1 while R4 is the backup relay of R3.

Conclusion

The simulation of the circuit I test model of the town of Rincon, together with several photovoltaic power plants for different faults, were carried out in the digsilent program. Optimal adjustment coordination of the relay is identified through the PSO algorithms through the programming language m through the Matlab program. The results in Table 2 demonstrate that PSO is able to find the optimal solution. In some branches of the network there were considerable changes in the fuse setting currents, this indicates changes in the type of fuse due to a curve with more melting time. According to this research, the changes in the coordination of the network protections occur at a time when the photovoltaic generation reaches its maximum values.

Automation system for the photovoltaic-thermal procedure (PVT) with connection to digital machines (Website)

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Abstract

Due to the increasing development of renewable energy projects in Colombia, encouraged by the 1715 law, many developers are taking advantage of subsidies, incentives and funds. However, many isolated regions with more than 1 million inhabitants still lack electricity. Furthermore, Colombia is in the equatorial region.

Keywords: automation, IoT, machine learning, photovoltaic, programming, sensor, system, web.

Introduction

The increase in photovoltaic solar energy projects in Colombia requires adequate variables for monitoring. Using an automated thermophotovoltaic system allows it to be used in different types of applications such as green hospitals, hotels and houses. Some research has already been done on control models of PVT systems that propose advanced techniques for more precise monitoring. Other researchers develop equations and energy balances about the water-energy nexus yielding on PVT systems efficiency improvements. In this research, the system will be automated and configured through a web application software that can be used on different types of platforms and hardware that allow monitoring technical variables. A real PVT system will be used to validate the software and to instrument the system as is shown in figure 1.

Technical Data	
Nominal power	180 Wp - 190 Wp
Power tolerance	-0/+3%
Product warranty	5 Years
Performance guarantee	90/80% - 10/25 Years
Thermal Properties	
Operating temperature	approx -20 °C to 75 °C
Idle temperature	75 °C
Collector energy output	approx 550 W/m²

Figure 1. Module Technical Specifications. Source: PVT datasheet. http://wiosun.co/Wiosun_English.pdf - Downloaded January 2019.

Problem

In today's society, many homes, buildings, industries, hospitals, among others, make excessive use of natural energy resources, such as water. In the same way, there is no adequate control of the use made of it, sometimes even wasting these resources, therefore, it is proposed to develop a system that is capable of monitoring, regulating and control the main variables in technologies that use renewable resources. In this way, save these resources automatically through user configuration when necessary, with the purpose that, over time, the user can demonstrate consumption data and adequate savings of these resources so that these technologies are sustainable and can be preserved in the future, thus generating an improvement to the environment and the economy of the user.

Objectives

- Design the monitoring system in bifacial solar panels for different types of environments (Rain, Sun, Cloudy).
- Design of a website in ASP.NET with SQL connection. Including settings and automatic control system.
- Automatic validation of the system working together, User - Page.
- Create and design a computer system between PVT elements and digital elements (Website) to obtain real-time information to be processed and displayed on the website.

As a future objective, it is intended to carry out a system based on machine learning/artificial

intelligence which will be trained to predict the behaviour of the PVT system with the data obtained through the sensors responsible for measuring certain variables.

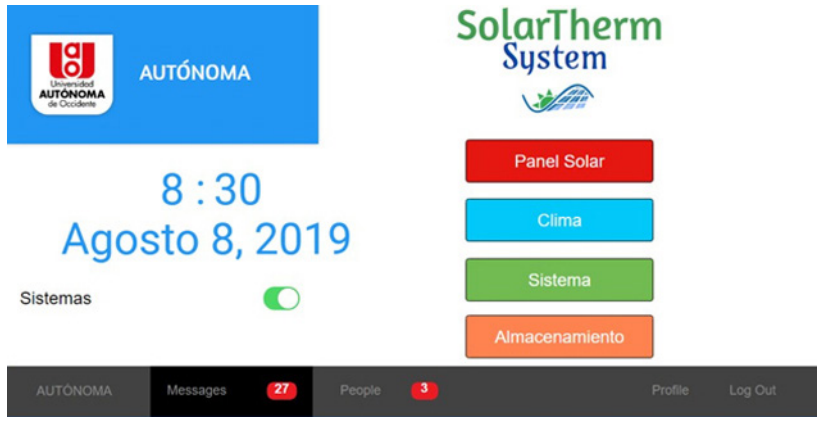

Figure 2. Mock-up of the web page interface. Source: own elaboration.

Methodology

The project development will be carried out in the following stages:

- Automatic system design (Control of energy produced by the system, storage and distribution).
- Thermal control of water, storage, consumption and distribution of liquids.
- System automation configuration according to the user's energy and thermal consumption.
- An adaptive system according to the emitted radiation.
- System design and implementation costs.
- Behaviour test in different environments of the equipment that will be used in the design implementation.
- Analysis of the results obtained from the team behaviour test.
- Automatic system assembly.
- Programming of the system sensors.
- Website development.
- Website programming and connection between the system sensors and the web interface.

Results

- Reduction of water and energy consumption in homes, schools, companies.
- Increase awareness about energy and water savings in a monetary way.
- Creation of a system between the mechanical machine (PVT) and the digital one (Website) so creating an easy user interaction.
- Energy storage for cuts or blackouts due to electrical failures, for constant use.

Conclusion

The design of the software and hardware to be developed is expected to obtain monitoring data for proper PVT control. Variables such as voltage, current, power, battery charge, energy consumption, solar irradiation, among others will be obtained. With the use of these bi-facial solar modules, it is expected that you have control of water distribution in different parts of the facilities where it will be used. It can also be concluded that the initial implementation investment for the design will recover as soon as the control of the system and the automation show savings in energy and thermal consumption. The investment is expected to recover in the first two years of operation. In addition, the PVT system has a long service life with high efficiency values, whether maintenance is performed, which makes the system economically viable and the technology solution sustainable. Finally, the User-Website interaction

will be improved with automation methods through the internet of things, in this way it can facilitate the use of the system and In the future and the future implementation of a system with machine learning/ artificial intelligence which will serve as support for the renewable energy objectives for the coming years, improving the accuracy of real-time and future behaviour.

Originality

The aim of this research is to integrate a user-friendly communication interface for monitoring thermal and power variables. This should be done between the software and the user, making everyone understand the state of the system parameters. Users can check different variables such as voltage, intensity, temperature and power among other variables. Users can configure and make decisions easily with the understanding of the information given by the software.

Limitations

The lack of information if they provide to the user when handling the different bifacial panels, do not have the knowledge about the full uses that they can have, in addition, you have little information about the daily, monthly or annual water consumption and energy.a

Chapter 3. Industry 4.0 for Energy, Water, Air and Biorefineries

Keynote Speakers

Ambient intelligence as low-cost solutions in health environments

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Abstract

Introduction: This article presents different technological solutions in health environments, based on low-cost technologies, in the province of Chiriquí, Republic of Panama, between 2012 and 2019 as part of the Research Group on Emerging Computational Technologies. **Problem:** The implementation of technologies to the health sector is often difficult, due to the high cost of the equipment required. The development of solutions based on low-cost technologies make it much easier to solve these regional problems. **Objective**: To solve health-related problems, based on the implementation of low-cost technologies immersed in ambient intelligence. **Methodology**: Our work methodology focuses on the final product. We begin with a study of the needs of the health sector, compare existing solutions, raise product requirements, propose a low-cost solution, implement the solution, evaluate the results obtained and adjust according to the needs of the sector. **Results:** The implementation of low-cost solutions in the health sector, allows to solve financing problems for areas of the country that do not have the necessary economic resources to attend the problems they have. **Conclusion:** This project seeks to offer proven solutions to the proliferation of technological needs in the health sector. These types of technologies can be developed from universities' research groups, providing low-cost technologies to all health sectors. **Originality**: Through this research, we can offer affordable, high-efficiency solutions that can be used in health sectors. **Limitations:** All health developments must be approved by the bioethics committee, which can delay the development and implementation within the project.

Keywords: ambient intelligence, disease solutions, health solutions, low-cost technologies.

The unavoidable use of Artificial Intelligence and Deep Learning with convolutional neural networks in the optimization of any renewable energy and biorefineries

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Abstract

Introduction: This article is the product of continuous research and business experience itself, from which the use of the most innovative and disruptive technologies such as Artificial Intelligence and Deep Learning with powerful neural networks is derived in the best imaginable optimization of renewable energies. **Problem:** There is an unsustainable unlimited use of all kinds of imaginable natural resources, water, wind, sun, etc. It makes the unavoidable use of the most disruptive and innovative technologies to end this waste with universally environmental damage. **Objective:** The objective of the research is to promote and promote in a global way the widespread use of technologies and arranged as Artificial Intelligence and Deep Learning in the management for the most dynamic, efficient use of all types of natural resources. **Methodology:** Efficient use, optimization of these high and disruptive technologies imply understanding and characterizing who worldwide uses these technologies today in the field of different renewable energies. **Results:** The unsustainable use of natural and renewable resources is related to the indiscriminate misuse by people, without being of the climatic change already in a very serious situation and without short visions of reversing, improving, these technologies more speeds, more precise, agile, operative to save, not waste, optimize at unsuspected levels in its proper, perfect efficiency. Only the use of these disruptive technologies leads us to go around a dangerous world. **Conclusion:** This research study seeks to generate a change in people's behaviour and the use towards efficiency, optimization and modification of user practices to favour the real sustainability of natural resources with renewable energies. **Originality:** Through this investigation, it is detected, diagnosed and at the same time the greater widespread use of innovative and disruptive technologies is promoted to make natural resources better and more sustainable with renewable energies as a great objective, where there will be no apologies for not being more Efficient, optimal and harmless for a better natural sustainability of the universal environment. **Limitations:** The great ambition object of the study, research makes it difficult not impossible to obtain the perfect data but any beginning will be fantastic in pursuit of the objective and what is pursued.

Keywords: artificial intelligence, deep learning with neural networks, natural resources optimization, use in renewable energies

From industry 4.0 to cyber-physical systems: a framework to manage renewable energy smart systems

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Abstract

The "Industry 4.0" concept, initially confined to the industrial sector, has become very popular in recent years, and has entered the academic (as an example, University of Pau and Pays de l'Adour- UPPA) offers an International Master's degree with this title), economic and even political fields. From a technological point of view, it is very often associated with the IoT (Internet of Things).

First, the conference will focus on the presentation of Industry 4.0 as the 4th Industrial Revolution, its challenges, the new industrial context, global initiatives at the international level, and research priorities. In conclusion, Industry 4.0 will be characterized along different axes, in order to put it in perspective with the more general CPS (Cyber-Physical Systems), going beyond the industrial world to potentially reach all organizations in the context of the "digital transition". This will be an opportunity to position the IoE (Internet of Everything) as an evolution of the IoT characterizing the new connected environments integrating Things, Services/Process, Data and People, which will allow to present a general framework for CPS.

We will then look at the different possible areas of application. A priori, this framework should make it possible to intelligently manage any connected environment, known as smart systems. Renewable Energy Smart Systems are only one example among others, but very interesting in the context of UPPA's policy. In 2017, the UPPA obtained a label of excellence, E2S (Energy and Environment Solutions), which guides the allocation of human and financial resources in the fields of Energy and the Environment.

The second part of the presentation will focus on our research work on a framework for smart systems based on an environment connecting Things, Services, Data and People. The network is characterized by the use of various technologies, and must be available all the time, from anywhere, for everything and everyone.

The overall objective of this work is to design, develop and deploy secure autonomous systems in large connected environments. This is called SoS (System of Systems). While, the specific objectives are: 1) to manage data in order to produce value-added information, and beyond new knowledge, 2) to offer adapted services

to improve processes (production, control, etc.) in order to allow greater autonomy in action and decision-making for various fields of application, with a particular focus on Energy and Environment.

Our contribution deals with a Smart Open Connected Environment Management System (OpenCEMS) pluggable to various application domains. The areas of research in Computer Science are: Software engineering, Data management, Network and Security. More concretely, it is a platform composed of a generic part (core), from which it is possible to build ad hoc smart systems for different fields of application, such as renewable energies.

The development of this platform is based on the integration of different modules developed in different projects, aligned on an adapted autonomous architecture, with a modelling effort based on the MDE (Model Driven Engineering) approach.

Keywords: connected environment, cyber-physical systems, industry 4.0, Internet of Everything, smart systems.

Smart Energy Solution: Design based on Communities' Challenges: A Framework to manage Renewable Energy Smart Systems

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Keywords: renewable energy, smart energy systems, smart territories, sustainable development goals.

Introduction

The Government of Colombia recognises the potential of resources it has throughout its territory to supply clean energy within Colombian territory. For this reason, the Law 1715 of 2014 was launched and it states that "the Government will develop strategies for the use of renewable resources for sustainable economic development, the reduction of greenhouse gas emissions and security of energy supply". Therefore, the use of renewable energy smart systems is becoming a priority in Colombia.

Problem

Generation and energy consumption are a major issue in different countries around the world. Nowadays, projects under development seek the modernisation of electric power generation and distribution systems. One of the main strategies is the design of context-adaptable micro-grid architectures. The micro-grid concept focuses on a controlled, monitored and highly autonomous use of electric power supported on information technologies, for the optimisation of energy transfer, minimize risks and increase the system's quality, efficiency and reliability.

Objective

Identify and analyse the strengths and opportunities for improvement in the applicability of smart energy systems. There are five strategies identified as the most relevant, whose different characteristics contribute to an automated and smart distribution, control, and supervision of electricity according to supply versus demand.

Methodology

It was based on the current state of the art literature review from ISI/Scopus databases within the last five years' timeframe (Mera-Paz, Colmenares-Quintero & Maestre-Gongora, 2019).

Results

The following frameworks were identified and analysed as the most promising in the public domain:

Smart Grid Architecture Model (SGAM) is characterised by a neutral technological position. This architecture entails a set of interoperability layers that permits the interaction between conventional and renewable energies. Business layer: Outlines the business objectives, regulatory and political framework, based on cases of use and micro-grid functions. Information Layer: Structure and models data. A communications layer where protocols and regulations for communication are established. Components Layer: Consist of location of domains - generation, transmission, distribution, distributed energy resources (DER), facilities for customers - and other areas - process, field, station, operation, company and marketing. From the compendium of options, the architecture provides a comprehensive methodology for achieving a proper functioning micro-grid. The management of cases of use (Jacobson, Spence & Seidewitz, 2016; Zakariazadeh, Jadid & Siano, 2014) allows the sharing of information between projects that implement similar cases, with different technical solutions. The result is the operation of a so-called intelligent network.

SGM – Smart Micro Grid (Zhenjie & Yue, 2009; Zakariazadeh, Jadid & Siano, 2014). It is based on the concepts of smart grids and has a microgrid configuration, which allows interoperability functions. It relies on three main layers that articulate the architecture's operation: Operations Control Layer, where monitoring, control and supervision is carried out. This layer has a centralised control that uses sensors and automated control systems for creating a distributed operating network capable of managing the micro-grids electrical power and resources. It has an emphasis on detection and solutioning of failures. It is also characterised for the implementation of methodologies based on traditional and evolutionary processes. The application of agile methodologies to date for this type of architecture is not evident in the documents. Processes Layer, where all business and regulatory processes are managed. Station Layer, where activities such as functional and non-functional procedures, registration, storage, protocols and guidelines of infrastructure, equipment and communications are established and where information is administered.

AMI – Advanced Metering Infrastructure (Rua et al, 2010; Hart, 2008; Abdulla, 2015). This architecture slightly breaks down the paradigm of layers or levels as there is a strong bidirectional combination of engineering, communication, and management stages where architecture becomes a system that combines smart meters, communication grids and systems for data management. It is an interesting concept that allows us to understand the behaviour of supply and demand management. Some documents mention the complex security risk situations due to possible data alteration. However, other documents argue that the solutions are within the reach of regulatory frameworks and public policies for the architecture's adequate use and implementation (Karnouskos, Terzidis & Karnouskos, 2007; Mohassel, Mohammadi & Raahemifar, 2014).

ADA – Advanced Distribution Automation (McGranaghan & Goodman, 2008; Brown, 2008; Zavoda, 2008). ADA architecture consists of bi-directional smart meters. An increase of energy distribution automation processes is possible with an integrated real time monitoring system that optimizes the efficiency of energy delivery. The overall result is the reduction of failures and interruptions, and a rise in the quality of service expectations. The architecture's fundamental basis are a set of sensors, transducers and Smart Electronic Devices (SED), that work together to gather a large amount of information concerning the micro-grid behaviour using a Scada system - supervision, control and data acquisition.

DER–Distributed Energy Resources (Paddock & San Martano, 2018; Daneshvar, Mohammadi-ivatloo & Zare, 2018). This architecture seeks to promote the use of energy resources by optimizing operations with a proper planning and design of the energy network. For this, a distributed system of power generation is established. In planning, the analysis of geographic zones and the social and economic impact of the region are key (Georgilakis & Hatziargyriou, 2013). An interesting feature of DER architecture is its adaptability to conventional electrical energy systems by

means of sensors and a microgeneration system with connections and control of alternating current (AC) to direct current (DC; Marzband et al, 2016).

Conclusion

The concern for climate change and the effects of greenhouse gases have allowed renewable energies to boom in the world. This has generated a transformation and evolution in the planning, design, implementation, monitoring and control of electrical energy networks through the search for new technologies and forms of connection. In this context, architectures for micro-grids appear as an efficient solution towards this transformation. Getting to know the trends of use of architectures, their components and functionalities for the micro-grid, represent a fundamental element to provide solutions to communities or organisations not interconnected or with needs to efficiently manage the flow of energy and minimise the risks of environmental impact. Also, it is concluded that there is a trend in the use of architectures for micro-grid, which along with the advances in the technological development for renewable energies and aims at the pursuit of achieving the objectives of sustainable development.

Acknowledgement

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Sensorization to manage environmental crises (or: Risky tools to address new risks)

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Abstract

Climate change is introducing new kinds of risks, like flash floods in deserts that have seen no rain in decades, tailings ("relaves") threatening mining towns, and sudden desertification of agricultural lands. Decision makers claim for aggressive sensorization to capture the raw data they need, and old and new kinds of sensors are being deployed to monitor these newly arising conditions wherever they appear.

Many of these sensors and equipment are connected to the Internet, giving raise to persistent risks, the so-called Operational Technologies / Information Technologies (OT/IT) chasm. This talk will present our work addressing this chasm at three levels: strategic, methodological, and technological.

At a strategic level, a maturity model of OT/IT collaboration allows to evaluate organizations regarding their readiness to build, maintain and operate secure OT/IT hybrid systems; gap analysis against target profiles allows to derive improvement roadmaps.

At a methodological level, we will present modern techniques to reuse advanced technological knowledge: software architecture tactics (specifically, for security, availability and performance) and to evaluate trade-offs among them (using softgoals).

At a technological level, we will describe briefly a SCADA-ERP bridge that connects OT-side SCADA networks with IT-side ERP systems; the software development to address the security concerns took one order of magnitude more that the functionality-related development.

Keywords: architecture trade-offs, OT/IT chasm, readiness maturity model, SCADA-ERP bridge, secure cyber-physical systems, software architecture tactics.

Short presentation abstracts

Automated IoT based water quality monitoring system

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Abstract

Water is one of the essential resources in the world. Its optimal condition is a big concern for living beings that use it in enormous amounts for many everyday activities. This paper shows the design of a monitoring system for physicochemical variables on water. The variables are dissolved oxygen, turbidity, temperature, and pH present in water bodies. The system uses sensors and a microcontroller with internet connection capable to receive the data and then send it to a server hosted on the web where they are processed and stored in a database. There is also a software product through which the values recorded can be displayed and analysed by the people working on the monitoring process. This project was developed using the software life cycle methodology; analysis, design, development, implementation, and testing. The main result of this project is a system prototype using open-source hardware and software to reduce system costs, and also the design and architecture of the system. The implementation of the system provides the possibility to improve the crop profitability through the monitoring of different physicochemical variables in the water, implementing tools to guarantee the effectiveness, precision, and low cost. The goal is to offer an easy way to acquisition and implementation monitoring system.

Keywords: Internet of things, low-cost, remote monitoring, water quality.

Introduction

Water covers approximately 71% of the earth, which translates into about 1.386 cubic kilometers (USGS, 2019), and 97% of it is found in the oceans. Humans use water not only for drinking, bathing or washing, but also use it through the products we consume. Only agriculture by itself gets to consume more than 70% of available freshwater (The World Counts, 2019). In many of these processes, that water must be in an optimal state; which means that it hasn't been greatly polluted or affected by external factors. There have been many technological advances in the last 100 years, but at the same time, new ways to pollute the environment have also appeared (Nasirudin, Za'bah & Sidek, 2011). Around 5 million people die due to waterborne diseases around the world (Geetha & Gouthami, 2016). Nevertheless, the efforts and techniques to prevent and reduce pollution gain relevance with every passing day and the tools to support this process are of great interest to society. The traditional way of measuring physicochemical parameters of water consists of manual collection of samples at different points, followed by analytical methods performed by professionals. Although it is a method that guarantees good results, it is not the most efficient way to obtain them (Grossi, Lazzarini, Lanzoni, Pompei, Matteuzzi & Riccó, 2013). Some of the disadvantages of this method are the limited temporal space coverage it provides, workforce costs and the lack of real-time reports (Vijayakumar & Ramya, 2015). Due to the disadvantages of the existing system, it is required to develop a system that allows real-time and continuous monitoring of water quality (MoDWS, 2013; Ragavan, Hariharan, Aravindraj & Manivannan, 2016). This paper presents the design of a low-cost sensor system for monitoring physicochemical variables present in a water body. The methodology followed for its development, the system and results and conclusions of the research will be shown.

Materials and Methods

The system developed, follows the steps outlined in the parallel software life cycle methodology (Pressman, 2005). First, an analysis of the current water monitoring process was carried out to identify functional and non-functional requirements oriented to the measurement of physicochemical variables. The next step was to design the architectural software and hardware diagrams that represent the artifacts, processes and firmware behaviour. The programming part had two parallel projects: first, the corresponding objectives were reached to implement the different technologies chosen to develop a hardware prototype for physicochemical variables sensing. The other parallel project was the cloud server implementation on which the data collected by the nodes was handled. Upon termination of the two parallel projects, follow the system testing stage. After having done the respective tests and verifying that the product obtained met the requirements imposed on it, the system documentation was done.

Results and discussion

The system uses four sensors: DS128B20 for temperature (Maxim Integrated, 2019), Gravity DFRobot Gravity: Analog pH meter V2 (DFRobot, n.d.a), dissolved oxygen (DFRobot, n.d.b) and turbidity (DFRobot, n.d.c). These are in the water, and they are continuously recording the respective values and sending them through a physical connection to an analog input of the ESP32 microcontroller (Maier, Sharp & Vagapov, 2017; Augustin, Clausen, Townsley, 2016), which is capable of connecting to wireless networks. The device makes use of LoRa (Angrisani, Arpaia, Bonavolontá, Conti & Liccardo, 2017), which is a wireless communication standard, characterized by being able to send data up to 10 kilometers away. Through the use of LoRa, the microcontroller implements a Machine-to-Machine (M2M) communication protocol known as Message Queuing Telemetry Transport (MQTT; Light, 2017) to send the recorded data to a server in the cloud, this data is in a lightweight text format called JavaScript Object Notation (JSON) (Severance, 2012). To send data with the protocol required the implementation of an external server, known as Broker; in this case, MQTT. The monitoring system cloud server was developed using environment Node.js. The server uses MongoDB (Chodorow, 2013) database system to save the values received. It uses data structures similar to the JSON format. The data was stored in the server for interpretation and execution on a cloud-hosted platform developed with the Angular framework (Fain & Moiseev, 2016). In this platform, the user can visualize the current water conditions and

can take the respective measures. The system design and the general data flow are shown in figure 1.

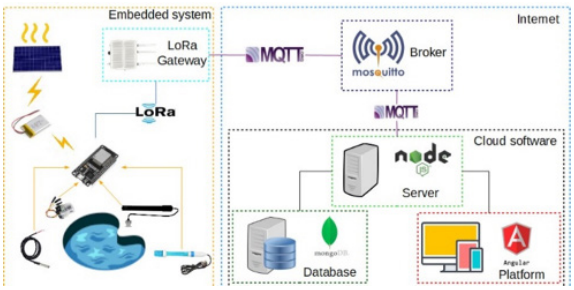

Figure 1. General System Architecture. Source: Own elaboration.

The embedded system is powered by solar panels, which are responsible for recharging a lithium battery to which the ESP32 microcontroller is connected.

Conclusions

The system provides an ecological impact because the monitoring of water conditions allows the user to decide in time when it must be regulated, also presents a social impact to replace the manual process for the measurement of water variables with based IoT technology with a low cost, and the need to be physically close to the water for monitoring quality variables is not necessary. It also provides an economic impact because it takes measures to regulate the state of the water, stopping a worsening of the situation and thus avoid spending huge amounts of money to face the consequences that a polluted water body can cause. The end goal of the system is to provide society the possibility of improving the water quality control process by monitoring different physicochemical variables, applying appropriate tools to ensure efficiency, accuracy, and low cost. The LoRa communication standard, which is of low power consumption and has a long-range for data sending, allows the system to be deployed in very remote places while keeping an ideal functionality. Also, the use of Open Source technologies provides the means to the development of a more economical end product.

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Development of an administration system based on internet of things for photovoltaic energy use and storage

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Abstract

This article aims the design of an energy management system for the power supply of a sensor network of an agricultural irrigation system, using a battery that receives photovoltaic energy from a solar panel. The objective of the research is to develop the design of an energy management system for the intelligent and sustainable power supply of a sensor network using a battery that receives photovoltaic energy from a solar panel**.** The methodology used to develop the application was software life cycle methodology; the software allows users to visualize the behaviour of the battery charge status and panel performance. The main results are a software platform that enables protection of the battery system against overcharge and over-discharge as well as a sustainable system of power supply for the sensors. Through this research, a system for photovoltaic energy-saving and, use in a sensors network, is developed using the Internet of Things.

Keywords: battery management system, Internet of things, solar panel.

Introduction

The use of renewable energies is a relevant aspect of today since they present a solution to climate change (Owusu & Asumadu-Sarkodie, 2016) and the depletion of non-renewable energies such as fossil fuels (Shahzad, 2017). One of the main options among renewable energies is solar energy, which uses photovoltaic technology to transform sunlight into electricity. This technology has proven its usefulness as a source of energy in satellites, water pumping systems, cooling systems, solar houses, and electronic devices (Ptasinski, 2015). The storage of renewable energies such as sunlight, is essential to achieve a good implementation, both in applications within the electricity grid, as well as outside (Hall & Bain, 2008). Since storage is an integral part of the use of renewable energy, supervision, and management of the collected energy is necessary, since the system may have failures such as damage to the battery due to excess current, decrease in the life expectancy of the battery over or prolonged discharges, among others. For this, one of the solutions that have been proposed by the scientific community has been the use of embedded systems and the internet of things (IoT) systems to monitor and manage energy storage in real-time. This article presents an IoT based system for battery administration and monitoring of photovoltaic energy storage. The system uses solar panels, and the Internet of Things to deploy and manage the information through a web platform, for this, uses voltage sensors at the input and output of the battery, as well as relays guided by a microcontroller, to cut off the flow automatically in situations of overcharge or over-discharge. This system will provide the power supply to a sensors grid used for crops irrigation in agriculture activity.

Materials and Methods

The energy management system consists of inputs, outputs, an administration system, and a web platform.

Input

The system uses multiple solar panels that provides energy to the batteries. The system has a solar charge controller, and a battery charge managed, avoiding overcharges and discharges based on their capacity (Epever, s. f.). The former relies on a pulse width modulation mechanism (pwm) to control the charge and keep the battery within stable parameters (Khan & Pervaiz, 2013). Batteries with unbalanced charges in their cells do not perform properly, affecting their longevity (Cao, Schofield & Emadi, 2008). Battery Management System (bms) of type SHLJ-2S-20A is used to balance the load between cells, in addition to provide protection against overcharge, over-discharge, and short circuit. Immediately after the panel network, AC5712 (Microsystems, s. f.), and LV25-P (Voltage Transducer LV 25-P, s. f.) voltage sensors were installed. The purpose is tracking the amount of energy that is entering the battery and allow the user to detect failures if the state of charge is not consistent with the flow supplied. Sensors are connected to a relay that is responsible for cutting off the flow of current to the battery. The relay is activated when the battery is fully charged by user or system through the web platform.

Output

The system uses an AC5712 current sensor and an LV25-P5 voltage sensor to calculate the battery charge level and inform the user of the voltage and current that he would be receiving. To avoid overcharging a relay is connected before the device responsible for cutting off the current flow to the input of the battery. As in the input, the relay will be activated by the administration system or the user through the web platform.

Management system

The main purpose of the management system is to avoid overcharging and prolonged discharges of the battery. For this, it is essential to know the state of charge (SoC, for its acronym in English) of the battery, which can be estimated from various methods. One of the most commonly accepted is the voltage method, which consists of converting a battery voltage reading to the SoC value using a known discharge curve (Murnane & Ghazel, s. f.). However, the voltage is affected by other battery conditions such as temperature, service life, among other factors, making it an inaccurate method, not to mention the need for a stable voltage range for the batteries making the voltage method slow and difficult to implement (Yanhui, Wenji, Shili, Jie & Ziping, 2013).

Web platform

The web platform displays the information of the sensors and battery and provides user control over the inputs and outputs through the activation of the relays. The ESP8266 is responsible for collecting the information from the sensors and sending it via the internet to the server using the MQTT (Message Queue Telemetry Transport) messaging protocol, used to send the information from the microcontroller to the server (Hunkeler, Truong & Stanford-Clark, 2008). Once received by the cloud server, a Non-SQL database, like MongoDB (Han, Haihong, Le & Du, 2011), stored the data. The charge estimation (SoC) will be carried out using the Coulomb counting method, based on the integration to the charging and discharging current time, based on a known state of charge and nominal capacity of the batteries (Chang, 2013). A Software application shows data and information through a user interface developed with Ubidots (s. f.). On the application, you can see the information of the current, the voltage, and the power of the input and output of the energy system.

Results and discussion

The battery cannot be charged and discharged at the same time. However, it can be connected to a source and serve as a source at the same time, that is, the battery can receive the energy that the device does not require and store it and, in turn, be the direct power supply of the device in scenarios where the panel cannot produce power. These are achieved by designing the system in parallel. Since the current in a series circuit is the same at all points (Young & Freedman, 2011), there is only one current sensor in the battery and another in the device. As for the voltage sensor (V) it will be parallel to the solar panel, battery and device, therefore, its readings will always be the same at each of these points since, for the elements of a circuit that are connected in parallel, the difference of potential (V) is the same in each element (Young & Freedman, 2011). The relays are the final control element of the system. They are connected directly to the microcontroller, which in turn receives information from the current and voltage sensors. Figure 1 shows the components of the system and an architecture scheme.

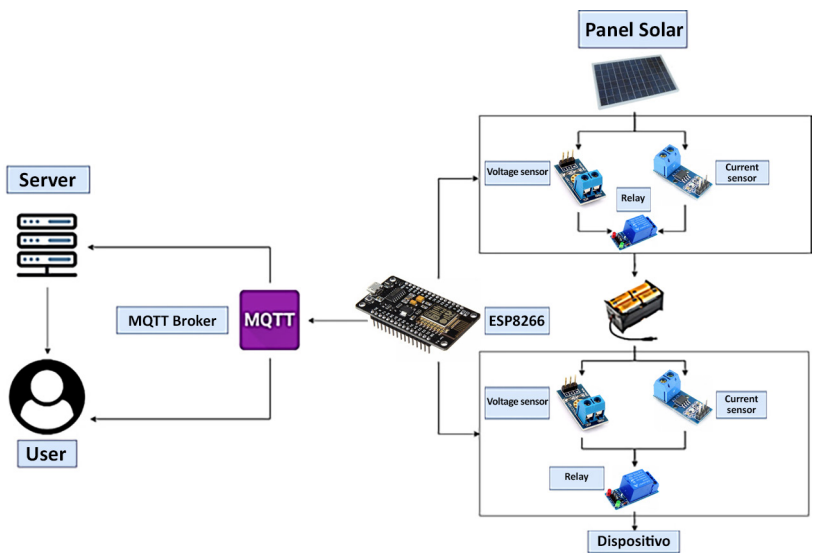

Figure 1. Structure of the proposed system. Source: Own elaboration.

Conclusions

The proposed system uses solar panels and lithium-ion batteries, for energy harvesting and storage respectively. The protection of the battery system against overcharge and over-discharge is achieved. Also, load balancing between cells ensures the longevity of the energy storage system. Systems based on the Internet of Things, such as a wireless sensor network, can adopt the present design to operate autonomously and check

battery system performance through remote monitoring. Future research can be done to improve and extend the functionality of the current design. The measurement of solar intensity at different stages of the day allows establishing more appropriate operating times. Besides, this design only contemplates a basic scheme of photovoltaic energy storage, without taking into account the use of resistors to ensure that the minimum or maximum supply required by the battery is reached for proper operation. By the above, a solution with low environmental impact and high energy use was obtained, this forms a fundamental basis for promoting an autonomous intelligent system deployment through the use of clean energy.

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Sustainability applications integrated in a university building in a tropical zone with GRIPV system

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Abstract

The Edificio de Ingeniería Eléctrica (EIE-UIS) is a green construction pilot and a Lab located in Universidad Industrial de Santander (Bucaramanga, Colombia). This building allows to study the performance of the passive and active strategies (PAS) for tropical warm conditions, which is useful for researchers due to information on real cases of green buildings is lacking. Results of PAS, the PV system installed on the rooftop and data recorded by the monitoring system have been described below. In some periods of July, the PV system represented up to 100% of the building power consumption. The highest power demand of the building was 42.08 kW and the highest PV power generation was 10.18 kW. Thus, the PV system represented 24.20% of energy consumption. The PAS saves the energy consumption of the building up to 70% compared to similar ones. The automation of luminaries and cooling equipment's represented respectively 33% and 50% of energy saved consumption. Finally, the PV system saved USD 5,041 in energy consumption and reduced 11.87 TonCO2 emissions.

Keywords: green construction, passive and active strategies, PV generation, smart metering, URE applications.

Introduction

The humanity dependence on energy systems is growing; the economy capacity of one nation, relations between energy demand growths of the country, has a direct implication with the quality of life of the population (Wells, Rismanchi & Aye, 2018). In this sense, the inherent supply risk of a community brings aggravating economic, security and health consequences to people (Qazi, 2016). The increase of energy demand has a relation with the footprint for human activities (Feng et al. 2019). Globally, the buildings represent 40% of primary energy use, 40% of natural materials, 15% of clean water and cause 40-50% of greenhouse gases (GHG) in the world (Robati, Daly & Kokogiannakis, 2019). In the buildings, the growth of energy consumption happens for two main reasons: population growth and population growth per square meter increased in vertical constructions (REN21 2019). The finally use of energy in buildings concerning to three main reasons: electrical

applications, residential water heat and indoor thermal comfort (Oropeza-Perez & Østergaard, 2018).

Passive and active strategies (PAS) implementation reduces the final consumption applications as the thermal comfort indoor, the indoor and external illumination, service applications, among others (Chi et al. 2019; Fernandes et al., 2019). Some papers present results about the PAS and distributed resources implementation in their installations, in different climate conditions (Feng et al. 2019; Sun, et al., 2018; Sun, Gou, & Lau 2018; Yu et al., 2019).

According to green applications in the buildings, the Edificio de Ingeniería Eléctrica (EIE-UIS) has implemented the following PAS: rainwater use, waterless urinals, hybrid illumination (solar tubes and luminaries), illumination and cooling control, illumination and cross ventilation natural, green rooftop, and PV system. Also, the EIE-UIS has devices for monitoring electrical and microclimate variables.

Materials and Methods

The methodology used in the investigation, described below, highlights the efficiency energy (URE, local government program) applications and describing the monitoring and PV system.

Edificio de Ingeniería Eléctrica (eie-uis). Is located at 7° 08' north latitude, 73° 08' west longitude, 960 meters over the sea level and its climate may classified as warm-tropical climate. The average temperature is 24°C and the irradiance average maximum is 1063 W/m^2 (Osma-Pinto & Ordóñez-Plata, 2019a; 2019b) (Figure 1. a).

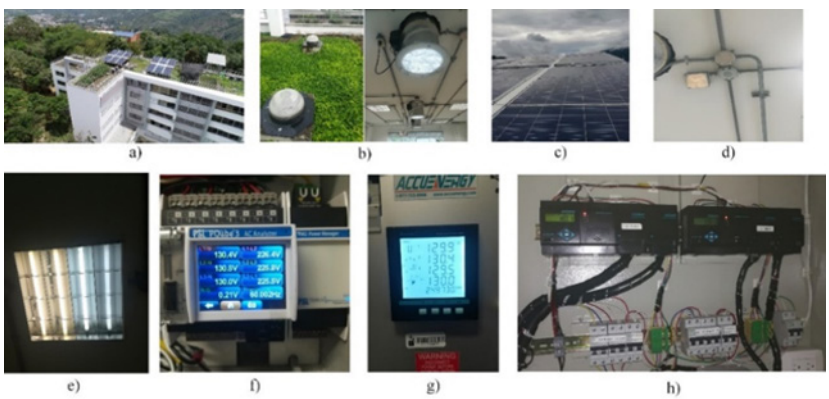

Figure 1. a) EIE-UIS. b) Solar tube. c) PV panels. d) Inner occupancy sensor. e) Dimmable lumminaries. f) PQube3 analyzer. g) Acuvim IIR smart meter. h) AcuRev2020 smart meter. Source: Own elaboration.

URE applications in the EIE-UIS. EIE-UIS has installed PAS for two main reasons: live laboratory and sustainability (Osma-Pinto & Ordóñez-Plata, 2019b). EIE-UIS has installed 23 solar tubes and high windows that represents the 70% of façade improving the illumination and cross ventilation natural. Besides, the occupancy and inner and outer temperature sensors are used to active the air conditioners and luminaries. These elements looking for high efficiency energy impact.

Smart Meters – Metering and PV system. EIE-UIS has installed eight Smart Meters (0,2s and 0,5s class). The micro-inverters recording information about the PV system operation to WEB platform – Enlighten. EIE-UIS has a PV system (PVS) as prosumer on the rooftop (≈ 76 m^2). EIE-UIS has 43 PV panels (UP solar, Trina Solar, Canadian Solar, Jinko Solar) and 43 micro-inverters (37 M250 y 6 IQ^7+, Enphase). The monitoring system makes possible to characterize the energy building behaviour. The PV system allows the reduction in the final energy consumption.

Results

In this section, some results obtained for PAS and PVS operation was described below.

PAS and GRIPV system results. The save water due to rainwater use and clear sewage reduced by 50% (1800 m^3 to 900 m^3 per year). The PAS automated reduced the energy use in 33.5% (Osma et al. 2015), and the hybrid illumination saved 50% of energy (Osma-Pinto et al. 2014). The green rooftop, natural ventilation and heat extractor indoor reduced the consumption by 40 MWh/year. The green rooftop saving 1.58 kWh. The large area of windows represents an energy gain by 304 kWh. EIE-UIS has a better performance in 74% and 89% respectively, compared with two buildings type (Cárdenas-Rangel, Osma-Pinto & Ordóñez-Plata 2018). Green roof integrated photovoltaics (GRIPV) increased the energy injected at the electrical network by 1.3 ±0.4%, with PV panels height between 50-70 cm of the surface. Also, forced irrigation increased the net energy generation by 10% of one PV panel (Osma-Pinto and Ordóñez-Plata 2019b).

PVS operation and EIE-UIS consumption results. PVS1 and PVS2 (37 PV panels) injected 31.92±5% MWh, since October 21 of 2015 to august 12 of 2019. PVS3 (6 PV panels) injected 0.432±5% MWh since June 12 to august 12 of 2019, so the total PV energy injected was 32.352 MWh±5%. During July, the maximum electrical load was 42.08 kW±0.5% on July 25 at 17h: 00. The maximum PV power was 10.18±0.5% kW on July 27 12h: 40 and the power consumption was 9.61±0.5% kW during the same scenario, showed 0.57±0.5% kW of power injected to the transformer of the building. Maximum PV power injected (7.74±5% kW) to LV transformer was on July 03 at 11h: 20, with 3.78±5% kW of EIE-UIS consumption. PV system represented 22.13% of the electrical energy of EIE-UIS, considering 6h to 18h.

Conclusions

This research presents the PAS integration and the PVS in a university building. The PAS implemented saved up to 70% of clean water; also, the hybrid illumination integrated (solar tubes and luminaires) allowed the reduction in 50% of energy consumption; the luminaries and air conditioners automated saved 33.5% of the consumption. The green rooftop implementation, natural cross ventilation strategies and the heat extractors indoor, reduced 40 MWh/year in energy used. In addition, this strategy reduced the thermal stress, mainly, in the fifth floor. The PV injection to the building represents 22.13% of the total energy consumption on July. The building saved electrical energy pay in USD 5,041 and avoided the 11.87 TonCO_2 emissions only by the PV system installed. Finally, the PAS implementation and PVS makes possible the many research academic interesting, knowledge the energy interaction between the different energy strategies implemented and the energy behaviour of the building. It is important to highlight the main key of the academic in the national sustainability progress through this projects environmental type.

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A study of consumer perceptions with respect to green marketing in supermarket chains located in Bucaramanga, using factor analysis

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Abstract

This article is the product of the research "Consumer Perception against the Green Market in Supermarket Chains in Bucaramanga through the Factor Analysis Technique", carried out during 2017 and 2018 in the municipality of Bucaramanga in the department of Santander. **Problem**: The need to establish the perception of Bumangueses in relation to the green market in the supermarket chains of the city, tried to identify through an analysis of defined variables, what is the pattern of behaviour and the tendency of appreciation of citizens with the Bucaramanga business establishments. It is wanted to know how is the appreciation of the consumers in front of the variable "Cleaning" and "Price" of the supermarket chain? **Objective**: Apply marketing techniques, statistics and factor analysis using the Google platform tool and SPSS software, in order to identify the perception of consumers against the green market in supermarket chains in Bucaramanga, Santander. **Methodology**: Identify, through a market research, the study variables that generate bias in the information collected through a reduction of factors in order to provide a quality analysis and establish the appreciation of consumers against the "cleaning" study variable for Evaluate your perception in relation to the supermarket chain by applying factor analysis. **Results**: With the development of the study, and the techniques applied; it is possible to determine the appreciation of consumers quantitatively in terms of variables related to green market such as cleaning and prices. Conclusion: This project seeks to generate a change in the consumption behaviour of the green market towards efficiency and modification of the practices by the owners of supermarket chains regarding the variables prices and cleaning. **Originality**: Through this research, integrated and sustainable management strategies for green market consumption are formulated for the first time, with the analysis of relevant variables in these aspects and recommendations to shopping centres regarding the requirement of certifications (Security Food, ISO22000, Good Manufacturing Practices in BPMA Foods, Hazard Analysis and Critical Control Points, HACCP). **Limitations**: The lack of information provided and awareness by the commercial centres of the municipality regarding the issue of health of global interest and access to sampling points.

Keywords: data analysis, factor analysis, factor and variable reduction, SPSS software.

Introduction

Currently, the green market is ever expanding and abounds in the city of Bucaramanga, leading to steep competition that continues to increase. In this climate of greater competition, consumer perceptions are of utmost importance when it comes to choosing the best supermarket to shop in (Vargas-Hernández, 2009).

In order to carry out the study, information was collected with the use of surveys to inform the market research and identify the strategic variables for supermarket chains. Marketing techniques, statistics and factor analysis were applied to the data using Google Analytics and the SPSS software package. The amount of data generated necessitates the use of the Statistical Package for the Social Sciences (SPSS) software since it is ideal for detailed analysis of big data (Abuin, 2015) and functions well for factor analysis which is a method of grouping similar variables into dimensions in order to create homogenous groups out of multiple variable sets (Fernández, 2011), thus allowing for the management and recognition of necessary factors to attain sound and reliable results from the study in question.

Materials and Methods

The tools provided in Google Forms were used to carry out a survey covering 13 variables that could reveal the degree of customer satisfaction with respect to green products available in supermarket chains. A scale of 1-10 was defined for each variable mentioned, with 1 being very unsatisfactory; 2, 3, and 4 being poor; 5 and 6 being average; 7, 8, and 9, being satisfactory; and 10 very satisfactory.

Market research- SPSS software analysis. The results produced by the market analysis were run through the SPSS tool by entering the defined variables, processing the survey outcomes, and then finding statistical data to which exploratory factor analysis could be applied through the Google platform. This form was used to survey 106 people in the Bucaramanga Metropolitan Area. The results were then obtained from a tabulation carried out by Google Forms in accordance with the scale for each variable.

Results of the spss factor analysis

The following discrete or independent variables were defined in order to carry out the data analysis:

- Product mix
- Cleanliness
- Customer Service
- Prices
- Quality of vegetables
- Quality of meat and fish
- Location
- Parking
- Store appeal
- In-store signage
- Wait time at cashiers
- Operating Hours
- Environmental initiatives

Table 1. KMO matrix and Bartlett's Test

Kaiser-Meyer-Olkin sampling adequacy measure.	,860
Bartlett's test of sphericity Chi-squared approximate gl	581,999
	78
Sig.	,000

Null Hypothesis: it is feasible to carry out factor analysis on the data set. Source: Own elaboration.

Correlation amongst variables in the study was detected given that the value obtained was significant, meaning above 0,5. The relationship amongst the variables is meritorious since KMO is equal to 0,86. In addition, the null hypothesis can be accepted because the tests show that it is feasible to carry out factor analysis on the variables under study. It can be seen that all the variables being studied are meritorious for applying factor analysis which in turn determines a good sample fit.

Table 2. Matrix of Rotated Components.

	Components		
	1	2	3
Product Mix	,204	,206	,715
Cleanliness	,677	,084	,415
Customer Service	,325	,703	,112
Prices	-,006	,784	,249
Quality of Vegetables	,695	,200	,268
Quality of meat and fish	,786	,078	,109
Location	,185	,062	,770
Parking	,302	,206	,740

Store Appeal	,664	,270	,304
In-store signage	,582	,488	,228
Wait time at cashier	,187	,829	,091
Operating hours	,551	,040	,271
Environmental initiatives	,676	,466	-,034

Data extraction method: Principal component analysis. Rotation methods: Normalization between Varimax and Kaiser. Rotation converged in 6 iterations. Source: Own elaboration.

Based on Table 2 of rotated components, it is possible to see that the 13 variables in the study can be reduced to components 1, 2 and 3 because their rotations are so linear in nature. In addition, these factors tend to group together in accordance with shared traits.

Considering that the sample size for the current study is 106, the factor load used to interpret the factors was that of 0,55 and all variable with a value in excess of this were suitable for analysis in the study. When evaluating the variables based on a factor load higher than 0,55, it was found that the 3 variables that are of greatest importance to consumers include:

- Wait time at cashiers (0,829).
- Quality of meat and fish (0,786) (Food safety, ISO22000, Good food manufacturing practices BPMA, Hazard Analysis and Critical Control Points, HACCP).
- Prices (0,784).

Discussion

In conducting this study, and using the analysis techniques that were applied, it was possible to discover customer perceptions in a quantified way. The data analysis does not show any skewing of the variables and as such it can be concluded that the quality of the study was good.

With respect to the "cleanliness" variable: 72% of the population sampled rated cleanliness in supermarkets to be good and very good when surveyed on this question. At the same time, the correlation coefficient reaches 0,908 showing a good sample fit and quality data. This variable also groups well with component 1 since the factor load is 0,677. In other words, it is important to the study.

Conclusions

Based on the results of the factor analysis, the variable "operating hours" has the lowest value and therefore it is recommended that operating hours be expanded so that better service can be provided and customers use the supermarket more. One of the lowest factor loads is attributed to "in-store signage", and as such it is recommended that distribution is defined in such a way as to preserve perishable goods without generating biases (ISO 14000, Food safety, ISO22000, Good food manufacturing practices BPMA, Hazard Analysis and Critical Control Points, HACCP).

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Data analytics in smart renewable energy networks: ICT TOOLS

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Abstract

Data analytics is a data management technology used for operational planning for integrated industrial and service systems and management decision making. The integration of electricity networks and renewable energies have created management and administration problems that have raised costs for its final users, which have implied integration of digital systems. The aim of this work was to make a theoretical approach to data analytics and business intelligence technologies applied to smart electricity networks with renewable energy. A bibliometric review was carried out with the Scopus digital base and the analysis of two real study cases of the use of data analytics. The results showed the importance of the use of data analytics and business intelligence in the management for electric companies. The document concluded by pointing out how business intelligence and data analytics are being applied in specific cases of energy companies and their importance in decision making. Digital resources of industry 4.0 are shown and integrated in renewable energy processes. The limitation corresponds to the difficulty of accessing to statistical data in the country.

Keywords: business intelligence, data analytics, renewable energy, smart networks.

Introduction

The advancement of ICT in the nascent fourth industrial and technological revolution of industry 4.0, and the significant volume of data generated in the production processes, merits being processed and used as useful knowledge in the management of electric power companies. Through the use of data analytics, the purpose of this work is to make a theoretical approximation of market intelligence and data analytics technologies, applied to an smart system of an electrical network, which facilitates converting data into knowledge for management decision making, beyond business intelligence (BI). The methodology included a bibliometric review in digital databases, giving priority to the most recent and most cited articles on the frontier of knowledge, and its reference to technological trends. The results expose the importance of the use of data, data analytics, BI, as well as its application in smart electricity networks, in the generation of new knowledge for management decision making. The document concludes by pointing out the importance of data analytics, its application in smart electricity networks, in BI in companies in the sector.

An approximation to the state of question

The renewable energies

Some of humanity's most important inventions in recent centuries have been electricity, the combustion engine and the Internet. Electricity is very much the backbone of the productive activities of daily goods and services in most countries. However, a good part of the current sources of electricity generation is finite and exhaustible (Okoro & Madueme, 2004). Thus, environmental and global warming problems are forcing humanity to review the problem related to conventional polluting energies, either by CO2 or others (Panwar, Kaushik & Kothari, 2011).

Smart Grid

The technological advancement of information and communication technologies (ICT) has facilitated the modernization of these electricity networks, a system known as Smart Grid (Escobedo & Arroyo, 2017). Smart Grid is an intelligent system where ICT, sensors and intelligent systems converge in order to make it easy to manage and monitor the process of generation, transmission and distribution of electrical energy. This is defined as: "a modernized network that allows two-way energy flows and uses two-way communication and control capabilities that will lead to a series of new functionalities and applications" (NIST 2010, p. 5). The Smart Grid (SG) network makes it possible to integrate electrical resources from different sources such as conventional energy and renewable energy; technological resources such as automated systems, smart consumer devices, electrical energy storage and data storage. A SG has the ability to collect significant volumes of data of various kinds.

Big Data Analytics in Smart Grids

The innovation of products, processes and procedures is leading to positive impacts on the productivity of companies. Thus, ICT and Big Data are supporting relevant opportunities for the electricity sector to place added value in terms of technical, economic and social gains, however, it is a challenging task. In fact, the improvement of the technologies of the electrical network, measurement and communication, generate important volumes of heterogeneous Big Data from diverse sources, propitiating computational complexity, standing out the need for planning, operational data integration and data security.

Operational and system planning are challenges for companies to make proper use of the volume of data and process it for managerial decision making. The BD infrastructure includes the methodological architecture that facilitates access, processing, storage, management and analysis of the data, as well as monitoring and forecasting the volume of data for decision making.

ICT Tools in Smart Grid and Renewable Energies

The emergence of ICT in the so-called third industrial technological revolution, especially the Internet and software have facilitated the design, structure and management of smart grids and data analytic.

Business intelligence and data analytic

The need for energy companies, to properly manage the different resources has made data and information a fundamental raw material in decision making, suggesting the need to collect, store, organize, process, analyse and correlate data from multiple sources to convert them into new knowledge, necessary information for decision making, planning, predicting, optimizing processes and revaluing them in order to take the necessary actions (Khanna et al, 2015).

Therefore, the combination of software program optimization, intelligent network management, coupled with the application of ICT computing intelligence happen to be good tools for these purposes. BI and data analytics (DA) are shown to be two of the most relevant solutions to the management of Big Data (BI&DA). These two techniques have the ability to transform raw data collected from sources of different kind into useful information. BI&DA also includes practices and methodologies focused on the energy business. With these, high impact applications such as: planning, decision making, cybersecurity and market intelligence in the electricity sector can be achieved (Escobedo & Arroyo, 2016).

Business intelligence and data analysis (DA), or BI&DA is a unified term that consists of data analysis. This concept was introduced in the company as an analytical component around the year 2009-2010. Recently it has been used as an analytical technique for complex applications of big data volumes which require advanced data storage in terabyte and exabyte values, including technological sensors and social networks (Chen, 2012).

The BI architecture process for a company has four phases: data source; data integration; data marts and data presentation (Escobedo & Arroyo, 2016). The first phase, called data sources play an important role, since they affect the integration process. The origin of the data in a company can come from multiple sources, internal and external as well as structured and unstructured information. The internal data can be: historical and operational data. External sources can be: Internet, market companies, consultants, suppliers, etc. Different data sources can be related to different structures. The data can come from several platforms. The organization and preparation of data requires experts in the field for planning and organization. The second phase –data integration– is the process of extracting, transforming and loading large volumes of data, plays an important role in the activity of finding, correcting the quality problems of the data found, before efficiently loading them into the data warehouse.

In phase three of metadata, is related with the BI phase, which is one of the most relevant components: storage or warehouse. This process supports integration, cleaning, aggregation and consultation tasks, it also allows the physical propagation of data, when handling business records for the previous tasks. This phase, commonly known as data mart is made up of several thematic areas, which are organized to be able to provide statistical support for decision making, according to the needs of a specific area of the company. The data pantry is organized to meet specific needs (Watson, 2007).

Phase four is the presentation of the data. The rapid visualization of the information product of the data processing facilitates the dynamic exploitation of the results through the analysis of patterns and atypical behaviours of the data. The BI essentially includes two types of tools: a) analytical processing and b) advanced analysis. The first group corresponds to the analysis in the spreadsheets, application software, specialized business portals, easy access online analytical processing and visual panels, these provide the BI managers the possibility to track ad hoc those key indicators that allow taking timely decisions. The second group includes the so-called data mining, forecasting or predictive analysis, text analysis, and artificial intelligence algorithms. The latter are used to predict certainty measures on specific events (Escobedo & Arroyo, 2016).

Materials and Methods

For its theoretical approach, this bibliographic document applied a bibliometric method using information taken from the Scopus database. The case study methodology was used.

Results

In the following section two study cases are presented in regard of the application of ict in renewable energies.

BI&DA System in an Electric Energy company

BI&DA data analytics was applied in the Mexican Electric Company, most specifically in the Integral System of Occupational Health and Safety (ISOHS). In terms of its structure, the system is composed of: the company's architecture, plus the ICT technology architecture. The first includes the strategic plan of the company and the BP mapping. Meanwhile, the technological architecture comprises definition of the data set and data flow; communication definition; information system management; information systems application management; business management; handling units; security system.

The ISOHS industrial safety system has three sections: infrastructure security and health protection; accidents; and security management (Jacome et al., 2011). In the present case, the system architecture was designed for data collection, preparation and analysis. This was structured as BI & DA-SISST (Escobedo & Arroyo, 2016).

BI&DA for a photovoltaic system

Escobedo & Arroyo (2017) present a case of BI&DA application for a photovoltaic system. This was done with the aim of: being able to make reliable and timely decisions; obtain information on real-time about the ER generation processes and historical data analysis; being able to have timely and flexible information and data, through the control panels; and the improvement on the integration of ER in a Smart Grid network. The case exposes the construction of a Big Data infrastructure to collect the data, store, process, analyse and monitor it in a photovoltaic system. The case exposes the architecture and its connection to the network, as well as the variables that make it easier to measure performance in operational terms of the network. The Big Data system is composed by logical layers. The flow of information is given as follows: data acquisition; data send; data reception; processing; verification of alerts; storage; notification of alerts; and analytics. The application case shows two types of analysis: generation forecast analysis and panel analysis. The latter exposes the performance of the operating processes of the photovoltaic system and an essentially descriptive analysis is shown.

Conclusions

The use of technologies such as data analytics and business intelligence in smart electricity networks, contributes significantly to the generation of new useful knowledge in business managers. In business intelligence processes, there are several important software, the BI being one of the most used in the processes of analysis of important volumes of data. The relationship of BI&DA technologies in the management of the use and application of Big Data shows that it is being used successfully in electric power companies. The limitations were empirical data

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System for performance assessment of solar home systems

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Abstract

Off-grid solar photovoltaic (PV) systems are a good alternative in rural remote areas where access to electric power is limited due to their power grid lack. A successful implementation of a PV system involves knowing and monitoring its performance, therefore this study presents a PV test system for off-grid solar home system (SHS) performance assessment, analysing a case study based on the behaviour of a user's daily demand in the rural area or non-interconnected zone as Hato Corozal, Casanare. Design aspects of the system were also elaborated. Key performance parameters identified to be monitored are solar irradiance, power generation, energy consumption and battery charge status. The sized system satisfies the energy requirement without a batteries depth of discharge deeper than expected, showing the capacity of the system to make studies in longer periods with the possibility of generating different demand behaviour scenarios, which are recommended for strategies development that let improve the PV systems performance. Findings in this study suggest that sizing with appropriate performance parameters allows optimizing factors as associated costs, components operation and lifespan.

Keywords: off-grid, performance, photovoltaic, rural, solar home system.

Introduction

Solar photovoltaic (PV) energy is considered a good alternative for rural remote areas where there is no power grid and for off-grid applications at a small scale, so-called solar home systems (SHS), are used to supply the lack of electric power in developing countries (Salas, Olías, Barrado & Lázaro, 2006). A typical shs consists of solar generator (PV module), inverter, battery bank and charge controller, as well as the connected appliances. Solar PV modules charge the batteries during the daytime to supply the night consumption, while charge controller manages the input and output energy of the battery bank (Lotsch, Goetzberger & Hoffmann, 2005; Mohanty, Muneer, & Kolhe, 2016).

Colombia is a developing country that receives solar radiation almost throughout the year with an annual mean of 4,5 kWh/m^2/day over its territory (Ideam & Upme, 2017); despite having a huge scope of solar energy generation, there is still a lack of energy supply in about 51% of the national territory belonging of remote rural or non-interconnected zones (ZNI for its abbreviation in Spanish) (SSPD, 2018). Less than 3% of the population in the country is supplied with this type of energy, allowing to identify a deficit in the three elements that drive PV development in a country: politics, research and monitoring (Rodríguez-Urrego & Rodríguez-Urrego, 2018). Monitoring the performance and loss factors of PV systems is important to assess overall efficiency and to enhance productivity (Goura, 2014), thus a successful implementation of solar PV system involves knowledge on their operational performance under varying climatic condition (Makrides et al., 2010).

This article presents the design of a PV test system for off-grid solar home system (SHS) performance assessment analysing a case study based on the behaviour of a user's daily demand in the rural area or non-interconnected zone as Hato Corozal, Casanare.

Methods

Energy requirement assessment. To determine the daily energy requirement, E_{daily} (in Wh/day), it was necessary to identify all the household electrical loads with their wattage and the mean amount of time they were used in a day as shown in Table 1. An approximate total power consumption of 0,90 kW and a daily energy requirement of 2,54 kWh/day was obtained, which coincides with the value actually monitored in Hato Corozal, Colombia (Salazar & Muñoz, 2017) and the 2,67 kWh/day reported for rural users (strata 1) in the department of Casanare (Avella Pedraza, 2014).

Table 1. Load and energy requirements assessment

Load/ Appliance	Quantity	Power consumption (W)	Daily usage hours (h/day)	Daily energy consumption (Wh/day)
Lights	6	15	4,0	360
Pump	1	310	0,5	155
Fridge	1	140	10,0	1.400
Blender	1	220	0,2	44
Cell phone	1	6	2,0	12
Radio	1	16	6,0	96
Television	1	50	5,0	250
Decoder	1	15	5,0	75
Fan	1	50	3,0	150
Total	14	822	-	2.542

Source: Own elaboration based on data from (Salazar & Muñoz, 2017).

Load monitoring. Once the sizing and selection of the PV system components was carried out, loads were programmed by timers that allowed to turn them on/off at specific times to emulate the daily load curve. Then, Figure 1 was followed for the connection of the components with the PentaMetric monitoring tool to analyse system performance, which has three shunt that measures hourly current data and two connectors that measures voltage, energy and temperature from: the batteries and PV modules, while for inverter only current was measured, so the energy was calculated considering that inverter voltage is the same as battery bank voltage. Solar radiation was also monitored with a weather station available in the renewable energy laboratory of the Universidad Autónoma de Bucaramanga (UNAB) and monthly data were obtained.

Materials

The inverter charger used is a TECA IIP-241000BF with 1 kW of rated power and 3 kW of surge power, which allows connection to the power grid to receive energy and to charge the batteries while supplying the demand of the charges. The four parallel-connected PV modules are JAP72S01-325SC with a rated power of 325 W.

Then, four Magna MA12-100 batteries were selected: two in series to increase the DC bus voltage to 24 V and two in parallel to increase the capacity of the battery bank(Magna, 2016). The solar charge controller is the Acacia ICM-4024150 with a maximum current capacity of 40 A.

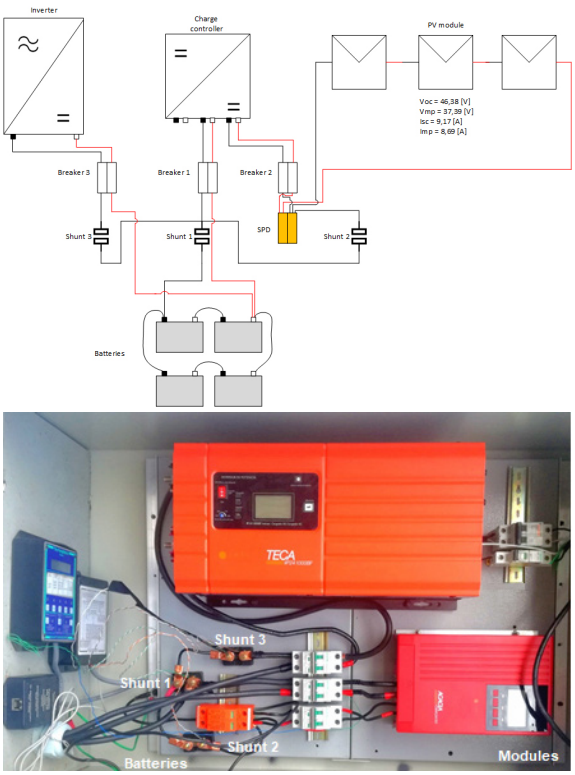

Figure 1. PV system layout and final installation. Source: Own elaboration.

Results

According to the behaviour of the proposed system, the daily load curve emulated for a Colombian rural zone was obtained in Figure 3. The mean energy consumption was 2,41 kWh/day. Figure 2 presents the batteries state of charge (SoC) and its respective voltage. Batteries voltage was maintained in the range of 26,8 to 27,3 V from 10:00 to 18:00 h due to the PV generation supplies loads and charges the battery bank in this period. The peak voltage and highest SoC was presented at 10:00 h with values of 28,4 V and 118% respectively, which happens one hour after the highest generation, as shown in Figure 5. The minimum SoC was 79%, a higher value than the proposed in the sizing.

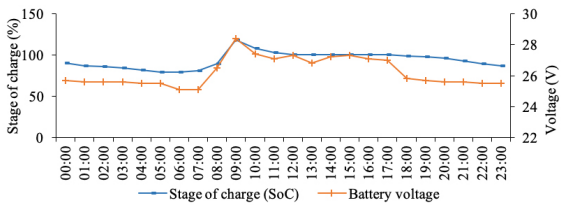

Figure 2. State of charge of battery bank. Source: Own elaboration.

Figure 3 shows the solar radiation behaviour and the PV generation of the system. The peak generation of 587 Wh was reached at 9:00 h with a solar irradiance of 776 W/m^2 and a performance ratio of 0,77. The highest solar irradiance of 864 W/m^2 was presented at 12:00 h and generated 269 Wh with a performance ratio of 0,32 given the low consumption and full SoC of the battery bank. After 14:00 h the performance ratio was in the range of 0,7 and 0,93 with solar irradiance less than 250 W/m^2.

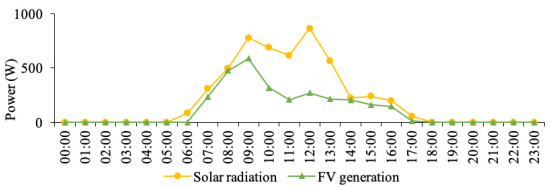

Figure 3. Solar radiation and FV generation. Source: Own elaboration.

Discussion

Some studies have been carried out to determine the performance of large grid-tied systems and off-grid

systems that were already in operation (Shiva Kumar & Sudhakar, 2015; Singh & Kaur, 2018). There are also several projects developed in rural or non-interconnected zones (Florez, Tobón & Castillo, 2009; Hernández, Trujillo & Santamaría, 2015; Rodríguez-Urrego & Rodríguez-Urrego, 2018), however it is not usually found a performance assessment of the system in its different stages, while in literature research there is not enough information available about the performance of solar home systems (Nieuwenhout et al., 2000). Considering this, it is difficult to know if the installed systems are functioning efficiently thus it is being assumed that sizing criteria are precise. Findings in this study suggest that sizing with appropriate performance parameters and having control of those variables that affect the system performance allows to know if the system is under-sized or oversized.

Conclusions

A system for performance assessment of solar home systems (SHS) was designed, sized and implemented for monitoring their performance parameters through measured data such as solar radiation, batteries state of charge SoC and PV generation since most of the studies have been done either for existing on-grid or for off-grid PV systems.

The sized system satisfies the energy requirement without a battery SoC of 79% battery and a DOD deeper than expected. A PR of 0,77 was obtained, nevertheless this value decreased despite having a good solar resource due to a low energy consumption by the loads and the full battery bank SoC. The PR increased after 14:00 h when the energy required exceed the PV generation. When battery bank is under-sized two cases could occur: DOD deeper than expected or PV generation wasted. In this study the second case was presented, while if DOD are higher than expected affects batteries state and lifespan. Oversizing systems causes costs increases due to higher capacities than required.

Findings in this study suggest that sizing with appropriate performance parameters allows optimizing factors as associated costs, components operation and lifespan.

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Business intelligence for the provision of energy services in non-interconnected zones in Colombia

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Abstract

This paper aims to evaluate the provision of energy service in non-interconnected areas in 2018 using open data from the Colombian government and business intelligence methodology. The ETL (Extract, Transform, Load) steps are performed through the analysis of 10 datasets each with 13 Variables with monthly information from January to October 2018. The analysis focuses on the variables: Location of the ZNI, active energy by month, reactive energy by month, maximum power by month, maximum demand day by average daily hours of energy service, average daily hours of no energy service by state. It is concluded that the departments with the greatest deficit in hours of service are those of the Pacific coast and San Andrés and Amazonas those with the greatest demand.

Keywords: business intelligence, data analytics, industry 4.0, off-grids zones, power BI, sustainable development goals.

Introduction

Non-Interconnected Zones (NIIZ) are areas that do not have access to the National Interconnected System (NIS) of energy. In Colombia, these are the municipalities, townships, localities and unconnected hamlets where about 3.04% of the Colombian population lives (Mining Energy Planning Unit –UPME– 2015) and include about 66% of the National territory which, due to geographical and environmental conditions, are isolated from the NIS, where energy to meet the needs of its inhabitants must be generated in the same area.

This paper presents a Business Intelligence analysis of the current status of service provision in Non-Interconnected Zones of Colombia using the quantitative reports of the National Monitoring System available in the open data portal of Colombia.

Data analysis has an important role in generating knowledge, obtaining patterns and predictions important for the formulation of strategies, this the role of Business Intelligence, take the information and optimize it to have greater clarity and thus meet the needs of customers. Within the architecture of the BI it is important that a correct interaction between its components is given. Brannon (2010) describes the importance of four components for this platform, which are explained below: (a) Systems Source: Collect data resulting from different sources obtaining structured and unstructured data; (b) Acquisition of data: process of extracting, transforming and loading data centralized data storage; (c) Data Warehouse: This is the repository where the information that was acquired by the ETL is stored. BI developed effectively, involves having a single reliable data source (Eckert & Sakiri,2015); (d) Reporting and Analysis Tools: allow analyses and representing information, through visualization, statistical or predictive analysis.

Methodology

Data Collection. In this step the object of the study is identified: The state of service provision in different Non-Interconnected Zones (NIZ) that have Telemetry in Colombia monitored by the National Monitoring Center. Ten datasets were taken, each with 13 variables and an average of 80 records of municipalities with monthly information from January to October 2018 (October and November not available). These data sets are obtained from the national government's open data website. For this study, it is of interest to analyse: Location, active energy, reactive energy, maximum power maximum demand day and average daily hours of energy service.

Cleaning. Once the cleaning process of each data set (normalization of data types, obtaining a single dataset, identification of outliers, null fields, empty or not coherent) was carried out, it was stored in a single file with 12135 fields, among which there were 1388 between empty fields and fields in zeros, the latter were eliminated. In the observations column, the reason for the empty fields in different municipalities is explained; most of them were due to damage to the telemetry systems.

ETL (Extract, Transformation, Load Processing). Once the information was organized and consistent, it was necessary to analyse it in order to prioritize the analysis of interest: A) Location of the NIZ; B) Active energy by month; C) Reactive energy by month; D) Maximum Power by month; E) Maximum demand day by average daily hours of energy service; F) Average daily hours of no energy service by state. The Business Intelligence process regarding the provision of energy service in non-interconnected areas was carried out in the Power BI software.

Visualization. For the visualization of the variables mentioned above, samples were taken in different functionalities of Power BI web, such as: Queries written in natural language with the name of the variables of interest, which facilitates the updating of dataset; the option of quick conclusions of Power BI web was used, which provides different visualizations according to the analysis it makes, offering graphs that are mostly consistent with what is being searched for; vertical bar graphs, circular graphs, maps were used.

Results and Discussion

From all the information collected, reports were generated and a dashboard was made, where reports are stored for potential stakeholders.

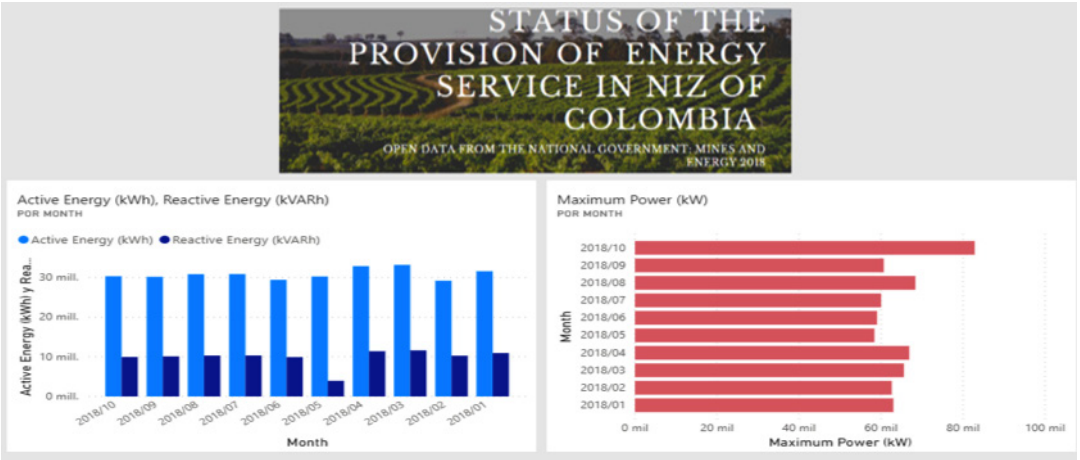

Figure 1. Total Active and reactive energy and Total Maximum power per month in ZNI Colombia. Source: Own elaboration.

It is calculated that the average active energy during the 10 months is 30 million 861 thousand kilo watts per hour (kWh); being March the one with the highest consumption and February the one with the lowest during 2018. For reactive energy, the annual average is 9 million 878 thousand kilo volts-amperes reactive per hour (kVARh), where the month of May, was below the 4 million kVARh as shown in Figure 1. This is justified, because May is the month in which there are more missing data. It is appreciated that the power oscillates between 58 and 69 megawatts (MW) in total of each month, with an average of 64mil kilowatts; for the month of October there is a considerable increase (82 MW), surpassing by more than 10 thousand kilowatts to the previous periods of the year as it is shown in the figure 1. The departments with greater demand of energy are San Andrés, Amazonas and Vichada with 53%, 12 % and 9%, respectively, adding 74 % to the national demand. The largest consumption of both active and reactive energy was in the Department of San Andrés, given that it is the area of high tourist deployment during all seasons of the year (Figure 2). The total reactive energy of San Andrés is well above the active energy averages of all other departments. In addition, it is observed that the average of both energies for Magdalena, Guaviare, Valle del Cauca, Bolívar, La Guajira, Caquetá and Casanare; their values are low, but they have similar averages with respect to both energies, and in comparison with San Andrés or Amazonas, it can be said that it is almost negligible.

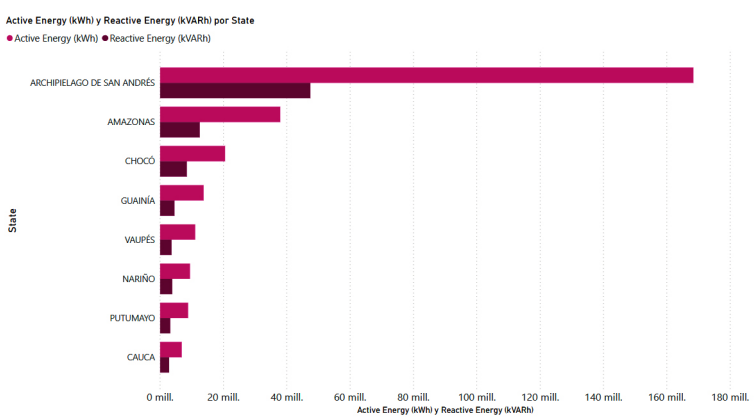

Figure 2. Total active and reactive energy by department in ZNI Colombia. Source: Own elaboration.

In the analysis of the annual total of hours without service by department, Chocó (25%), Cauca (21%) and Nariño (20%) are the departments with the greatest deficit of hours in service provision, accounting for 66% of the national total. The rest of the departments in NIZ are below 6% each, in total hours without energy service per year in the country.

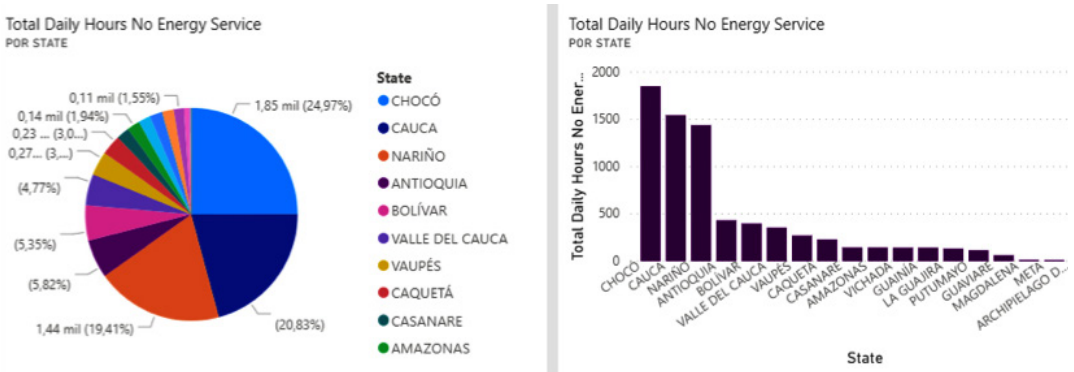

Figure 3. Total Hours Without Energy Service by Department in niz. Source: Own elaboration.

Conclusions

The data collection methodology used to prepare the BI proposal was by obtaining Open Data from Colombia, which facilitates access to the information, but the quality of the data must be evaluated in more detail to generate visualizations and make decisions regarding this information.

To elaborate a BI solution, it must be taken into account what you want to analyse and how stakeholders want to visualize the information, because it is much easier to understand graphs and maps, to have information in hundreds of Excel records or a database.

The above analysis is an important input for future estimates of service delivery in NIZ and the possibility of energy projects that can be developed in these areas for the benefit of communities.

Acknowledgements

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Solar energy harvesting system design for estimation of autonomy energy in a wireless sensor node

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Abstract

This article proposes an energy harvesting system for the design of an autonomous wireless sensor node. In some scenarios, the use of wireless sensor nodes allows the Information and communications technology (ICT) to automate processes. However, their implementation has a high cost, for example, the change of batteries when they run out of power. The objective of this research is to develop a solar energy harvesting system, which guarantee the node to have energy autonomy. For this purpose, we present the design and the implementation of one system that integrates a buck converter, a maximum power point (MPP) control and a wireless sensor node. This system is connected to a solar panel to harvest energy from the environment. In addition, in the implementation of our design, we do measures of voltage at the output of the buck converter and estimation of energy autonomy in the wireless sensor node.

Keywords: energy harvesting system, energy autonomy, solar panel, wireless sensor nodes.

Introduction

Autonomous wireless sensor nodes are implemented in wireless sensor networks (WSN). In the cases where the energy autonomy have been reached, the nodes are used for purposes like monitoring snail activity (García-Lesta, Cabello, Ferro, López & Brea, 2017) or office automation (Abella et al., 2019). In the implementation of autonomous nodes it's common to find three different units that conform it: the unit of sensing and processing data, the unit of wireless communication and the unit of power. Examples of autonomous wireless sensor nodes have implemented rechargeable batteries or supercapacitors as unit of power (Grosso, Rinaudo, Patti & Acquaviva, 2018). Nowadays, one of the most common energy harvesting systems implemented for the purpose of energy autonomy in the nodes use solar panels as a source of energy. These systems require the connection between a converter and a solar panel. Solar energy harvesting systems requires a reduction of voltage, that can be implemented with a buck converter (Faraji, Farzanehfard & Adib, 2017). Autonomous Wireless sensor nodes with solar panel include a MPPT control in order to improve the energy harvesting system function. Implementing this control requires to determine the limits of the control signal and to adapt the parameters of the converters in the energy harvesting system (Chiang, Shieh & Chen, 2008). This paper will investigate the output of a buck converter with a MPPT control connected to a two Li-ion batteries and a wireless sensor node. Furthermore, the paper will expose an estimation about the number of hours that it takes for the design of the solar energy harvesting system to have energy autonomy of the node.

Materials and Methods

The purpose of this article is to present the design of an energy harvesting system of a wireless sensor node. The design consists of an 4.5 W solar panel connected to a buck that reduces the voltage from 10.26 V to 7.2 V. This converter is connected to one sensor node and two Li-ion battery cells of 3.6 V in each one. In outdoor scenarios, the power supplied by the panel depends of the changes of temperature and radiation. In the converter, the ratio between the output and input voltage is presented in equation 1. This ratio is called duty cycle, which guarantees a constant value at the output of the converter, if the correct proportion is maintain between the input voltage and duty cycle (Rashid, 2017).

$$D = \frac{V_{out}}{V_{in}} \quad (1)$$

In the design of the solar energy harvesting system, the node integrates three units and the buck converter in one system, which is suggested by recent developments of autonomous wireless sensor nodes (Abella et al., 2019). The components for the node was based on the design of the Arduino Uno (Rinaldi, Natalisanto, Muliyono & Said, 2019), the components of the converted was design as its shown in Hamid, Rahimi, Chowdhury & Sunny (2016) and the selection of the batteries was done based on the existing models for the batteries of Li-ion (Gao, Chin, Woo & Jia, 2017). In figure 1, the circuit of the autonomous node is shown. In this circuit, the buck converter supplies the Lion cells and the node. This reduction of voltage requires the use of IR2104 to minimize the spikes of current, due to the switching process in the converter. In the design of the solar energy harvesting system, the simulations of different solar panels were done. Each simulation allow us to estimate PV curves and the maximum power point of the solar panels for different values of temperature and radiation. The simulations were done in Matlab/Simulink as indicated in previous works (Bellia, Youcef & Fatima, 2014). This simulations was done to choose the solar panel that can fix the required consumption of the sensor node designed.

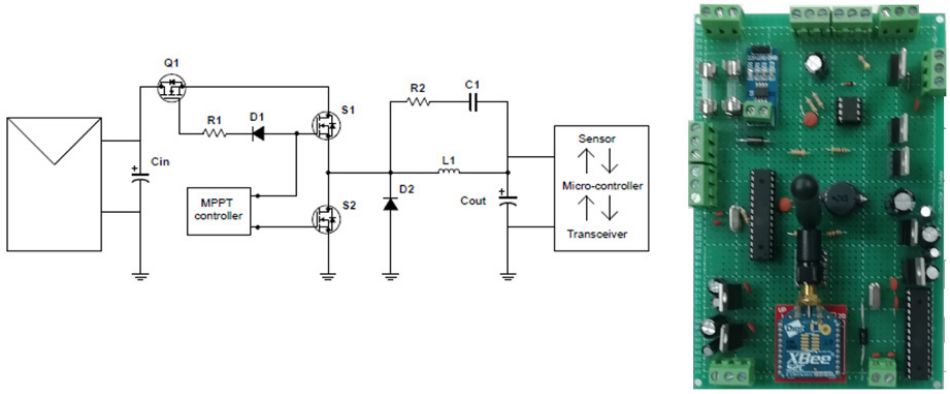

Figure 1. Circuit of the wireless autonomous sensor node. Source: Own elaboration.

Results

The panel used for the autonomous sensor node is 4.5 W. In the converter, the control signal was manually changed in between 50% and 99%. We did measurements that are done in the buck converter with a load of 15 Ω and one Li-ion battery This allows us to identify the limits for the duty cycle as 70 % ≤ D ≤ 80 %. The form of the signal when the 15 Ωresistance is connected to the converter is presented in the figure 4. In the buck converter duty cycles bigger than 90% shows us inductor spikes close to 30% of the output voltage. Measurements for the consumption current of the node and the Li-ion cells give us values of 0.06 A and 0.5 A respectively. The efficiency of the implemented system was calculated as shown in and for our proposed design it gives an efficiency of 50%. The proposed design allows us to estimate energy autonomy for the node if it sends packages each 20 min.

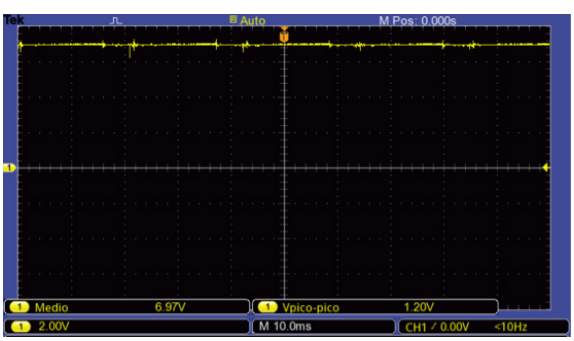

Figure 2. Signal in the inductor for a resistance of 15 Ω as load in the converter. Source: Own elaboration.

Discussion

As a matter of discussion we introduce the topic of the spikes in the signal of the inductor. The spikes presents values close to the 30% of the output voltage of the converter, because it was necessary to compare this values with the output signal of another converter design. This comparison allow us to establish the spikes that can take values of the 22% in order to guarantee a good transition performance of the converter.

Conclusions

This article has presented an energy harvesting system with the implementation of a MPPT control. The system has proved to be useful to determine the real consumption of a wireless sensor node and a pack of two cell of LI-ion batteries. This allows us to define the parameters of the MPPT control and to estimate the energy autonomy than can be reach with the proposed design. In the future, our work will concentrate to improve the efficiency of the implemented system, using a control over the charge of the batteries.

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Industry 4.0. An opportunity for the economic growth

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Abstract

The appropriation of continuous advances in technology is one important activity to improve industries and the economy of a country. This paper exposes a general view of the integration of "Industry 4.0" as a tool to improve the competitiveness of the productive sector. One of the biggest problems improving the productive sector is the misunderstanding of this technological concept and how it can be implemented in its processes. A general structure of the principal technologies used in Industry 4.0 through its three principal areas (automation, software, communication) are presented in this paper, and it is analysed how industrial competitiveness can be structured within "Industry 4.0" exposing the smart factories as the result of this integration, following with the discussion, conclusions and the most important risks detected in this process.

Keywords: colombian industries, competitiveness, industry 4.0, technology adoption.

Introduction

The global economy is going through a new phase characterized by digitalization and connectivity. Technologies such as the Internet of Things (IoT), Cloud Computing, Big Data, Artificial Intelligence (AI), and 3D printing, among others, reinforce the importance of the manufacturing industry through the construction of personalized and intelligent products (Cuquet, 2018; Kovacs, 2018). Therefore, on the improvements in productivity developed by the industries, there is a great opportunity to adopt new technologies and methodologies. Elements such as Industry 4.0 can help to the productive sector of the region in Santander to improve its competitiveness because the economic growth of these industries depends to a large extent on the adoption of new tools to be more competitive. The objective of the article is to describe the broad framework that Industry 4.0 implies due to the lack of knowledge of the productive sector and put forward a future research proposal in Santander.

Industry 4.0

Many people think that Industry 4.0 is something related to video games, the internet, or robotics. As a concept, Industry 4.0 is the current industrial revolution, which consists of the digitalization of industrial processes through the interaction of Artificial Intelligence with machines and the optimization of resources focused on the creation of effective commercial methodologies (Drath, 2014). This implies changes oriented towards intelligent infrastructures and the digitalization of methodologies, consequently, this process will have a more concrete impact on the way of doing business. Figure 1 presents a Venn diagram of Industry 4.0 in which is indicated its three principal focus areas (advance automation, advance software, and advance communications), and into its relationships are contained the different technologies.

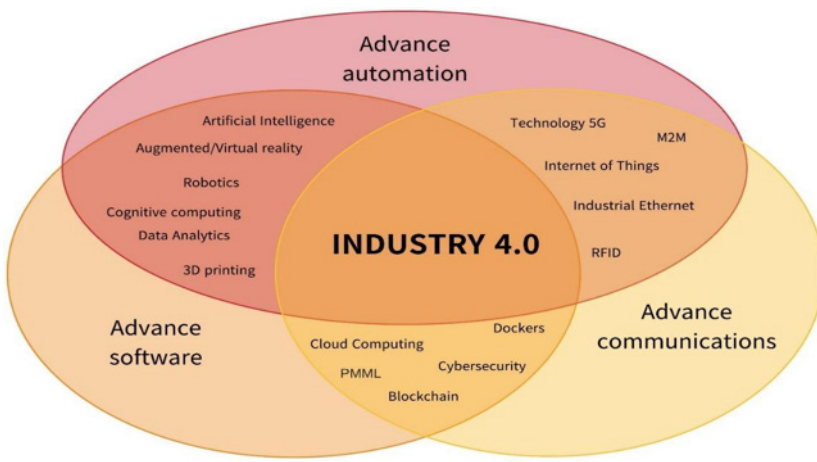

Figure 1. Industry 4.0 Venn diagram. Source: Own elaboration.

The interaction between advance software and advance automation can be observed with technologies and tools such as Artificial Intelligence, Data Analytics, Robotics, Augmented/Virtual Reality, Cognitive Computing, and 3D printing (Fox, 2017). These tools help the productive sector to increase its productivity and develop efficiently new products in which innovation is a crucial component (Lasi, 2014). Furthermore, these tools are related to the interaction of the physical components and software applications in an intelligent way. The interaction between the advance automation and advance communications presents tools such as Internet of Things (Mohammadzadeh, 2018), technology 5G, Industrial Ethernet, M2M (Machine to machine communication), RFID (Radio Frequency Identification), and Industrial Ethernet which are some technological elements that permit a complete interaction and

communication between the components of an industrial process including administrative, logistic, and productive sections. Finally, the interaction between advances software and advances communications give us tools such as Cloud Computing, Dockers, Blockchain (Brilliantova, 2019), Predictive Model Markup Language (PMML), and components of cybersecurity that allows the multiple interchanges of information using different ways and types of communication (Oravec, 2017). The integration of these components can improve business operations and revenue growth, transformed products, supply chain, and customer expectations (Alcácer, 2019).

Discussion

In recent years, concern for the competitiveness of nations has increased significantly, especially in developing countries, where it has become aware of the importance of this factor for economic growth and improving the quality of life of the population (Rensburg, 2019). On the other hand, companies must inexorably improve productivity in existing sectors by raising the quality of products, adding desirable characteristics, improving product technology or exceeding production efficiency (Bolwijn, 1990). An example of the implementation of technologies Industry 4.0 is the case exposed to the machinery-based companies, in which the product does not undergo any manual manipulation during the production process, then the concept of efficiency is of vital importance. Through the Overall Equipment Effectiveness indicator (OEE), is measured the overall efficiency of a production line or a process and quantify all the losses (waste) that prevent it from achieving 100% efficiencies. The OEE is the relationship between the correct product that is produced and the theoretical product that should have been produced (Gibbons, 2010). This case gives clarity of how technologies associated with industry 4.0 can help the industries in the strategy of efficiency and reducing losses. One of the most important elements that are needed in the battle against industry losses is "information". Obtaining the data and processing them is of vital importance. In very early stages, it could be solved with part of the production in paper and spreadsheets, but as it is needed to deepen and make the information more reliable, it is essential, at least, the capture in automatic of the stoppage times and powerful software that cover all the needs and facilitate its analysis. Capturing information through tools such as the Internet of Things, RFID, or technology 5G is very important to analyse the process, using this information as Big Data and applying techniques of Artificial Intelligence, Data Analytics or Cognitive Computing permit to solve many problems and reduce losses in the production systems. Within the losses caused by the availability, the changes of format or model, suppose a high contribution. The lots tend to decrease and the references to increase, so it is essential to reduce the time spent on these changes. It can start with an in-depth analysis of the process of change through the SMED technique (Single-Minute Exchange of Dies), to finish with the development of a standard that minimizes time. Implementing Smart Glasses, they can leave the hands of the operator free and show the necessary information to help the latter perform the work according to the standard. Also, can be used the Augmented Reality with cameras that record all the changes and through complex algorithms based on Artificial Intelligence could propose improvements in the procedures. Another example is losses associated with poor maintenance that can also be reduced with proper management. Faults that cause loss of availability, and degraded performance that causes loss of performance, can be reduced with proper maintenance management. A great advance, which until now has been very limited, is offered by predictive maintenance, which allows preventive actions according to the real state of the machines and therefore exhausts the useful life of the components. Implanting the corrective beyond the analysis of vibration or term-graphic studies leads industries to the use of Cyber Physical systems, the Augmented Reality or the Big Data to relate productive events, with performance histories or with autonomous sensors that allow monitoring important variables. Furthermore, the use of fault diagnostic techniques based on Artificial Intelligence in the supervision tools of the process can reduce the probability of accident occurrences, micro-stops, and failures caused by bad operations (Vásquez, 2017). Smart factories are an important option to improve the competitiveness of the industrial sector. As was exposed, the term IoT describes the technologies that connect objects, from consumer electronic components to industrial components, to the Internet.

Meanwhile, the Industrial Internet of Things (IIoT) refers specifically to the impact of this innovation on industrial applications, furthermore, the three key capabilities of smart factories are remote monitoring, predictive maintenance, and process optimization (Uchihira, 2015). Remote monitoring: The visibility of the operational status of the machine components (both historical and real-time) allows plant managers to remotely monitor and diagnose systems quickly, as well as identify and resolve problems before they impact on machine availability and productivity compounds. Predictive maintenance: The predictive analysis allows more precise planning of the maintenance of the machine, which can help to reduce the time of inactivity of the machine, increase the mean time between failures (MTBF); and reduce the costs of unnecessary preventative maintenance and spare parts inventory. With predictive maintenance, much of the guesswork is eliminated because maintenance decisions can be made based on historical and real-time data from the machine itself. For example, wireless vibration and temperature sensors can detect signals of misaligned, lose or worn parts in a machine. Wireless sensors transmit that information to a wireless controller that makes the data available immediately (via text or email alerts) and for long-term analysis. Process optimization: The interconnectivity provided by IIoT technologies allows seamless communication between machines, components, and people. This interconnectivity allows the optimization of processes based on data-increasing efficiency and productivity. For example, a wireless notification system can be used to alert managers and technicians needed on the line, reducing the need for technicians and managers to constantly review each production line and for workers to leave their positions of work when they need assistance. A system like this could be configured for an operator to press a button or turn a switch to alert the manager or technician that is necessary for the production line. A light turret connected to the gateway exits would then indicate which production line needs attention from a manager and colours could be assigned to indicate the need for a technician (yellow) or administrator (red). Using a wireless network of connected devices to streamline communications, managers, technicians and line workers can use their time more efficiently and productively. Similarly, a wireless solution can be used in pick-to-light and part-calling applications. All these tools mentioned permitting the industries to be more competitive.

Furthermore, every year companies invest millions of dollars in technology or tools related with Industry 4.0, investments that can be optimized by means of one accompaniment and consultancy that help the industry to determine which technologies to acquire and how these can be adopted in order to obtain the best benefits. Including the academy and the scientific sector in this process, supporting dynamically this working to the rhythm of the industry. In Colombia, the investment of capital per capita in all companies of Santander had an average nominal growth close to 0% between 2013 and 2016 (5% without considering the oil sector), while at the national level it was 7%. In addition, in this variable Santander ranked 16th out of 24 departments in the Annual Manufacturing Survey (AMS). The highest rates were recorded by Bolívar and Meta, with 48% and 24% respectively (Santander competitivo, n. d.). Therefore, on the improvements in productivity developed by the industries in Santander, there is a great opportunity to adopt new technologies and methodologies.

Conclusions

Industry 4.0 is here and it would be wise to take the advantages it offers to improve businesses. It is detected as a great ally in the search for value and excellence through these new technologies. For those industries that are evaluating how to start, it can be considered, as an alternative, to start step by step according to its more important needs. One of the most important actions is to develop a study or research that includes a deep analysis of each productive sector and sub-sector (OIL&GAS, Energy, Agro-Industry, Health, Manufacturing, between others) in the region of Santander. The most important risks detected in this process are the following seven: First, not having designed a plan in which, in an orderly manner, try to solve the main problems that are previously detected and quantified; prioritizing is essential. Second, try home solutions, which will need a great internal effort that not always can be provided and that lengthen the process forever. These solutions often lead to deep disappointments, time losses, and significant costs. Third, not considering the starting

point and the human resources available. The current templates must be formed and recycled, one new incorporation must have a different profile to the one that should be foreseen. Fourth, get carried away by inclinations or trends in the sector that have nothing to do with its real needs. Fifth, avoid the letter to the wise men. In the conceptual phases of the project, industries tend to conceive all kinds of needs and all of them seem vital to them. Sixth, leave the supervision of the plant in the hands of technology and forget about the importance of living the processes close and near to the machines, and finally seventh, running too much and saturating the organization.

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Methodology based on gamification to improve the teaching-learning processes towards the challenges of sustainable development in primary, secondary and Engineering students

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Abstract

Introduction: The teaching-learning process of the challenges of sustainable development, is currently an isolated element of the curricular plans. With this research, it is proposed to make an improvement supported by a playful methodology and videogame. **Problem**: Lack of knowledge of the sustainable development goals and its little importance in the teaching-learning processes have diminished the progress in proposals from the academy to contribute to solutions to the country's challenges. **Objective**: Create a methodology and s videogame that contribute to the improvement of the teaching-learning process towards the challenges of sustainable development. **Methodology**: The research is framed in a methodology of constructive relationship between teachers and students, allowing both to explore common ideas about the challenges of sustainable development that exist in Colombia and its possible solution. **Results**: Improvement of the teaching-learning method, through a methodology supported in gamification, consolidate in a videogame. **Conclusion**: This project will generate solutions and strategic routes to face the challenges of the Country, having a structured knowledge of the objectives of sustainable development. **Originality**: This project is original and born from the needs observed by researchers in academic, business and industrial works at national and international level, and the absence of knowledge and ownership by young people about the challenges of sustainable development. **Limitations:** The Project had no limitations.

Keywords: challenges of sustainable development, gamification, methodology, teaching-learning process.

Introduction

Human beings have a great capacity for rationality. This has allowed us to question ourselves for centuries about the phenomena that influence the process of teaching and learning, from an evolutionary perspective. Jaffe (2007) stated: "The rational thinking of human being has adapted to catch the objective reality in which he lives and also the phenomena with which he interacts". In the world today, the inconveniences that affect the economy, peace, education, and the environment are a reality, that is why nations have framed the challenges of sustainable development to improve the quality of life and conditions for a good life. Colombia is no exception and, in various ways, situations that require solutions to challenges are presented and needs of the community. It is appropriate to mention that creativity is much stronger at an early age, curiosity, the capacity for wonder in children and young people allow to generate hypotheses to challenges. These skills and/or competences rely on a learning process or teaching model. The aim of the research project is to create a methodology supported by the technique of gamification and videogame software to teach and learn about the challenges of sustainable development building collaborative teams solutions to the country's challenges.

Methodology

The project applies a mixed research methodology, where quantitative elements are combined with the grounded theory and qualitative elements. Which, in an articulated way, consolidate the creation of a methodology to improve the teaching and learning process of sustainable development goals and a videogame software. Which in will allow young people to collaboratively propose solutions to the challenges of the Country.

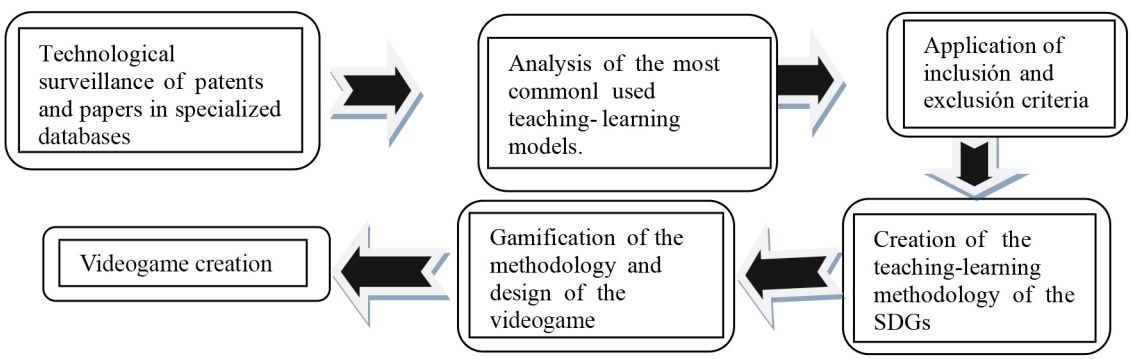

Figure 1. Mixed research methodology. Source: Own elaboration.

Technological surveillance of patents and papers in specialized databases

In this phase of the Project, it was possible to observe and analyse the scientific, technological environment and the present and future impacts of technology (Escorsa, 2001). For this purpose, the following databases for patents were used as search engines: Google patents, patentscope, uspto, carrot 2 and for the search: Proquest, Springer, Science direct, Scopus, Dialnet, articles in order to understand the relationship that may exist between the teaching-learning model and the objectives of sustainable development, in a period of the last 5 years (2015 to 2019), with surveillance a role of detection and observation is achieved, patent surveillance is highlighted as a source of technological information as a resource of structured information and for the exclusivity of its contents since it is estimated that more 80% of the current technical knowledge is contained in the patent documentation (Muñoz, 2006), from the searches performed, the results are shown in the next table.

Table 1. Results of technological surveillance.

Database	Results "Teaching learning model" Number of documents	Results "Sustainable development goals" Number of documents
Google patents	**58.100**	**13.300**
Patentscope	**2.344**	**17**
Carrot 2	**119**	**126**
ProQuest	**777.707**	**1.075.474**
springer	**342.269**	**174.149**
Science direct	**121.052**	**319.238**
Scopus	**37.744**	**25.144**
Dialnet	**3.397**	**639**

Source: Own elaboration.

Analysis of teaching-learning models

With the results of the technological surveillance, an information profiling through some guiding search questions (table 2) was carried out, in order to provide clarity to the research process and to consolidate an analysis of the most common teaching-learning models.

Table 2. Search questions.

Search questions	Motivation
Q1: Which are the contributions of the scientific community against the teaching-learning model?	**Identify the most representative concepts and theories against the teaching – learning model**
Q2: What technological tools are combined between the objectives of sustainable development and the teaching-learning model for minors and young people?	**Classify relevant technological tools for the teaching-learning process focused on the challenges of sustainable development.**
Q3: How a videogame can improve the teaching-learning of sustainable development goals?	**Measure the impact of the operation of a videogame for teaching-learning focused on the challenges of sustainable development.**

Source: Own elaboration.

Inclusion and Exclusion criteria

With the analysis performed, the information was filtered by defining criteria for inclusion and exclusion. The inclusion criteria define the characteristics that link the paper or patent against the research approach. The following are taken:

CI1: The paper or patent proposes an approach to the purpose of research.

CI2: The paper or patent raises an articulation between the teaching-learning model and the challenges of sustainable development.

CI3: The paper or patent mentions a technological tool or videogame for the teaching-learning model of and content towards the challenges of sustainable development.

Exclusion criteria were raised as follows:

CE1: The document does not approach the research topic raised.

CE2: The paper or patent does not propose any solution or approach to the research topic.

CE3: The paper or patent does not mention the keywords or does not approach the subject of research.

Results

It will be expected with the research to directly improve the teaching-learning model oriented towards the challenges of sustainable development, with the possibility of applying the playful methodology in different scenarios, covering a large number of children and young people that articulate in collaborative work, propose and provide structured solutions and aimed at the challenges of sustainable development, the methodology and a videogame will be the results that allow the proper articulation of the object of the investigation.

Conclusions

The concern of the different nations around the behaviour and characteristics of the challenges of sustainable development have generated a boom in planning and transformation in the face of postulates that help find innovative and context solutions that involve new generations. Knowing about teaching-learning models and orienting them towards the challenges of sustainable development, allow to increase the knowledge and the possibilities of mitigating the effects and consequences of the challenges. Properly used videogames are an adequate mechanism to strengthen the competences and skills which enhances creativity and soft skills.

Acknowledgements

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Methodology for modelling photovoltaic arrays based on simulated data for fault detection using machine learning

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Abstract

The present article presents the development of a methodology for the monitoring of direct current (dc) delivered by photovoltaic (PV) systems. The modelling of an artificial neural network (ANN) training-based PV system to solve a non-linear regression problem is shown in detail. The goal of this research is to estimate the current output in a PV system from weather conditions (irradiance and temperature) and voltage in its terminals, this is so that the comparison between measured and estimated current can be done in order to be able to detect system failures. The model found was trained using data obtained from simulations. The system's assessment gives an error percentage below 1.36% for the test data, which is a lower error compared to other approaches in literature. The proposal and assessment are composed of three PV modules, but the methodology can be applied to an n-module system. Lastly, it is expected to implement and assess this methodology in real modules for future works.

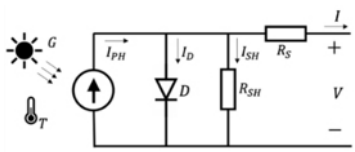
Keywords: artificial neural network (ANN), photovoltaic (PV) modelling, solar energy.

Introduction

The harnessing of renewable energy is a challenge that draws the attention of researchers around the world; solar and wind energy are power sources that have drastically diminished the use of conventional fossil fuels due to their environmental friendliness, sustainability, safety, and zero CO_2 emissions (Pierdicca et al, 2018). According to Kabir, Kumar, Kumar, Adelodun & Kim (2018) the power capacity worldwide with PV systems increased from 138 GW in 2013, to 227 GW in 2015, however, these systems are out in the open meaning they are continuously exposed to adverse weather conditions which might affect the system's performance. Energy losses are, annually, close to 19% due to different flaws, as shown in Firth, Lomas & Rees (2010). For this reason, it is important to monitor the system for fault detection and diagnosis. Now, for fault detection in PV systems, it is started with the system's model so that its behaviour can be predicted and compared with the real behaviour. This article proposes an ann training-based methodology to determine the system's model.

Related work

The most commonly used mathematical model for predicting the energy production in photovoltaic panels is the One Diode Model (ODM), based on Madeti & Singh (2018) and Harrou, Sun, Taghezouit, Saidi & Hamlati (2018; see Figure 1).



$$I = I_{PH} - I_0\left(e^{\frac{q(V+IR_S)}{nk_BT}} - 1\right) - \frac{V + IR_S}{R_{SH}}$$

Figure 1. One Diode Model (OMD) of PV module. Source: own elaboration.

The ODM relates the resulting current (I) and voltage (V) of the PV module according to the module's parameters and are presented in Equation (1), where I_0 is the saturation current in diode D, n is the quality factor of the diode, q is the electrical charge of an electron, T is the solar cell's temperature, R_S and R_{SH} are the series and derivation resistances respectively, and, lastly, I_{PH} is known as the photogenerated current. The ODM depends on five parameters not given by the PV module manufacturers (I_{PH}, I_0, n, R_{SH}, R_S). Research has shown different approaches to extract these five parameters. In Harrou et al. (2018) three different ways are mentioned: analytical, iterative, and evolutionary computational methods, as presented by Tamrakar & Gupta (2015); Subudhi & Pradhan (2011) and Madeti & Singh (2018).

Model development

The proposal presents an evolutionary computational approach, where reports a methodology for current (I) estimation from PV system's measured irradiance (G), temperature (T) and voltage (V) information. A three-module PV system connected in series is exhibited in this case, as can be seen in Figure 2a, in each of which irradiance and temperature are measured. It is worth mentioning that irradiance and temperature could be measured zone-wise instead of module-wise in cases where a large number of PV modules are presented. The estimation of the value for the current (I) is needed to solve this issue, working on it as a non-regression linear problem using ANN.

Figure 2b depicts the implemented ANN; this is a fully connected 4-layer neural network Therefore, the estimated output is the result of forward propagation and is given by:

$$\hat{I}_{1\times1} = \mathrm{G}_3\left(a_{3,1\times100}w_{3,100\times1} + b_{3,1\times1}\right)$$

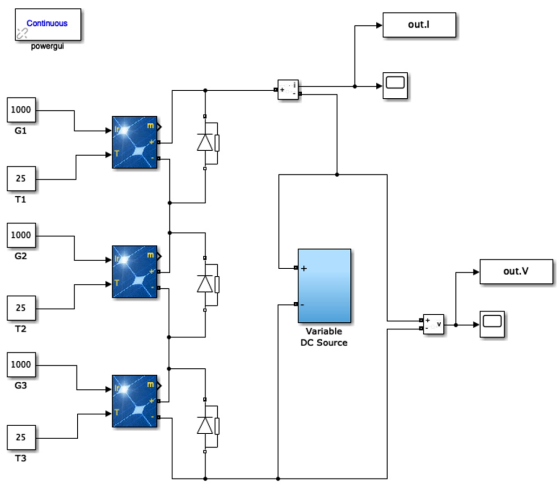
With: $a_{3,1\times100} = \mathrm{G}_2\left(a_{2,1\times100}w_{2,100\times100} + b_{2,1\times100}\right)$

$$a_{2,1\times100} = \mathrm{G}_1\left(X_{1\times7}w_{1,7\times100} + b_{1,1\times100}\right)$$

Where w_1, w_2 and w_3 represent the parameters, or weights, of the NN, b_1, b_2 and $b3$ are the NN's bias and $G_1(z)$, $G_2(z)$ and $G_3(z)$ are ReLu-type activation functions which are described as follows:

$$G_1(z) = G_3(z) = \begin{cases} 0 & z < 0 \\ z & z \geq 0 \end{cases}; \quad G_2(z) = \begin{cases} 0.001z & z < 0 \\ z & z \geq 0 \end{cases}$$

PV architecture



Proposed neural network

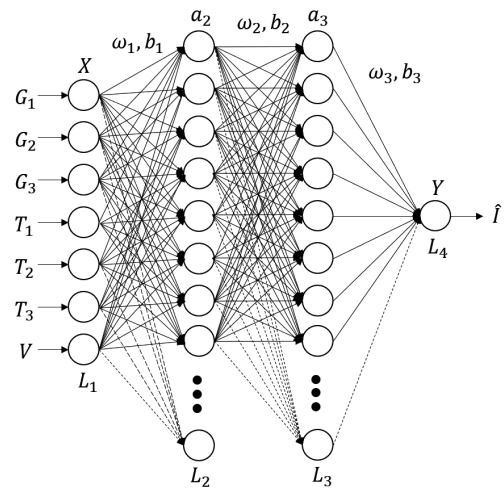


Figure 2. Implemented architecture. Source: own elaboration.

Thus, the optimum values of w_k matrices and of b_k vectors are obtained in a way such that the applied cost function (J) is minimized:

$$\underset{w,b}{minimize}\ J = \underset{w,b}{minimize}\ \frac{1}{2m}\sum_{i=1}^{m}\left(\hat{I}^{(i)} - I^{(i)}\right)^2$$

Where m is the number of samples obtained from the training set, Î and I are the estimated and measured current respectively. Lastly, the parameters are adjusted applying the back-propagation algorithm and the Adam optimizer.

Results

The simulation is carried out using PV modules with the following electrical parameters for standard test conditions (STC): Peak Power (P_max) = 100 W, Voltage at Max. power (V_{mp}) = 18.7 V, Current at Max. power (I_{mp}) = 5.35 A, Open Circuit Voltage (V_{mp}) = 22.3 V, Short Circuit Current (V_{mp}) = 5.69 A, Cell number = 60 and Standard Test Conditions (STC) = $G = 1000\frac{W}{m^2}; T = 25\,°C$.

The dataset was generated with the assistance of MATLAB's Simulink tool and the Specialized Power Systems toolbox, and the scheme shown in Figure 2a, for which different simulations were performed varying the different characteristics. A total of 945472 samples were obtained, this training set is randomly distributed and separated into two groups: 80% of samples for training and 20% for testing. Table 1 shows the hyper-parameters applied to the network and Figure 3 reports the behaviour of J for the training set and the testing set.

Table 1. Hyper-parameter values for ANN

Hyper-parameter	Value
Training Samples	756378 Samples
Test Samples	189094 Samples
Learning rate	0.001
Neurons in hidden layer one ()	100 Neurons
Neurons in hidden layer two ()	100 Neurons
Epochs number	150
Batch Size	2000

Source: own elaboration.

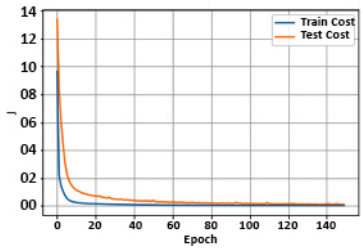


Figure 3. Training and testing costs. Source: own elaboration.

Otherwise, Figure 4 presents system's responses to different simulations, both for measured and estimated values. Figure 4a shows a simulation for the same weather conditions in the three PV modules, and Figure 4b visualizes the model's behaviour under different irradiance and temperature conditions in the PV modules.

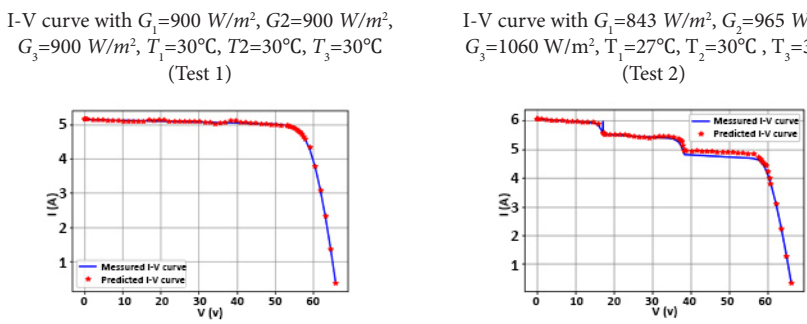


Figure 4. Measured and predicted I-V characteristics under different test conditions. Source: own elaboration.

Finally, for the assessment of the system's accuracy on tests 1 and 2 depicted in Figure 4, Figure 5 shows error percentages between the obtained results from the proposed model and the measured values from the simulation are compared as defined by equation (7).

$$\%error_i = \frac{\left|\hat{I}_i - I_i\right|}{I_i} * 100\% \quad (7)$$

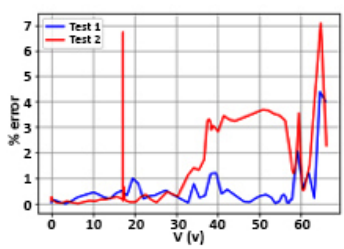


Figure 5. Error percentage for tests 1 and 2. Source: own elaboration.

Therefore, an average percentage error of 0.40% for test 1 is calculated, whereas an error of 1.36% for test 2 is calculated.

Conclusions

A methodology obtaining a mean square error below 2% between measured and estimated values for test data is presented. This shows that the model has a very good behaviour for a non-linear regression problem. An alternate way of modelling the behaviour of PV modules is proposed. For this case an ODM is not used, but a model from ANN is instead created. This instance does not depend on manufacturer's parameters; the accuracy of the system depends only on an appropriate training data set. Moreover, the system is found to behave very fittingly in simulation. Figures

4 and 5 showcase two situations; the first situation comprises small changes in weather conditions and gives an error of 0.4%, whilst the second situation is comprised of changes in weather conditions and the error given is 1.36%. The former corroborates that the methodology employed is an excellent alternative to the models found in literature.

Acknowledgement

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Toolbox (software) for teaching and learning training research aimed at the appropriation of renewable energies in educational institutions in the city of Popayán

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Abstract

The current environmental problems are affected by the implementation of pedagogical strategies that, from educational scenarios, promote that people adopt a responsible and committed position to the care of the environment. **Problem**: In this sense, it is found that the formative research has been neglected by the education centres and this has generated problems of understanding about the importance of taking care of water, energy and the environment. **Objective**: This work addresses a systematic review of information and its subsequent consolidation through a technological diagnosis on the relevance of a software prototype called "Toolbox for formative research and the appropriation of renewable energies". **Methodology**: The technological diagnosis for the creation of the toolbox (software) for the teaching and learning of formative research aimed at the appropriation of renewable energies was based on information from a mixed methodological proposal, which combines statistical analysis and theory based on observation exercises and narrative analysis. **Results**: With this project the route of creation, development and subsequent implementation of the toolbox (software) is proposed, taking advantage of the formative research that offers comparative and competitive advantages for the teaching-learning model in middle and higher education centres; it fosters a constructive relationship between teacher-student, allowing both to explore and create under common ideas that makes it possible to contribute to sustainable environmental development. **Conclusion**: The appropriation of renewable energies at an early age, allows a higher level of development and creativity that allows educational institutions to strengthen their teaching processes, and also affects the ease of learning and capturing processes and procedures by students. **Originality**: The project is original and complies with the research lines of the PSIEDU group that is strengthened in processes aimed at educational improvement, the authors are responsible for the use of the bibliographic material and the recognition of the copyright of the documents used in the exercise of the draft. **Limitations**: The document has no limitations, the processes are carried out within Colombian standards for education, training research and work with children, according to the bioethics processes of the Universidad Cooperativa de Colombia.

Keywords: formative research, renewable energy, technological diagnosis, toolbox.

Introduction

The world and its current conditions require different strategies and dynamics to understand the reality of energy consumption and all the damage it generates in community settings. The issue of climate change, air pollution are factors linked to the absence of knowledge and appropriation of the concepts, elements and procedures that are carried out as alternative options to the generation of energies, among them and those that are worked within this project are known as renewable energies.

Problem

In the educational institutions of the city of Popayán, there is an absence of knowledge about the concepts, procedures, techniques and components that can allow the appropriation of renewable energies and their use. There are also serious shortcomings in the way which is adapting formative research and the roles assumed by teachers and students. Formative research is the process through which professors and students undertake together the task of seeking answers to scientific procedures and processes which (Oliver, 2014), in an articulated didactic and pedagogical way, and with a sequence of defined steps, allows to strengthen a teaching-learning model through the curriculum. On the other hand, it is essential to know that scientific creation with rigor, requires fostering positive attitudes towards research, which demands from teachers and students to assume this process as a Right (Aldana & Joya, 2011), which underlies an obligation.

Results

This work addresses a systematic review of information and its subsequent consolidation through a technological diagnosis on the relevance of a software prototype called "Toolbox for formative research and the appropriation of renewable energies".

As a result, the creation path for software development and its subsequent toolbox implementation (software), in middle and higher education institutions, is presented, taking advantage of formative research that offers comparative and competitive advantages for the teaching-learning model in middle and higher education centres; it fosters a constructive relationship between teacher-student, allowing both to explore and create under common ideas that makes it possible to contribute to sustainable environmental development.

Discussion

At the academic level there have been many discussions between what is taught is science or research, but is also important to stop to think What kind of research? Bunge (1967) says that the human being continuously seeks to understand the world and the situations that surround it, in order to improve its comfort and living conditions, according to that contribution to that transformation of ideas they are called "science". On the other hand, Aldana & Joya Ramírez (2011) mention that it can be described as a rational systemic, accurate, verifiable and feasible knowledge; concluding that science can only be carried out through research, a process inherent to the human being, linked to the tendency to find a logical sense for the events that surround it and give answers and solutions to problems that arouse their interest (Stenhouse, 2004). Formative research, on the other hand, is understood as a problematic and critical attitude of learning, teaching and curriculum development, both in the school environment and in educational practice, which is intended for the production and use of knowledge in a particular and contextual way, very close to the participants; creating a relationship of mutual complementarity where students, teachers and institutional actors (fathers and mothers, administrative staff and public policies) play different roles, based on the above, formative research is the academic scenario that can contribute to mitigate the lack of knowledge of the concepts, words, procedures, techniques and elements that allow the appropriation of renewable energies in today's world and especially for the academic institutions of the city of Popayán.

Conclusions

The educational institutions of the city of Popayán require a way to be able to teach in a structured way and in collaborative work within a problem-solving attitude or through problem-based learning and learning criticism such as strengthening their curriculum and the way in which to produce content

for the appropriation of young people today, on the other hand there is the teaching and development of the concept in the face of a critical, creative and purposeful analysis that allows students to land the general knowledge to a particular one and be able to understand solutions that improve the conditions of the use of energy, water and the mitigation of climate change and greenhouse effect among others.

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Design a virtual power plant for the control and administration of plants and renewable energetic infrastructure in the Colombian environment

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Abstract

This paper is result of the project named "design of a VPP in the Colombian environment". **Problem**: The optimal management of the supply and demand of energy produced by renewable energy projects is important. Here the question is how to manage, distribute and make the most out of unconventional generation in independent projects by different infrastructures In the Colombian environment. **Objective**: Design a Virtual Energy Plant for the management of renewable energy plants with isolate infrastructure, with an algorithm for managing the distribution of energy load, considering environmental conditions and energy demand in Colombia. **Methodology**: Understand and define the requirements of the environment where it will be implemented the research, and a review of the optimization algorithms, definition of test scenarios and simulation of the determined parameters. **Results**: A design of a VPP is achieved with an algorithm that improves the efficiency in the distribution and management of renewable energy of small prosumers in the Colombian environment. **Conclusion**: Centralized control for a defined network area can immensely optimize the planning process, operation and allow generation process movements (active and reactive power control) by involving the VPP control centre. **Originality**: This research proposes VPP development and algorithm formulation, it is the first time it has been proposed for the Colombian environment. **Limitations:** Definition of communication models to interconnect the different prosumers and the collection of information on energy and environmental conditions in the Colombian environment.

Keywords: optimization, renewable, virtual power plant, VPP.

Introduction

Within the worldwide needs and requirements associated renewable energy generation infrastructures, there is a deficiency associated with the administration and optimization of the supply delivered, generating points regardless of the technology used. Taking as an example some countries such as Germany and Australia, a line of work is observed to address these needs with developments focused on virtual controls based in exchanges from which interconnections of different plants and independent infrastructure are made, and where centralized algorithms are also run that allow optimizing the supply and distribution of energy taking into account analysis of environmental behaviours, and conditions of supply/demand, carrying out control over each point in the field.

In Colombia, there is currently another vision. It is observed that the majority of renewable energy infrastructure is focused on self-consumption, and this is also observed in different analyses on the national interconnected system where we find that only 1% of the country's energy was supplied by unconventional energy. However, it is expected that thanks to the regulation of Law 1715, which gives tax incentives to investments in renewable energy, the path opens up for more alternative energy projects to be generated, the above makes important the optimal management of the supply and demand of energy that these new projects will produce, where the question "How to manage, distribute and make the most out of the unconventional generation in independent projects and infrastructures?" is prompted. This question projects a line of research seen in the development of this virtual management in the in Colombian environment, where it is possible to perform analysis and optimization of energy supply processes, where we have analysis of environmental behaviours that can affect the generation of energy in the different areas of the country and that allow adjustments and control of the operation of the different areas to be possible supply the required demand.

Materials and Methods

It were taken different develops and researches worldwide with the objective of supporting the idea application and have a baseline of the information. From these, is possible to define different proposals for the creation of VPPs model with their respective optimization algorithm where we find, stochastic and deterministic models (Montes Ruiz, 2015), and heuristic and mathematicians models (Han et al., 2019), baseline on which an evaluation is carried out for determine which of them apply to the conditions defined in the Colombian environment. In addition to the above, it is considered a sample where used information and data generated by the projects on which the university works in different regions of the country. About atmospherical and climatic condition the data from weather system is taken to be considered in the evaluation of the algorithms based in studies developed on Italy (Caldon, Patria, & Turri, 2004; De Filippo, Lombardi, Milano & Borghetti, 2017).

To determine the charge and efficiency for the solar panels thermic and photovoltaic, it was used the algorithms developed in the Project "Virtual Power Plants" (Montes Ruiz, 2015), and doing adjustments to the electrical demand profile model found in research in China (Xiao et al., 2018) is adapted to Colombian conditions.

The methodology used for the development of the project is the Agile methodology is SCRUM, for its characteristic of agile methodology and in search of early victories and short-term results.

Results

The result of the research was the design of a virtual power plant in the Colombian environment, where communications conditions, implementation of IoT philosophy, geographical environment and environmental conditions were taken into account, as well as definition of requirements where we find the use of Cloud for storage and handling of information, it presents an advantage in the reduction of physical equipment and infrastructure required for implementation.

With regard to the management of algorithms with this definition, a load distribution and energy supply model is achieved, with which optimal service and energy addressing can be performed with the different renewable energy prosumers within the supply network taking into account SmartGrid philosophy (IBM, 2005).

The optimization algorithm finally is a combination of the different algorithms found in the research, during the definition and develop, it was found that

a single algorithm doesn't support the full research. The different algorithms individually solve part of the objectives, therefore is necessary to implement a multiple algorithm able to use all concepts, when apply the economical algorithm, mathematical algorithm, and simulator algorithm, is possible obtain an result approximate to optimization useful in Colombia. In the research will hope found a strategy to supply the diary energy demand using renewable resources.

Discussion

During the development of the project, a variety of advantages are identified. The most representative advantage was the programming information available to the system operator due to the centralized control for a defined network area. This can immensely optimize the planning and operation process and allow interventions in the generation process (active and reactive power control) by involving the VPP control centre, without having an expensive excess of direct communication with each small unit. A way to maximize this concept is designing an optimization algorithm oriented operational concepts by optimal identification of prices under changing market conditions and environmental condition, taken in consideration the information about location and day-ahead scheduling. Checking other results in Germany, Australia and China similar results are found, which indicates a good way to this research. However, there are many technical flexibilities like active and reactive power adjustments of decentralized generation units as well as storage systems, which can partly solve the uncertainty problem of demand and volatile generation forecast as well as the contribution of system services. The limitation of VPP develop is the communications. In this research, an investigation on this is no carried out, because it only analyses the conditions and requirements to communication IoT, and propose like an option by research and develop to continue the VPPs philosophy.

Conclusions

In Colombia, the main source of energy is the large plants and infrastructure provided by the energy systems. But this situation must change and there must be an increase in the number of Distributed Energy Resources and development of VPPs (Virtual Power Plant) with geographic distribution within reach, the integration of these DERs with VPPs will be present with a dynamic profile that provides control under optimization in the distribution of the generation of these resources. Its implementation could postpone investments in transmission and distribution lines, allowing the possibility of access and visibility in all energy markets, benefiting from generating income opportunities, thus generating an economic interest in the implementation.

The future about VPPs is optimistic, since it is a concept that has consistency, so it becomes a viable and interesting option to integrate DER and prosumers into the electric power system. The operation of the system can benefit from the optimized use of all available capacity in Colombia using VPPs. Additionally, it is concluded that the current revision can help in the development of future research in this field to open new windows for future and important investigations.

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Application of data mining in the decision-making process of energy projects in non-interconnected areas in Colombia

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Abstract

Currently, the geography of our country has areas that are not energy interconnected and require, in the short term, to propose energization solutions that allow the provision of service to be continued and, additionally, reliable so the costs are affordable to the local population. The energy resources currently used (coal, oil and gas) in the world are scarce and Colombia is no exception. Renewable energy is presented as a possibility that can approach these needs; additionally, they contribute to the reduction of greenhouse gas emissions. Consequently, it is necessary to design a proposal to support decision-making in ZNI (Spanish initials for non-interconnected zones). **Problem**: In non-interconnected areas the electricity supply is intermittent, this absence of the electricity service generates a problem for the populations, it is necessary to analyse and investigate solutions to guarantee the continuity of the energy service, which can contribute to improving the quality of life of these areas from the country. **Objective**: analyse the operational and demand conditions for non-interconnected areas based on data mining in order to support the decision-making process in the application of energy projects. **Methodology**: Data mining is not only the process of searching for patterns, it is also important to implement algorithms for the development of a data analysis process. Mining is defined as the process of extracting implicit or hidden information, not fully exploited and in most cases not previously known, from data available in repositories (databases) or in real time. This process is intended to generate useful knowledge from the establishment of relationships between data, such as patterns, trends and correlations. In conclusion, data mining processes transform large data sets into knowledge that is useful for decision making or to better understand some reality. **Originality**: Through this research, operational and demand conditions for non-interconnected areas are analysed in order to support the decision-making process in the application of energy projects. **Limitations**: The vulnerability in which many of the populations in these areas live and the possibility of promoting the implementation of energy solutions to provide a service that is continuous and that contributes to improving their standard and quality of living.

Keywords: algorithms, data mining, energy demand, patterns.

Introduction

The national geography has areas that are not energetically interconnected, most of these areas are hard-to-reach rural regions, far from municipal headwaters, where the access roads are rudimentary and, in some cases, non-existent. In some areas where there is service, it is unstable and with a high cost overrun, it is because of all these need factors that made the formulation of a proposal for data analytics relevant to support decision-making in the formulation of energy projects in ZNI. We found that the use of data mining provides benefits to identify and know the whole context, since it allows to find processes and extract the data that are really necessary, identifying patterns within different databases, where the records that provide information will be found relevant.

The proposal presented is to design a model in order to analyse the data found under the different operational conditions in the different geographies of the country to make a prediction of energy consumption in order to support decision making. This will be done based on data mining that gives us the finding of patterns, trends and with the implementation of the CRISP-DM methodology to ensure that the findings found are those that contribute to the solution of this project (García, 2018).

Materials and Methods

The methodology for conducting this research will be the CRISP-DM, then we will present the characteristics and advantages of using this agile methodology for the development of the project.

CRISP–DM is a methodology designed by a group of companies such as NCR (Denmark), AG (Germany), SPSS (England), OHRA (Netherlands), Teradata, SPSS, and Daimer-Chrysler, join licencing and propose a free distribution reference framework.

The life cycle of the model contains six phases with arrows indicating the most important and frequent dependencies between phases. The sequence of phases is not strict. In fact, most projects move forward and backward between phases if necessary. The CRISP-DM model is flexible and can be easily customized. For example, if an organization tries to detect money-laundering activities, you may need to screen large amounts of data without a specific modelling goal. Instead of modelling, your work will focus on exploring and visualizing data to discover suspicious patterns in financial data. CRISP-DM allows you to create a mining model that fits your specific needs. In such a situation, the modelling, evaluation, and implementation phases may be less relevant than the data preparation and understanding phases. However, it is very important to consider some issues that arise during later phases for long-term planning and future data mining goals (IBM, 2012).

Results

The result of this analysis will be the design of a model with statistical bases for the prediction of energy demand in non-interconnected areas of Colombia, the design of the model will allow to review the energy demand and the operational conditions of different areas of the national geography. During the development of this research the data will be the fundamental basis for the transformation of these to relevant information that allows to eventually support decision-making.

Discussion

In the development of this research, it is proposed to make a definition of the requirements of the operational conditions with which the design of the model can be carried out under the geographical conditions of the area, the existing data in non-interconnected areas in order to be inputs of energy demand analysis, additionally, reviewing the literature of models existing in different latitudes and that, possibly making an adjustment under the operational conditions, indicate the good on the way to the investigation.

Conclusions

Currently, in Colombia the main energy source are hydroelectric plants where they account for 69% of

energy sources, the graph is divided into two significant groups, renewable and non-renewable, the branch where renewable resources are with 12,016,000 megawatts installed which includes different sources of renewable energy such as wind, biomass, hydraulics and solar; on the other hand there is the non-renewable ones where it only allows 5,309.59 megawatts installed and are obtained by means of gas, coal and mixtures, the sources of unconventional energy only reaches 2%. This allows us to see the still lack of development in this field of research, and that the energy contribution may be greater if you have the incentives that the state indicates to support the development of these investigations (UPME, 2010).

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Prototype of physical variables measurement system in a cocoa crop

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Keywords: arduino, cocoa production, microcontroller, prototype, sensor.

Introduction

The cocoa of Huila is characterized by its fine and unsurpassed aroma, which has allowed it to position itself worldwide. In 2015, the Department of Huila produced 3,787 tons, while in 2016 it increased to 4,159 tons a year, showing an increase of 7.3 percent. In the municipality of Algeciras, from its green mountains about 126 families depend economically on the cultivation of cocoa. Therefore, it is considered necessary for the cocoa producer to identify environmental management measures, which are applied to the crop, as part of its monitoring and follow-up process, representative variables that guarantee quality to the cocoa Huilense almond are identified (Paredes & Gustabo, 2015).

Problem. The quality variables involved in the production of cocoa almond have not been systematically studied. 95% of Algeciras producers are unaware of the environmental phenomena present during their production.

Objective. Develop a prototype that allows data collection during cocoa production, using a plate with a microcontroller and a development environment, that identifies the variables present from its traceability, aimed at the quality of the crop in the municipality of Algeciras.

Methodology

Research methodology is mixed, using different information collection techniques in the following phases:

- The analysis of the cases of use of smart farming devices.
- Prototype design that allows the census of the physical variables involved in a cocoa crop.
- The construction of a small-scale prototype that records data on cocoa cultivation through the use of sensors.
- The small-scale prototype validation process in a cocoa crop.

- Process of analysis of the information obtained from the small-scale prototype to obtain mathematical models that allow decision making.

Results

Figure 1 shows the architecture of the system to take the variables involved in the quality of cocoa beans.

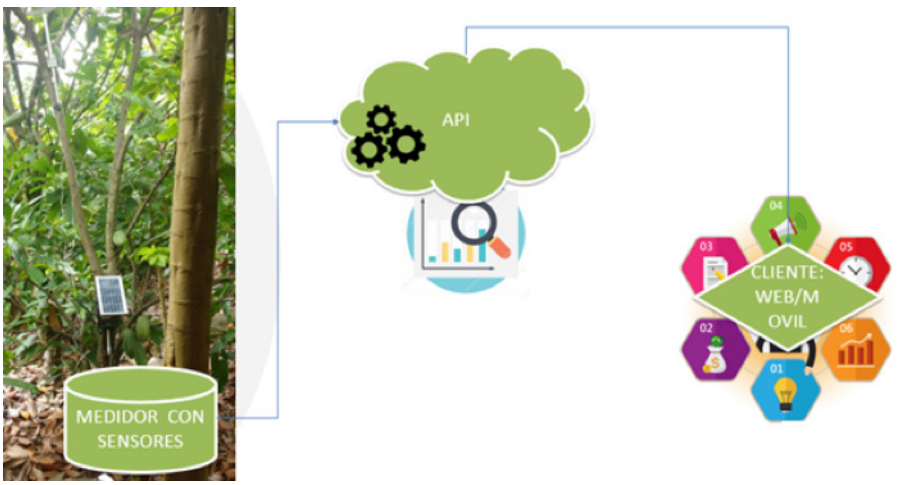

Figure 1. Architecture diagram of the variable taking. Source: own elaboration.

For the design of the prototype it is necessary to involve the sensor of environmental temperature, carbon dioxide, relative humidity and soil moisture. An *arduino* platelet to concentrate sensor data, perform calculations and send it to the cloud. To comply with this architecture, the following elements must be defined:

API: Application interface that contains a set of functions and procedures that meet charges to be used by other software (Piazarro Peláez, 2019).

Web client: application architecture to have Web services.

Figure 2 shows the prototype to take the data of the variables that influence the quality of cocoa almonds, the components used are described below:

Arduino: A development platform based on a free hardware electronic board with a reprogrammable microcontroller and female pins, which establish connections between the microcontroller and sensors and actuators in a simple way (Muños & Córcoles, 2018).

Relative humidity sensor: analogue sensor that measures relative air humidity using a condenser-based system.

Temperature sensor: use a multipoint communication bus to read many probes with a single digital input / output.

Co2 Sensor: measures the concentration of carbon dioxide in parts per million (ppm) in gases such as air.

Soil moisture sensor: measures soil moisture by varying its conductivity.

Prototype: construction of an object or thing that serves as a model to manufacture other equals.

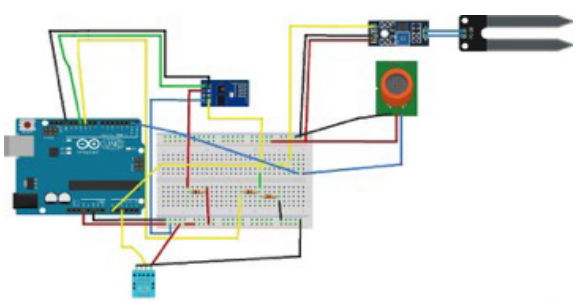

Figure 2. Design of the prototype for taking the data of the variables that influence the quality of cocoa almonds. Source: own elaboration.

The prototype test was carried out in a farm of the municipality of Algeciras during cocoa production in the department of Huila, finding 1004 records and representative variables such as:

- The temperature variable with a variation between 22 and 26
- The humidity variable with a variation between 63 and 85
- The variable carbon dioxide (co2) with a variation between 270 and 491
- The soil moisture variable with a variation between 74% and 75%

The mentioned variables were taken from 10am - 11:20 am on 04/16/2019

Table 1. Average of records.

AVERAGE OF RECORDS				
Temperature (°C)	**Humidity(%)**	**CO_2 (ppm)**	**Soil Moisture (%)**	**Observation**
23,27	**76,26**	**279,35**	**74,35**	**Cloudy day**

Source: own elaboration.

Conclusions

The construction of the prototype allows to take the variables involved in the quality of the cacao almond. It was necessary to understand each of the variables and the relationship between them. On an overcast day, the average of the 1004 records represents the temperature variables in a 23.27 ℃, with a humidity of 76.26%, CO2 in 279.35ppm and a soil humidity of 74.35%, data that are available to evaluate the quality of cocoa almond.

Originality

The prototype design would be the first for the measurement of physical variables in a cocoa crop in the municipality of Algeciras.

Limitations

Validate the design of the device in other municipalities with different climatic characteristics.

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Optimal dimensioning and simulation of renewable energy resources for water pumping in isolated areas: Dominican Republic case

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Abstract

During the rainy seasons, farmers have had problems to irrigate their crops, they require more water from tubular grounds, many times they have the option of pumping systems with diesel power generation, this being a source of easy access and easy installation, but of high costs operatives, maintenance and high pollution. In this investigation, we present an analysis methodology for the optimal selection of energy supply sources that use renewable energy forms, evaluating the best option by multivariable optimization methods with climatic data in the plantation itself. Within these energy options are photovoltaic, wind and diesel systems. We conduct simulations for a 10-acre crop area in an isolated agricultural area called estate 3 in the province of Azua. The results obtained in this research have benefits such as reduction of investment expenses, optimal selection of energy source, reduction of gas pollution, greenhouse effect and increase of the criteria of reliability of technological applications for the agricultural area. **Introduction**: This article is a research product "Optimization of the use of renewable energy resources for pumping water in isolated areas: Dominican Republic case", carried out during 2019 in the province of Azua, located in the southwest of the island of Santo Domingo. **Problem**: The scarcity of surface water resources (rivers, streams, irrigation canals, etc.) leads to exploring other forms of water extraction for agricultural use. **Objective**: The objective of this research is to design a procedure to optimally select renewable energy sources in pumping systems for crop irrigation using renewable resources typical of the area in the Dominican Republic. **Methodology**: Optimally evaluate energy resources and assess whether they can feed an estimated load and select the resource optimally based on their economic feasibility and availability in the area. **Results**: The means of generating energy for use in irrigation of banana plantations is the photovoltaic generation, its installation angle affects the number of panels. **Conclusion:** The use of a renewable generation medium depends on the type of crop and the climatic magnitudes of the area. **Originality**: Through this research, integrated and sustainable strategies for the management of renewable resources used in crop regions in the province of Azua are formulated for the first time. **Limitations**: Lack of information provided by the municipality and access to sampling points.

Keywords: energy pump, irrigation agriculture, solar energy.

Introduction

This research is motivated by investments towards alternative energy sources to improve energy efficiency (Bakelli, 2010). In the hottest months and with little rain agricultural production reduces. Water pumping by diesel generation is considered as the most striking option. In places where there is little rainfall and geographically difficult to access, in the Dominican Republic is a favoured location to develop renewable energy systems such as wind and photovoltaic. The purpose of this research is to improve the management of agricultural activities through the use of renewable energy technologies for pumping water for crop irrigation in isolated areas through availability and investment indicators such as: the probability of loss of energy supply (LPSP) and average level costs of electricity generation (LCOE).

Materials and Methods

Water storage system

The loading and unloading status of the storage tank can be calculated from the following e quations: Water loading storage tank,

$$SOC(t) = SOC(t-1) + [EH(t) - \frac{E(t)}{\eta conv}] * \eta tank \quad (1)$$

$$V = Q.\, t \quad (2)$$

Pump system

It draws water from the well and sends it to the supply tank that is at a height above the ground. Where the pumping power (Ppump) is estimated with the following expression

(Campana, 2013): $Ppump = \frac{2.725 Qp.H}{1000\eta}$ (3)

Where: Qp: is the feed rate of the supply tank (m^3/s).

Evaluation of photovoltaic and wind energy and diesel

Fotovoltaic Generator. Its dimensioning depends on conditions such as: solar radiation, delivery power of each panel, tilt angle and daily solar irradiation time. The power of the photovoltaic generator (Pm) can be expressed with the following expression

(Rezk,2013): $Pm = N.\, Am.\, Hn.\, \eta m.\, \{1 + \alpha\, (Tc + Tcref\ )\}\eta over$ (4)

Eólic Generator. Its feasibility depends on climatological and geographical variables. As they are: wind speed, direction, wind rotor elevation, forms of the surrounding terrain and efficiency of auxiliary systems. They generally record wind measurements for one year to indicate the feasibility of the wind project. The power is given by the following expression:

$$Pe = 1/2 \rho A v3 \quad (5)$$

$$Ps = 1\ Cp(\lambda).\, \eta m.\, \eta m \rho A v3 \quad (6)$$

$$v = vo\{\, y\, \}^{\alpha} \quad (7)$$

The capacity of wind generators depends on the intensity and direction of the wind speed. The higher the tower, the wind is more stable and constant. But its cost increases.

Diesel Generator. High energy availability depends on the energy of a fossil fuel, easy installation and operation.

The climatic data were obtained: https://es.weatherspark.com (weatherspark, 2019). With the help of the mateonorm software and the estimates of the photovoltaic system with the PVsyst software, the wind turbine power was estimated with the Enair software.

Results

An irrigation area of 10 acres was taken in the province of Azua called estate 3.0 where bananas are grown.

Table 1. Variables that define the energy requirement of an average day.

$L_{llenado}$	m3/s	0.00132
V_{tanque}	m3	19.008
$t_{llenado}$	horas	4
$Q_{irrigacion}$	m3/s	0.00011

Source: Own elaboration.

Sizing and simulations of renewable systems:

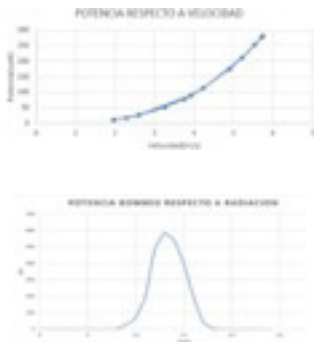

Figure 1. Power with respect to speed and radiation of an average day. Source: Own elaboration.

The photovoltaic generator can increase its power thanks to being a modular technology, the direct photovoltaic system resulted in a power of 540 watt of pumping and a photovoltaic panel power of 800 wp, while the regulation system with Mtpp resulted with a power of 360 watt and 454 wp in photovoltaic panel. The wind resource turned out to be insufficient for the estimated load of the pump. The power of the turbine could be increased, but the wind project's cones would be greatly increased, its tower has a height limit of 50 feet for a 350 watt turbine. Optimum working point of the pump; The optimum flow of the pump is 4.2 m3 / h, in this there is an efficiency of 65% for the motor that feeds the efficiency limit pump according to the manufacturer.

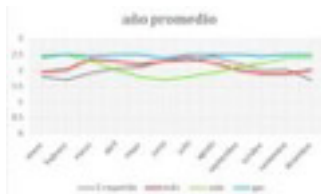

Figure 2. Energy generated with respect to energy required for average year. Source: Own elaboration.

Energy required for pumping system increases in the summer months and decreases the winter months, these limitations presented by the photovoltaic and wind generation is compensated with the 3 days of storage of the tank that supplies the irrigation circuits of the plantations.

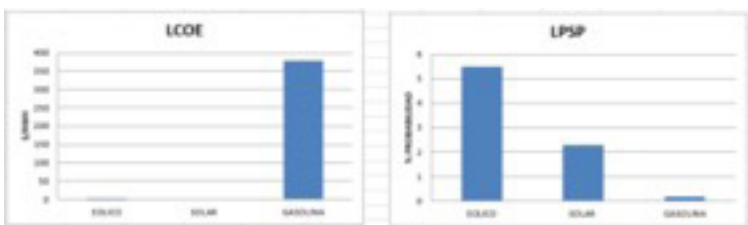

Figure 3. Loss of power supply probability (LPSP) and levelized cost of energy (LCOE). Source: Own elaboration.

The gasoline generator has high due high maintenance cost should be performed every 3 months according to the manufacturer. Also the high cost of fuel 4.24 $ / gal consuming 1.5 gal / day. The wind system only has OYM and a consumption of $ 250 represents high values because there is a unit that includes fixed gearbox systems. The LCOE may vary by region taxes and by the feasibility of energy resources of each technology. For each project in the case of easy fuel generation it represents a value of $ 3.16 / mwh against $ 0.14 / mwh of wind generation. The selected system is the solar one, although the photovoltaic panel power is high 454watt, this will depend largely on the inclination of the set ground and can provide a daily generation of 2.3 kwh / day.

We would like to thank all participants and speakers for their attendance and participation. We hope this was an opportunity for learning and cooperation.
We look forward to seeing you all in the next version of the Congress.


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