Edition #22
June/July
2017

Welcome to the all-new Revista

enlaces

Conectando puntos en la R9

SAC Team R9 - Technical Chapters - Student Activities - Volunteering at IEEE

POWER & ENERGY
FROM ANOTHER PERSPECTIVE

IEEE · IEEE REGION R9 · R9SAC team · IEEE PES Power & Energy Society®

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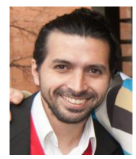

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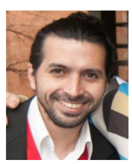

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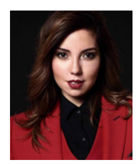

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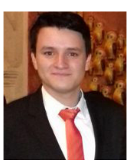

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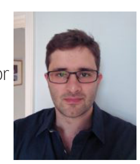

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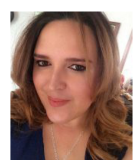

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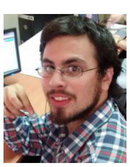

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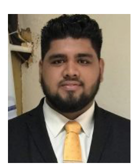

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enlaces

Conectando puntos en la R9

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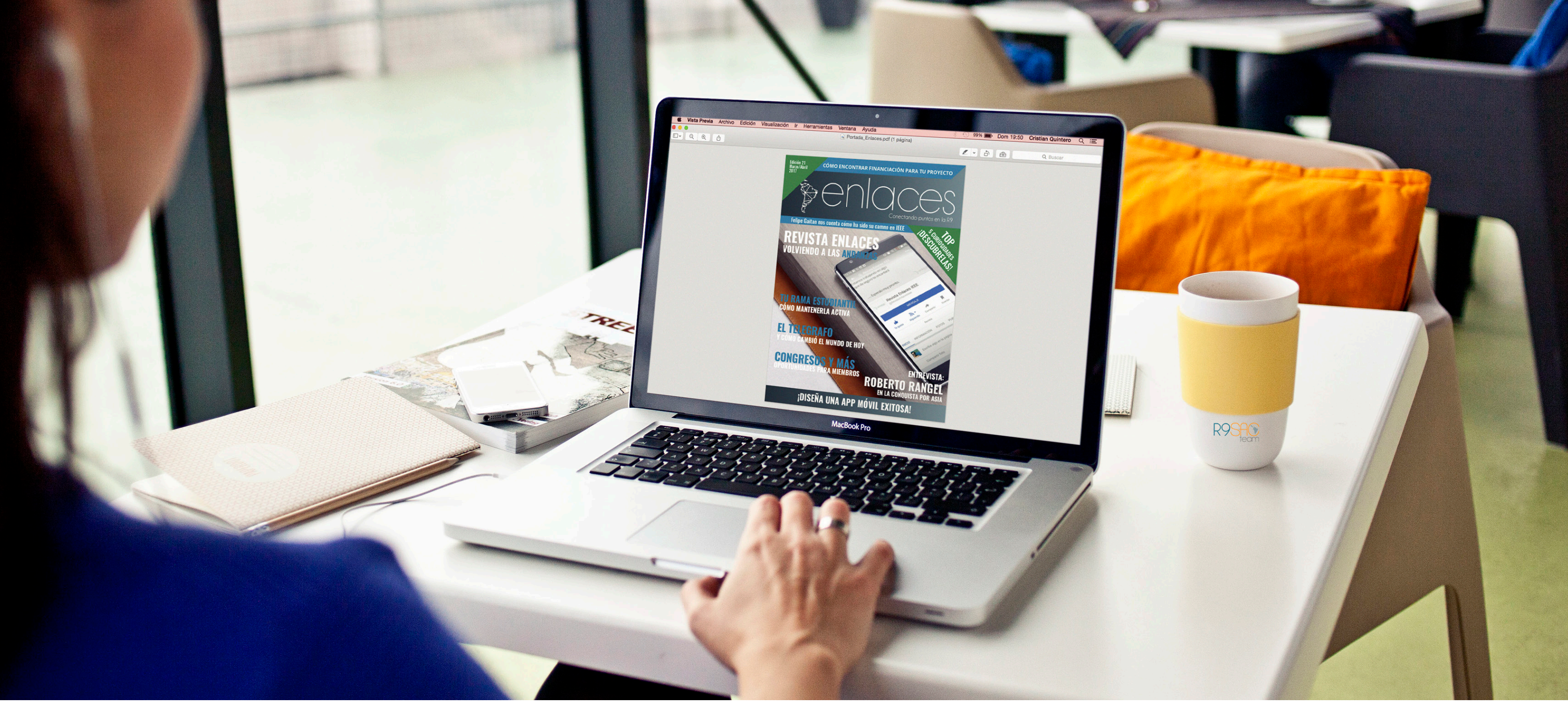
Traduction



The IEEE Enlaces magazine aims to disseminate information of general interest to all students and active members of IEEE in Latin America and the Caribbean. Counting with several sections and editorials, each edition seeks to be a reference and a guide for the connection between all the branches and students of the region, crossing borders and shortening the distances between them.

You can also be part of our magazine, send your nomination to be a member of the editorial committee to the links enlaces@ieee.org and we will indicate everything you need to collaborate in our editions.

IN THIS EDITION

Costa Rica Pura Vida

Juan Carlos Montero, vice president of Membership and Image of the IEEE Power and Energy Society (PES) tells us how the energy change that has benefited his country in recent years.

PES Student Chapters

Some of the best student chapters of the region tell us about their activities.

IEEE SIGHT UNAH Honduras

They tell us the realization of their first humanitarian project carried out in an Educational Center.

My path on IEEE

Felipe Gaitan tells us about his journey in IEEE over several years and how the institute has given him opportunities that changed his life completely.

EDITORIAL

Antonio Ferreira
Director Regional

"Connecting Points in Region 9"

Dear colleagues,

First of all, I would like to congratulate and thank the Region 9 SAC Team for bringing back Enlaces and for the quality of the magazine. Enlaces was created in 2009 as a means of communication between each Student Member in the Region and Region 9 Student Activities Committee, allowing for achieving Regional goals while preserving each Student Branch individuality, It had the slogan "Connecting Points in R9", strengthening the need for close collaboration not only between Student Branches, Sections SAC and R9 SAC, but also with *Educational Activities, Young Professionals, Women and Engineering, Technical Activities and Membership Development Committees.* Region 9 *Life Members* Committee would also welcome the opportunity to work with you.

I hope you will enjoy the magazine as I did since its creation. I am confident that it will maintain its tradition of being a valuable source of information not only to our student members, and I hope that, as well as the information that will help you carry out your duties as a volunteer, you will also find here information that will help you grow professionally.

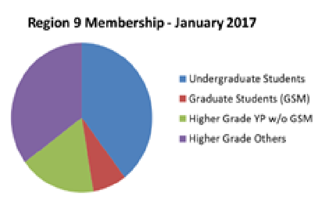
The last segmentation survey, carried out by IEEE Member and Geographic Activities Board, showed that the top reasons why both Higher Grade and Student Members joined IEEE were:

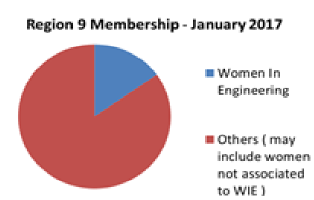
- To remain technically current;
- To have access to IEEE publications.

For students we can also add:
- To enhance career opportunities;
- To participate in student branch activities.

These are also the same top reasons to maintain the membership. Our Region has a tradition of having very active student members, who organize a broad range of activities, and I am particularly happy to witness the steady increase of technical activities promoted by Student Members, including the creation of several Student Branch Chapters.

When we look into Region 9 membership segmentation, we note that we are fortunate to have a very large participation of Student and Graduate Student Members as well as Young Professionals, our membership is young. For Region 9 Executive Committee, while providing us with members with the energy and enthusiasm inherent to this stage of our life, this also brings the obligation to develop activities aimed at this segment as well as pave the way so that you will still consider IEEE as your home institution after graduating. You are our future leaders.





I know that the Region 9 SAC Team has been working hard to develop programs and projects to help you as you progress in your years as Student Member and volunteer, and also with the focus to preparing you for your professional life. Do not miss the opportunity to interact with them. Region 9 Executive Committee is strongly committed to participate in these efforts and is closely working with the R9 SAC Team to identify how we can better serve you.

This will only be possible with your active participation and I am looking forward to your ideas and feedback.

Best regards,
Antonio C Ferreira
IEEE Region 9, Director 2016-2017

THE IMPORTANCE OF DOCUMENTATION

By Jimmy Túllume Salazar

The documentation of a company or organization represents its intellectual capital, that is, the "know-how" that has been acquired through experience. Failure to adequately document that hard-won knowledge could be lost. The same happens in an IEEE Student Branch, where year after year it performs innumerable activities of diverse nature, some with great results generating many joys, festivities until prizes, and others with some problems and difficulties that generate bad moments for the organizers, that nevertheless. Both situations are not documented, losing the opportunity to leave documented and evidenced the experience gained in the activity.

It is true that generating documents is tedious and complicated, nevertheless in the development of the engineering profession, making documentation such as: reports, project, prospects, etc. Is the day-to-day of every engineer, and cultivating this practice from the university period will add experience in vocational training, generating added value when it comes to practicing the profession.

Not only is it important to have documented the activities carried out by the IEEE Student Branch, but it is also vital to have documented the work plan, clearly detailing the objectives and goals to be achieved in this year, as well as the organization of The volunteers with their assigned roles and responsibilities, allowing to have a work route for the Student Branch.

"Documenting helps us analyze and realize what we did well and what we could improve".

What documentation should a Student Branch have:

1. **Work plan, with clear objectives and targets.**

2. **Main processes (Example: Request for new event, economic support for an event, etc.)**

3. Each of the activities carried out: Who have organized or participated.

4. **Projects carried out: Research, project competition, etc**

5. **Working memory per year: Compilation of the activities carried out in the year and the results obtained.**

The objective of generating these documents is to have a documentary repository that allows to demonstrate in an orderly way the work of the Student Branch, in order to get to their university authorities, make the reports to the IEEE, publish or share in social networks and/or magazines (Enlaces Magazine / Potential / Noticieeero / etc.) Apply to IEEE competitions (Exemplary Branch, Innovative Activity, etc.) currently our R9 IEEE RE's miss out on innumerable opportunities for not having documented their activities and sharing experiences to the next generations and directives of the Student Branch, to help continue to improve and grow the IEEE Student Branch and its members.

About the author:

Jimmy Studied Systems Engineering with postgraduate degrees in Software Engineering and Telecommunications Engineering and Management. IEEE member and volunteer for 10 years, which includes positions of management, leadership and organizational in different geographic units of IEEE, from the Student Branch Universidad Señor de Sipán that founded and led, Section Peru, Region 9 and Computer Society. He is currently Administrator of ICACIT and Project Manager at INGENOVA Group SAC and at IEEE he holds positions of RSAC IEEE R9, Student and Young Professional Activities IEEE Computer Society, Member of the Peru Section.


CUSCO - PERU 2017
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XX REUNION REGIONAL DE RAMAS IEEE R9
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IEEE
IEEE REGION R9
R9SAC team

Student Professional Awareness Conference (SPAC), a conference organized by students that involve discussions on various topics of professional development. Explore non-technical aspects that affect engineers' careers.

It is an event where students have the opportunity to listen to experienced engineers and trajectory on topics of interest in their professions.

It is organized by the student branches of the IEEE.

Interested in being a SPAC Program lecturer?
Sign up for the next **LINK**

2.0 Benefits of S-PAC

- To delve into the non-technical aspects pertinent to his career, such as financial planning, career growth, and entrepreneurship.
- To learn valuable management and planning skills.
- To become aware of employers' expectations.
- To learn from the experiences of outstanding engineers.
- To make contacts with lecturer engineers.
- To capture a better understanding of how IEEE works for engineers.
- To find out what other IEEE resources are available.
- To increase IEEE student membership.
- To motivate the participation of members in IEEE activities (Volunteering).

Speakers Manual Format

¿Do you need help? Contact with:

Federico Trejo Lezcano
Argentina, Coordinator SPAC and SPAVe
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A Webinar also called videoconference the conference in streaming, is a system that helps to transmit knowledge to that public that is interested in it (IEEE R9 members). This conference is conducted in real time through the Internet, to reach the largest number of people and facilitate access (WebEx IEEE). One of its main features is that users can interact with the speaker at all times, giving you the suggestions to be answered in real time.

In order to fulfill our goal of ***"Promoting the Professional Development of our Students"*** we have made a strategic alliance with several IEEE organizational units: Region 9, IEEE Computer Society R9 and IEEE Communications Society R9 and SAC Team R9 to continuously launch various webinar of interest to the IEEE community of region 9, both technical and soft skill topics.

See our Webinar Realized:
http://sites.ieee.org/r9-sac/es/programases/eventos-2/webinar-realizados

Sign up for our upcoming webinar:
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You want to provide a webinar or information, contact:

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Costa Rica Pura Vida

By:Juan Carlos Montero

Greetings, Friends.

My name is Juan Carlos Montero and I am the Membership and Image Vice-chair of the IEEE Power and Energy Society (PES). I became my membership more than 16 years ago, when I was an undergraduate student, searching for more information on technological trends and focusing my IEEE membership to the technical area that impassioned me, power systems.

An IEEE Student Member undoubtedly shows desire to become a better professional. That's why our technical society fosters that spirit through special benefits, such as the creation of student chapters in IEEE Student Branches in universities, discounts in conference fees, and creation of financial support programs for participation in the biggest PES events around the world. Power systems are, undoubtedly, a prior topic worldwide, as all people recognize energy as a critical element for our world and for the future. If you are a student or you know a friend who wants to appreciate IEEE PES, first year PES membership is free!

Costa Rica
and The Regionl Electric System

Costa Rican electric system is an independent control area inside the Regional Electric System (SER – acronym in Spanish), meaning it is responsible of attending national demand and warranting operational safety on its electrics network. SER implies the existence of a network synchronically interconnected, that is, connected through transmission lines in alternate current from Panama to Mexico, because of the connection of the latter to Guatemala.

Costa Rica's electric interconnection to other countries is important because it allows the country being part of the Regional Electric Market, receiving support from other countries' primary frequency regulation, and perceiving higher momentum for generators' dynamics. Participation in SER also implies their operation and planning must be done considering, not with an isolated view of the country, but considering the electrical systems of the other countries, coordinating with all countries' control centers. Remember that being interconnected makes that an event in frequency (low or over frequency) simultaneously affects all countries!.

Energy Pura Vida

In Costa Rica, biggest demand reported in 2016 was 1674 MW. To attend that requirement, the country has a generation park composed by hydroelectric, eolic, geothermal, biomass, and solar plants. Installed capacity composition can be seen in Table #1 . It can be highlighted that biggest participation corresponds to hydroelectric and thermal plants (the latter uses fossil fuels). This could make some people think Costa Rica uses lots of thermal energy. However, this is not true, because thermal generation is used with a low plant factor, as it is mainly used as a backup during the dry season the country experiences. Hydroelectric plants are mostly run-of-the-river type. Only Costa Rican state power enterprise, Instituto Costarricense de Electricidad (ICE), has considerable dam plants that bring energetic safety. During rainy season, hydroelectric plants participation is undoubtedly important.

Costa Rica has been widely mentioned by international media, as the country has achieved an important number of days without using thermal energy during the last two years. Morever, in 2016, **98.21%of annual energy (10.588 GWh) was attended with renewable sources!** This is a milestone for a country famous for its respect to nature.

Those results are due to, undoubtedly, power operation planning and optimization policy, and because of mother earth. In a country with those hydroelectric generation levels, managing resources, taking advantage of the Regional Electric Market and of existing dams is important. In the future, Costa Rica is planning to integrate more renewable generation plants.

"Ticos" keep celebrating

Costa Rican Electric System also celebrated 10 years without electric blackouts in April, and that's great news for all. This result is due to the efforts to apply first world operative safety criteria to all ICE operative areas. Technically, it leads to the coordination of all operation under the same principles, protection schemes designs, equipment maintenances, and more.

Costa Rican Electric System and all systems over the world are full of improvement opportunities that will be defined and analyzed by today's power and energy systems students and future engineers. There are lots of initiatives worldwide that IEEE PES is promoting for tomorrow's electric network. That's why I invite you to join IEEE PES and to be part of our project "More power to the future."

For further information about IEEE PES, visit our Facebook, follow us Twitter or in LinkedIn.

Tabla #1. Capacidad Instalada por fuente en Costa Rica al cierre del 2016

Type	Megawatts (MW	%
Hydroelectric	2328	67.15
Thermal	571	16.49
Geothermal	206	5.97
Biomass	40	1.15
Eolic	319	9.21
Solar	1	0.03

IEEE smart village
Empowering Off-Grid Communities

Join Our Mission

GET INVOLVED!

IEEE Smart Village, an IEEE Foundation Signature Program, is a major IEEE initiative to bring innovative and sustainable electrical systems to the developing world.

Whether you are an individual interested in making a difference, or a large organization that shares our mission, the IEEE invites you to fuel IEEE Smart Village's proven model.

VOLUNTEER

IEEE Smart Village invites volunteers from across IEEE societies and industry to come alongside us to help with organizational design and expansion of the program, participate in working groups dedicated to solving hardware and software challenges and assist with implementation in the field.

AMBASSADORSHIP

An IEEE Smart Village Ambassador can assist in-country. Whether it is corporate to corporate and high level government liaison, or boots-on-the ground village field work helping to deploy hardware and educate the village community, opportunities abound at all levels to promote a true social enterprise endeavor. Students and young professionals are encouraged to gain experience working in the field in assisting and mentoring our micro-utility deployment programs (similar to a Fulbright Scholarship). There are also corporate sponsorship opportunities for companies looking to fund an ambassador for an in-country deployment or provide a loaned executive to volunteer (on company time) directly with any of our 9 operating committees.

PARTNERSHIPS

Recognized multi-national NGO's, large humanitarian organizations, government ministries and associated programs have an opportunity to reach mutual goals for global expansion of the initiative by partnering with us.

NGO PROGRAMS

For in-country NGOs and other organizations with established humanitarian outreach programs, become an in-country host partner to establish a network of micro-utility stations nationwide. From seed funding through venture capital, IEEE Smart Village can guide program growth, mentor technical deployment and increase operational competency.

FUNDRAISING CAMPAIGN

We invite you, your colleagues and business associates to join our fundraising effort and help build our seed funding campaign. Invest in our life-changing mission today. Visit our web site for more information on how to give and how you can participate in IEEE Smart Village: www.ieee-smart-village.org.

IEEE smart village™
IEEE Foundation

An IEEE Foundation Signature Program

For more information on IEEE Smart Village, visit: **ieee-smart-village.org**

RNR COSTA RICA 2017

FORGING THE LEADERS OF THE FUTURE

The National Meeting of Branches of Costa Rica took place on March 4 at the Wyndham San Jose Herradura Hotel and Convention Center, its mission was to integrate all the country's student leaders and share the knowledge of some of the current leaders highlighted Of the Section.

The event consisted of a series of conferences, to analyze the roles within the IEEE, its benefits and what is expected in the future of the management of the student branches, these conferences were led by outstanding members of the Section such as the Engineers Juan Carlos Montero, Erick Chinchilla and Melany Carvajal, added to the valuable contribution of Jimmy Túllume Salazar R-SAC of Region 9, who encouraged the exchange of knowledge and generation of projects that promote the mission of the IEEE in Costa Rica.

IEEE Section Costa Rica considers it important that volunteer students and leaders of the Ramas remain motivated, trained and active to continue the good work they have been doing in their last periods, developing them spaces for training and strengthening their capacities, is One of the priorities for the Section to achieve outstanding participation in activities at the national and international levels.

The S-SAC (Student Activities Committee of the Section), made up of Engineers Melany Carvajal and Felipe Córdoba, are encouraging the implementation of more student projects in the country, the emergence of more Branches in other universities and to maximize and maximize Work of existing Branches.

RNR PERU, LIMA 2017

The IEEE Student Branch of the National University of Callao (UNAC) and the Federico Villarreal National University (UNFV) joined forces to hold the IEEE 2017 National Meeting of Branches held in the Constitutional Province of Callao, Peru from 2 to 5 March.

This event aimed to seek the integration of the different IEEE Student Branches of the Peru IEEE Section and in this way to exchange knowledge as well as experiences among students and professionals, as well as to encourage the generation of sustainable projects that support the IEEE mission in Peru And internationally.

In the event, the participants were trained in an integral way with tools oriented to the management And administration of a Student Branch as well as the student chapters that make it up and various soft skills were strengthened that facilitate the personal development of the participants for a successful labor and / or entrepreneurial insertion.

In that sense, within the activities we have Workshops and Skills Development, Information talks regarding IEEE membership retention, benefits and opportunities of IAS, PES and RAS, IEEE Sight, decision making and behavioral economics, a productive Meeting of presidents of the IEEE student branches, TISP WIE workshop, branch and regional fair as well as the traditional Ethics Competition.

Finally a gala dinner was held where prizes and awards were granted to the student branches of the IEEE Peru Section as well as the participation of groups of typical dances representative of our country.

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PES Chapter IEEE UPS Cuenca

The PES IEEE UPS Cuenca chapter that opened in the student branch has more than fifty members, carries out activities so that engineering students have the necessary knowledge that can enable them to be elite professionals. One of the events that the chapter has done is the Symposium (SEC), where the objective was to expose the research work of the university community at the "Universidad Politécnica Salesiana Cuenca" in the areas of electrical engineering and related sciences. The first event was held in 2015 where it was welcomed by reactivating the IEEE-UPS- Cuenca branch and having speakers related to the chapter such as the 2015 IEEE-PES Ecuador Section, in Diego Echeverría.

The SEC2016 was carried out with a great organization, reaching the participation of local universities with research works and technical talks with exhibitors and relevant brands within the electrical engineering industry.

The IEEE PES UPS chapter also showed great organization in the last year. With the catastrophe produced in the province of Manabi, active members of the chapter organized a collection with the student branch IEEE UPS CUENCA to obtain funds and provide assistance to those affected by the earthquake produced in that province. The collection was used to obtain necessary supplies and to give a treat to the handicapped children located in the areas of the disaster.

The ESP chapter of the "Universidad Politécnica Salesiana de Cuenca", in addition to organizing conferences dedicated to research topics, holds keynote addresses dedicated to the occupational field of electrical engineering, such as the event "Perspectivas Laborales y Campos Ocupacionales de los futuros ingenieros eléctricos del Ecuador" (Occupational Perspectives and Occupational Fields of Future Electrical Engineers of Ecuador) which included high- profile exhibitors, including Dr. Esteban Albornoz, who served as Minister of Electricity and Renewable Energy until 2016. Other speakers were managers of hydroelectric projects in the country.

Power and Energy Student Chapter (PES-UD) Universidad Distrital Francisco José de Caldas

The Power and Energy Society Student Chapter of IEEE Universidad Distrital Francisco José de Caldas Student Branch is the oldest and most awarded student organization in IEEE Colombia Section. This Chapter is currently composed by Electric Engineering students from Universidad Distrital, being in different semesters of the Electric Engineering program, having some volunteers close to become engineers and other volunteers just beginning to discover their career. All these volunteers are committed to learning, research, and personal growing; in the year 2013, we had a big quantity of members and volunteers, becoming one of the biggest chapters in Latin America.

In recent years, the chapter has developed different projects, such as introductory courses on Electricity and Electronics Labs for first semesters' students and MATLAB and electro-magnetic fields software Comsol tutorials. We also successfully organized, in association with the Student Branch, the Colombia Zona Centro Student Branches meetings. Our members have participated in international events in Bolivia, Malaysia, and Mexico. In 2014, cur Chair participated in the 2nd IEEE PES Student Congress. Our members also participated in the National Students Branches meetings and in both T&D Conferences in Medellin and Morelia.

A very important part of our chapter is the develpment of complementary activities to the activities taken place in the university, organizing lectures in different topics related to Electric Engineering, and also organizing an Electric Movility Seminar to impuls our interest and knowledge in electric vehicles. This seminar has had great acceptance and it's been successfully organized for three concecutive years. Also, as part of our contributions to society, we have organized two successful social activities to bring vulnerable children toys and clothing, as part of our WIE – PES partnership. We are very porud of these activities.

For our academic activities, we have developed technical visits, in association with important colombian power and energy enterprises, such as ISA, Intercolombia, and EPM. In these visits, we were able to know deeper the electric distribution chain, from generators like Jeripachi Eolic Park in Guajira (Colombia) and Betania Hydrioelectric Plant in Medellin, to distribution control centers. In one of the most important visits in Cali, we went to the ISA- Intercolombia Switching Center and XM (an ISA subsidiary) Electric Dispathing, to EPSA control center, and to the Universidad del Valle high voltage laboratory.

We also made visits to Torca and Bacata substaations in Bogota, the most modern substation in Colombia. All these visits can be watched in our YouTube channel, in which our member Cristian Quintero has made a great audiovisual work. Finally, in 2017, we want more, with more technical visits, new courses, our Fourth Electric Movility Seminar, and our First Power Seminar. All these activities are made to become better people, better students, and better engineers in the future.

Power and Energy Student Chapter Tecnológico de Costa Rica

The PES chapter of the Costa Rican Technological University was born in 2015 as a response to certain students' needs in engineering, because although the university has excellent bases, there are certain professional and interpersonal skills that the IEEE offers to their members, which they have decided to take advantage of. The chapter was created with less than ten students and has been so striking that it has increased due to the efforts of its members, more than fifty active and motivated members, who over the years have carried out activities that contribute to the generation of various skills in engineering and humanities ranging from lectures and tutorial workshops to technical tours, and volunteering to help the population. Participating in the PES chapter scholarship program, several of our members have benefited from traveling abroad and participating in important conferences such as the T & D LA in Morelia, Second PES Student Congress. We also highlight the participation of our PES members in events recognized as CONESCAPAN 2016 in Guatemala..

The year 2016 was a very active year for the chapter since sixty six activities were carried out, many of them very powerful and even internationally, such as "Semana PES" (PES week), which was complemented by its social activities (football championships), as academic (photovoltaic panel workshops, etc.), a DLP-type conference was organized with the renowned Dr. Luis (Nando) Ochoa on SmartGrids worldwide and a technical tour was made to AD Astra Rocket Company, to learn about the prototypes of the plasma engine and hydrogen based energy projects, ending with a camp as a social activity.

Another of the activities that had a great acceptance and a high impact in the student population was the "Electromechanical Week" in which advanced workshops of PLC, industrial software ETAP, workshop of photovoltaic panels, evaluation and awards of final projects were realized of courses of electric control of the race, as well as a good number of talks during the week, with guests of companies of high caliber nationwide.

The chapter has also been involved in topics that benefit the student community by bringing them workshops and tools that relate to their career courses and at the same time strengthen their knowledge for their professional lives. Interactive software workshops such as Matlab, SolidWorks, Dialux, Arduino, LaTex, and some others, providing a great help to careers related to the students chapter PES-TEC.

Among the most significant activities is the

First PES Convention, organized mainly by members of the PES TEC chapter in conjunction with the Student Chapter PES of the University of Costa Rica and the Affinity group of Young Professionals of Costa Rica, in this More than one hundred members from all over the country participated, including students and professionals, in addition to the presence of international speakers.

Another of the most important actions, where work began in the humanitarian field, was the visit to Shuabb Talamanca, an indigenous area near the border with Panama. TISP workshops were held to work with about forty children from the local school. PES members also organized a small Christmas party to celebrate Christmas and finally measures were taken to improve the electrical system as a future project. The dream does not stop, the achievements have been great, but the goals are higher. The chapter has always strived to improve the qualities of his members, and to generate not only engineers, but professionals critical of their reality and aware of their role within the planet and industry, so that there may be better ideas for future development of plans for the good of the society, coexistence among his members and so benefit the country.

Power and Energy Student Chapter Universidad Tecnológica de Panamá

The Pes chapter of the Technology University of Panama (UTP) student branch has always been committed to the professional and academic training of all its members and 2016 was no exception. During the year 2016, we carried out activities in which we obtained excellent reception by the members and the public.

In terms of training, in June a course was conducted using the software "POWER WORLD SIMULATOR". It had 51 students attending both undergraduate and master's degrees. It was dictated by Eng. Juan Jose Quintero, who is an IEEE member and in his time of student was volunteer of the branch.

Likewise, we support the faculty sponsoring THE FIRST ELECTRIC ENGINEERING CONGRESS of the Technological University of Panama through the PES Member Driven Initiative. With this award, we brought, with expenses paid, Dr. Martin Ordoñez of the British Columbia University of Vancouver, Canada and Dr. Gustavo Valverde of the University of Costa Rica. Those who gave lectures during the congress and in activities carried out by the professional chapter.

Finally yet importantly, we made technical tours to thermoelectric plants, to the National Dispatch Center and we gave lectures in order to bring the students closer to the Labor Field and to show them the reality that the Country presents.

SCHOOL ELECTRIFICATION WITH PHOTOVOLTAIC MODULES

Our interest in opening SIGHT in our Student Branch of the National Autonomous University of Honduras (UNAH) was born after a lecture given by IEEE SIGHT Committee Member 2015 Engineer Mario Alemán, in which we are very grateful to have given us the Enthusiasm and collaboration so that our first project has been fully funded.

Following SIGHT's focus areas for project support (Energy, Education, Health, ICT, etc.), we are presented with a great opportunity to be able to carry out this type of projects since in Honduras the non-coverage ratio of Electric Energy is Of 26% according to the report of 2015 presented by the state company ENEE (National Electricity Company), according to statistical data in Education presented by the UNAH in 2015 reveal that illiteracy in rural areas is 21.3% and in the urban area Represents 9.72%. In the Health section, approximately one million Hondurans and Hondurans lack access to water service and 2.2 million without access to improved sanitation. The exclusion is greater in rural localities with less than 250 inhabitants and in the peri-urban population, with a national percentage of 33% of the population without access to sanitation, data provided by RAS-HON.

Having knowledge of the difficulties that are present in the rural areas of our country, it was decided to make the project proposal "SCHOOL ELECTRIFICATION WITH PHOTOVOLTAIC MODULES" which consisted in providing access to electric energy through the implementation of a Solar Photovoltaic System The "Juan Alberto Melgar Castro" Public School, located in a rural area of the country, which houses 51 children between the ages of six (6) and (14) years old, is located in Los Cablotes village, La libertad municipality, Comayagua.

After identifying the area to develop the protion of data in the area of health and education, socializing with the community for the involvement and so that it can be sustainable. With this, we managed to identify that the area where the school is located is a mountainous place and in rainy times causes landslides contaminating the water sources that supplies the community being the most disadvantaged children, this has developed a disease called dysentery the Which causes stomach pain, diarrhea, bleeding, etc. Due to this situation, the children have reduced their academic performance by lack of attendance for more than two months to classes.

The Community Board of Trustees presents its situation to us.

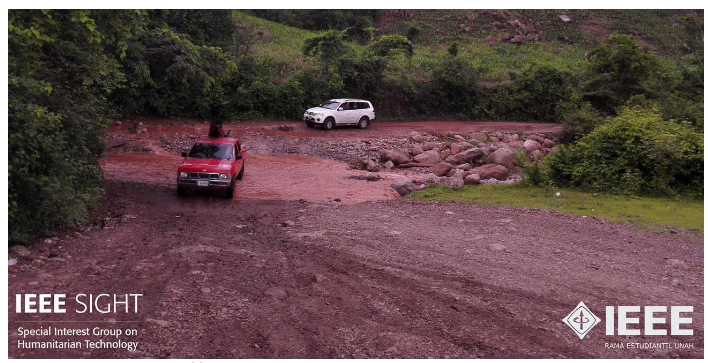
With the data obtained in the field visit we proceeded to provide a solution with the following:

- Solar modules. The village has no electricity and we have installed solar modules to power the water purifier and other things.
- A water purification system. Reducing cases of dysentery in children and adults can also bring purified water to their homes.
- Illumination. Classrooms are too dark on cloudy days and we install 5 LED bulbs per classroom.
- Wall fan: Two wall fans.
- Sound system. It serves for civic events, folkloric and cultural dances.
- School bell. Children can hear and know when it is time to enter class, play time and time to leave class.

On Friday, July 8, I arrived, the day our project began to take place, it was 6 hours long, a distance of 177 km from the capital city of Tegucigalpa where we face with a road difficult to access after a heavy rain the day after, rivers with a tail grown and in some stretches branches of tree on the street.

Upon arrival we were greeted by Director Karen Castillo, the teacher Juan Flores, some children and parents who from that moment joined our work which consisted of setting up in a classroom, painting the School, put the structure that would support the Modules Photovoltaic and excavation for Underground Electrical Installation.

It goes to village Los Cablotes, La libertad, Comayagua.



Difficult access in winter seasons.

Saturday, July 9 at 5:30 am, our second day of volunteering began, welcomed by a fresh morning and great landscapes in the distance. The breakfast is already served by the Mothers who very willingly cooked the three feeding times. It was concluded to paint the outside of the classrooms, the bathrooms and the pile to store water as well as the installation of the Solar Photovoltaic System, electrical installation in a classroom.

Sunday, July 10, we started with another fresh morning and with the energy to finish the project. Two wall fans, the water purifier and 13 LED bulbs

bulbs were installed. While the group of girls was preparing to develop the TISP workshop for the 51 children of the School in collaboration with IEEE Section Honduras, this activity was also joined by Parents to help their children in the challenge of " THE HIGHEST TOWER " and " POTATOES OF WALK".

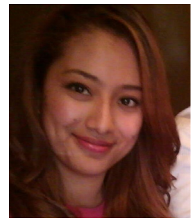
Angelito was one of the children who attended classes

We thank IEEE Section Honduras for the great management of giving a pair of footwear to each child of the school since some of them attended classes without footwear and others in zandalias, it was a blessing to be able to see their faces of joy and the satisfaction of their parents.

Dir. Lic. Karen Castillo
Working for children to have a better lifestyle is something that few worry about. As a teacher, the affection I profess to them motivates me to do more for them, but it is admirable how IEEE SIGHT volunteers do without to demonstrate that concern for their health and well-being, worked on a multi-benefit project for children and the community. It was also an experience that left a great mark in reinforcing the values of coexistence and teamwork. Of the best adventures being able to

Sustainability of the project.

As much as the director of the School and its teacher were trained to be able to make uses of the Photovoltaic Solar System, to provide the respective basic maintenance and the change of batteries every 6 years. The community patronage pledged in the purchase of batteries and filter water purifier system. The SIGHT UNAH Committee will make visits every 2 years to ensure the system is up and running and collect data on health and education improvements, thereby making the project sustainable.



Marco Trejo - Past Chair SIGHT UNAH
It was an excellent experience to carry out the project "School Electrification with Photovoltaic Modules" there was enough work, but very satisfactory to see that the community of Los Cablotes was supported, giving solution taminated water and giving them energy to improve Their quality of education and life.
Everything was carried out with the help of God, SIGHT and the work and commitment of volunteers IEEE-SIGHT UNAH with the support of IEEE Section Honduras, we hope that many more projects like this

This is how we concluded our first humanitarian project at the level of IEEE Section Honduras and as Student Branch, without first thanking the entire team of volunteers: Ing. Daniel Flores, Marco Trejo, José Castro, David Ardon, Luis Castro, Ana Reyes , Cristian Martinez, Emilia D'vicente, Gilma Castro, Gina Raudales, Luis Ponce, Norma Olay, Vicky Velásquez, Wilfredo Flores, Ing. Gina Houghton, Ing. Carlos Sierra, Ing. Daniel Boquín and the entire Los Cablotes community.

Inauguration of the project togeth-

Find us on our official Facebook site as: IEEE SIGHT UNAH

About the author:

José Castro is a student of Industrial Electrical Engineering at UNAH, a member of the IEEE since 2012 and has served as an active member of the IEEE RE UNA in the following roles: Technical Activi- Coordinator of Technical Activities, Vice President of the RE, Chairman of the Joint Chapter PES / IAS, co-founder of the Joint Chapter ComSoc / CS as well as co-founder of the SIGHT Humanitarian Service at the same time as Secretary and Translation Coordinator of Enlaces R9 Magazine.

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Experimentando con WIE

Annielke Nahzareth Guzmán Ibarra
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I. INTRODUCCIÓN

Rama estudiantil UNI Nicaragua del Instituto de Ingenieros Eléctricos en su trabajo por en promover la creatividad, el desarrollo y la integración, compartir y aplicar los avances en las tecnologías de la información, electrónica y ciencias en general desarrolla un calendario anual con actividades a llevarse a cabo todos los meses.

En el mes de Marzo por ser el mes de la Mujer a nivel mundial se creó una actividad de activación cognitiva para niñas de 6to grado de primaria. En dicha actividad las niñas pudieron aprender de forma teórica y práctica sobre ciencia y tecnología, descubrir la importancia de utilizar las matemáticas y otras habilidades de las ingenierías en la vida diaria. La metodología fue simple, se realizaron pequeños talleres (prácticas en el laboratorio) con el objetivo de presentar tres carreras de ingeniería de mucha demanda y mucho crecimiento en Nicaragua. (Química, Electrónica y Computación), dicha actividad se denomina "**Experimentando con WIE"**.

En de la Universidad Nacional de Ingeniería (UNI), existe un grupo WIE el cual está conformado por estudiantes de las distintas carreras de ingeniería, en acompañamiento a esta actividad contamos con la ayuda de miembros del capítulo estudiantil Computer Society e Industry Application Society.

II. OBJETIVO GENERAL

Romper el modelo estereotipado del ingeniero masculino, haciendo que la ingeniería sea accesible a las niñas y que se diviertan desarrollando juegos y actividades de las distintas carreras.

III. ALCANCES

Con esta actividad se pretende despertar en las niñas de primaria su creatividad y motivarlas a no limitarse a lo cotidiano de la vida, sino a que a incursionar en el ámbito de las tecnologías en un futuro con las ingenierías.

Se proponen tres talleres, donde las niñas acompañadas de por ingenieros, ingenieras y estudiantes, "aprenderán haciendo". La supervisión de profesionales y estudiantes de ingeniería garantizara el orden, cuido de materiales, y la seguridad de las participantes.

III. PLAN DE ACTIVIDADES

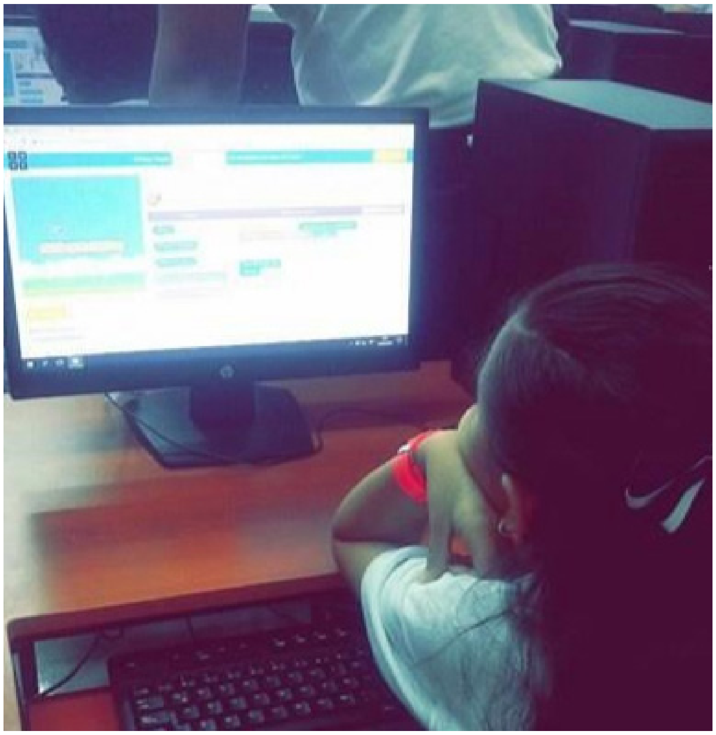
Introducción a la Programación
Ingeniería en Computación

Diseñado para permitir a las participantes crear programas informáticos sencillos. En este taller se presenta a la programación como una herramienta para desarrollar habilidades de solución de problemas, y perseverar en tareas difíciles.

Cada participante tendrá a disposición una computadora con Code Studio, una plataforma de programación y codificación muy utilizada para enseñar a programar de forma divertida. Está pensada para estudiantes de primaria por ser fácil de usar.

Uso de Arduino – Ingeniería en Electrónica

Diseñado para permitir a las participantes crear, programar y controlar un farol mediante Arduino, una plataforma libre que permite la automatización y el control incluso por medio de internet. Específicamente, se realizará el Encendido y apagado de luces LED, programando el Arduino



Taller de Computación, Introducción a la Programación

se podrá decidir hacia dónde se moverán las luces y qué colores se desplegarán en el farol.

Análisis y Proceso Mermelada de Piña Ingeniería Química

Diseñado para permitir a las participantes tener un primer contacto con un laboratorio de química de la vida real. Con este taller las participantes entenderán fenómenos químicos cotidianos, permitiéndoles desarrollar habilidades que les permitan analizar estos fenómenos desde el conocimiento escolar.

Taller de Química , Análisis y Proceso Mermelada de Piña

Población Meta:

15 estudiantes, todas niñas de 6to Grado del Colegio Liceo Franciscano, las que serán trasladadas a las instalaciones de la Universidad Nacional de Ingeniería. Se sugiere que las niñas porten su uniforme escolar y estén acompañadas por un docente asignado por el colegio.

Resultados Obtenidos:

- Con mucho éxito logramos mantener la atención de las niñas y el entusiasmo por recibir más talleres relacionados a la ingeniería. "**Lo que más me ha gustado de esta visita fue cuando trabajamos con las luces Led y vimos cómo se ahorraba energía, me gusto conversar con los profesores ellos nos han enseñado muchas cosas**" expresó la niña Stefani Paola Olivares Mendoza, estudiante del Colegio Liceo Franciscano.

- Enlazamos una mejor comunicación con el Director de la Escuela, consiguiendo que este nos pidiera realizar 1 taller al mes con niñas de distintos grados, para la motivación de las mismas.

- Nuestra Rama estudiantil ahora es conocida a nivel Nacional en relación a que somos y que hacemos ya que un periódico Nacional hizo una publicación sobre la actividad. Ver: https://nuevaya.com.ni/dia-la-ingenieria/

- Las entidades superiores de Nuestra Universidad se sienten orgullosos del trabajo realizado por nuestra Rama estudiantil indicándonos que contamos con el apoyo necesario para realizar más actividades educativas como esta.

Use of Natural Resources.

Application Project and International Seminar on Biodigesters.

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Abstract - This article aims to show how, through the realization of the International Seminar on anaerobic digestion experiments and small and medium scale biodigesters, it was possible to meet the existing need for lack of information, as a result of a failed experience of Implementation of a Biodigestor in the Muisca community of the town of Bosa in Bogotá DC; Obtaining as a result the construction of a methodological framework for the realization of projects that involve the approach to a determined community. This framework has as central axes the management and planning of activities, integration of the different disciplines of Engineering, together with the contribution of this to society; This was possible thanks to the joint work of the Colombian Network of Biomass Energy - RedBioCOL and the Network of Biodigesters for Latin America and the Caribbean - RedBioLAC, with the Faculty of Engineering of the El Bosque University, and therefore with the Society Of Power and Energy - PES, of the IEEE Student Branch of the same.

Index Terms- Biodigestor, Organic Waste, Anaerobic Digestion, Community, Acti-vity Planning.

II. CHALLENGE

In the first instance, after the verbal description of an IEEE Section Colombia professional regarding the possible needs of the Muisca de Bosa indigenous community in Bogotá DC. It is identified that the community has waste management needs and that; in addition, seek after the appropriate management of organic solid waste develop a path of entrepreneurship that has repercussions on monetary gains, requesting in particular the design and implementation of a biodigester to meet those needs. Thus, it is essential to focus efforts towards finding information that allows the formulation of solutions, which have the required Ingenieril rigor, thus promoting the successful completion of the projects and thus reducing the failures within the process the time to implement alternative solutions to problems related to the subject matter of study.

II. SOLUTION

Within the Muisca community, particula-rity is requested in the design and implementation of a Biodigestor for the ma-nagement of solid waste, in order to take advantage of its product in electricity network and fertilizer for the crops they carry out in their daily lives.

However, within the application of engineering, there may be differences in solution options, which must be previously approved by the Community

III. INTRODUCTION

One of the main environmental problems facing society today is the increase in the generation of organic waste. It is for this reason that the sustainable management of this type of waste has become a political priority, thus demonstrating the combination of common efforts that focus both on the reduction of greenhouse gas emissions and on mitigation of the effects of climate change [1].

In this context, it is important to mention that when a community presents a problem associated with the high generation of organic waste, it must make an analysis of each one and every one of the technical determinants that condition the solution alternative to be implemented.

In this way, anaerobic digestion can be considered as one of the best alternatives to take advantage of this type of waste, because through this microbiological process in the absence of oxygen, the organic substrate is decomposed and transformed into an energy source as it is the biogas and also obtain natural fertilizers for the soil [3].

However, as is the case of the Muisca Community, located in the town of Bosa in Bogotá DC, who present a problem associated with these aspects, it was not possible to implement a Biodigestor because in carrying out an assessment of technical feasibility It was not enough information and in turn the planning process of the design did not have the conditions given for successful implementation, given the conditions of the land and the uses established for the product generated By the biodigestor, which was a failed attempt in the realization of said proposal.

Thus, there is a need to obtain and exchange information such as the one presented at the international seminar on anaerobic digestion experiments and small and medium scale biodigesters, seeking to project, motivate and come to implement a technological tool that means a significant contribution in the management of organic waste, revealing both the difficulties and the benefits of implementing biodigesters.

It is important to mention that the lack of information generates the opening of a gap that is important to reduce, since with the construction of the methodo-logy presented below, a methodological framework is constituted that can be considered as a tool for the development of Future projects of approach to the community, based on the management and planning of activities, integration of the different disciplines of Engineering, together with the contribution of this to society.

IV. DESCRIPTION OF THE STRATEGY TO BE FOLLOWED

Based on the generation of organic solid waste, it seeks to implement mechanisms to improve the quality of life of communities through the use of these residues produced within them, through the implementation of technologies that contribute to the development of Economy as well as good living; For this, it is necessary an adequate management of organic solid waste, so as to provide them as an improvement alternative that targets the energy sector, the quality of the soil and with this, promote sovereignty and food sustainability; This is why it is sought to contribute through the knowledge and the implementation of technology, in the well-being of the communities, providing the necessary tools so that they can appropriate and empower themselves [1] the tools that surround them.

On the one hand, a preliminary assessment is ca-rried out for the diagnosis provided by a Profe-ssional from IEEE Section Colombia regarding the needs of the community against the disposal and management of organic solid waste as an alternative In favor of the community; To this end, field trips were made to the place where the project was planned in order not only to receive the approval of the indigenous community from the work of the chapters and therefore their intervention within the community, but also to identify the necessary requirements to carry out said project. On the other hand, throughout the development of the activity, the importance of including chapters such as PES, SSIT, IAS and CONTROL was identified in order to properly manage the project and implement the necessary technologies, through the competencies obtained in Each of the chapters under their areas of knowledge, in order to take it fully.

Consequently, after contemplating the need of the community and its interest in the elaboration of a biodigestor as an alternative solution to the problem initially described, developing ethnography a method of participant observation and data analysis [1], a search is derived of information regarding the needs and requirements that the development of the biodigestor entails; For this, the requirements, advantages and disadvantages of the implementation of a biodigester. Once established the basic theoretical bases for the elaboration of a biodigestor, proceed with the corroboration of the information in the field since when it comes to cultural research ethnography is essential as the main basis of know-ledge, which requires fieldwork. To do this, the community must be approached. [1].

For the approach to the community, it is indispensable to recognize the principles and values with which this community counts. The information regarding the foundations of this community and its progress over time, those that allow to recognize and to identify the methodology by which It was necessary to give way to the project, that is to say, to know in depth the principles of this community, it was understood the rigor of the processes by which it was necessary to proceed in order to concretize the intervention; After identifying the respect for their beliefs and their methods, proceeded to apply them.

Once the relevant rituals were carried out as a result of their acceptance in the community to be authorized to work with them. It was proceeded to identify if the manifested needs really pointed to the solution of specific problems since, people can not be forced to talk about what does not interest them and it is through the dialogue that comes to these generative themes [1]. After the elaboration of interviews and identification of priorities, the need for the community to make an adequate management of solid waste was acknowledged, while the community stated that it had problems related to the collection of garbage and that they also wanted to give a use of solid waste such as PET bottles and other waste generated in the community.

Within the site specifications that were obtained through the survey of requirements, the following information was obtained:

- The water used by the community to meet the needs of its communal zone was provided by the aqueduct and a part of rainwater harvesting.

- The community has all public services.

- They have support from the Ministry of Health, which assigns them a doctor who works together with a community healer.

They also have the support of the Ministry of Education and the Secretary of Government.

- The community is made up of about 726

families representing a total of 3500 people.

- The community wanted its waste transformed through a biodigester to be sold on the surrounding sidewalks to generate sustainable development.

- The land on which they live is rented and the manure supply that would be used for the biodigester would have to be purchased.

- They have a garden half a block away, which they want to involve in the project.

From this, it is suggested to take a predetermined step by step to achieve a successful project on the subject.
The project led by students of the University El Bosque develops field development processes for a biodigestor, as a requirement survey in the Muisca Community of Bosa, to establish methodologies in which it was intended to achieve an active functioning of the same, reaching to establish as not feasible the project for different conditions of the community and the terrain.

Scheme No 1. Self-elaboration of solutions. [3]

In scheme 1, the solution is presented in biodigestors by the RedBioLac with the participation of the speakers who participated in the seminar carried out by the members of the IEEE Branch of the University, members of the PES chapter, as representation of way ideal for the introduction of anaerobic digestion, small and medium scale biodigesters.

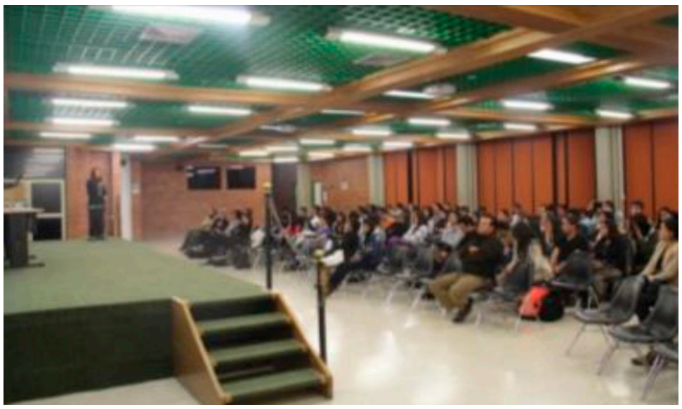
V. RESULTS

When approaching the community was obtained as a result of the lifting of requirements, that the development of the project with the community Muisca de Bosa can not be concluded as there are no optimum conditions of space or sufficient amount of organic waste able to maintaining a biodigester and at the same time sustainable for the community. In addition, another solution was proposed for waste management, such as the implementation of vermicomposting, recycling of waste and processing of waste, but finally, due to a lack of communication among the actors involved, lack of space and compliance with other requirements. The project was developed in its entirety.


Scheme No 2. Space available for implementation of the Biodigestor.

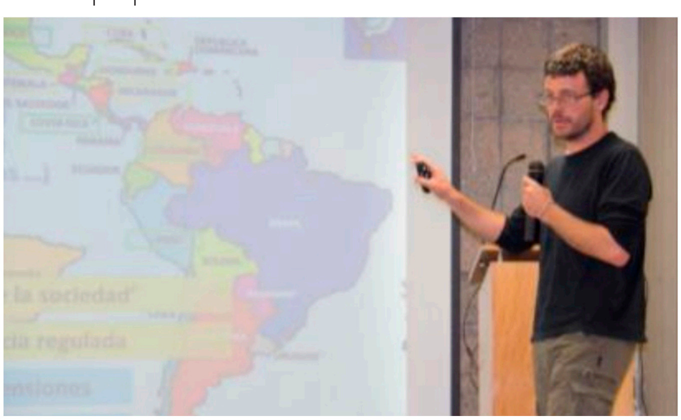
As a consequence of this, the student chapter PES of the Branch of the University of El Bosque identifies the need to acquire more information regarding the introduction and implementation of biodigesters. In order that the members of the Branch be trained in this theme and in the future, would be able to develop similar projects in their totality and achieve holistic and integrated work.

The members of the PES chapter propose an International Seminar on experiments in anaerobic digestion and small and medium scale biodigesters, which was the result of the articulation of the RedBioCol. Which is supported by the RedBioLac, allowing the participation of 4 international lectures (Argentina, Costa Rica, Ecuador, Chile), 4 national (UTA, CIPAV, UIS) and 124 attendees from the University El Bosque, Uniagraria, Sergio Arboleda, UIS, National Pereira, Buenaventura, University Cooperative de Colombia and Pontifical University Javeriana. As an introduction to different means of treatment and use of biol, low cost PFR reactor, small and medium scale asobiogas and biodigesters in Lac.



Scheme No 3. Seminar with the RedBioLAC.

Achieving through the participation of the exhibitors when exchanging information regarding experiences, advances and solutions between the participating institutions of the board of RedBioLAC and RedBioCOL as representation. A socialization of experiences to be able to reach an increase in the number of national and international agreements in active projects by the exponents or the relations that were established, in order to stimulate integral treatment and waste management as strategies for the welfare of the population.



Scheme No 4. Lecturer belonging to the RedBioLAC.

VI. CONCLUSIONS

Although it failed to achieve the main objectives of implementing a bio-digester in the Muisca Community of Bosa. It was a great contribution to take into account the taking of requirements and key knowledge to reach maximum results in which it is expected to achieve great aid in different Communities or where this type of exploitation mechanisms is required, both natural resources and organic waste.

After identifying that the biodigesters offer the advantage of the treatment of the organic wastes, extracting part of energy contained in the material, controlling the fertilizer for the bad odors and proliferation of flies, reducing the chemical and biological demand; Identifies that this technology can be implemented in rural and urban areas, benefiting individuals, biodiversity and sustainability. Likewise, this last aspect, one of the most relevant conclusions in the seminar, given its positive impact on the communities. The sustainability of the project is exposed through a variety of technologies as solutions to an inadequate service of garbage collection, entrepreneurship from separation of waste at the source and its action as a technology that solves the problems of the community adapting to their needs and requirements.

The socialization of international and national experiences in anaerobic biodigestion and the energetic use of organic waste was attended by several university institutions. From this seminar, a base is created to continue to overcome the challenges and to generate a joint growth with the volunteers of the Branch, thanks to the correct planning of activities, as well as decreasing the information gaps in terms of Biodigesters.

This project promotes the implementation of engineering to improve the quality of life of the communities that most need it, thus promoting engineering for the world.

VI. ACKNOWLEDGMENT

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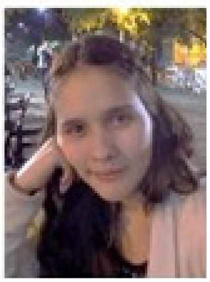
VI. BIOGRAPHIES



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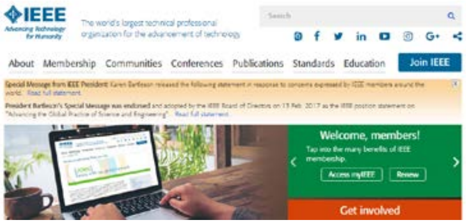

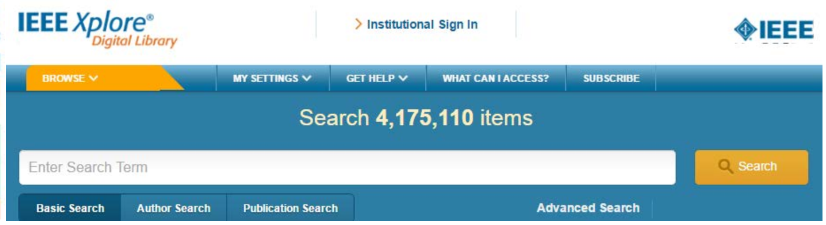

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Análisis de Riesgo y Flexibilidad del Plan de Expansión del Sistema Eléctrico de Potencia Paraguayo bajo Incertidumbre

F. Ferreira, *Student Member, IEEE*, D. Ríos, F. Fernández, F. Escudero, G.Blanco, *Senior Member, IEEE*

***Abstract*—Nowadays, power system planners aim to promote investments in generation and transmission capacity for keeping pace of the increasing demand that could benefit a country, in terms of economic growth and development. Furthermore, tailored investment valuation models could help to quantify the contribution of strategic flexibility in investment portfolios of such power system activities. In this sense, this paper seeks to assess the performance of scheduled investments within the Paraguayan power system focusing on risk analysis and management. Firstly, it is proposed a mathematical model which considers uncertainties in the demand growth, based on Monte Carlo simulations and the Brownian Motion with drift sthochastic process. This model is applied to calculate the system's Optimal Power Flow DC (OPF-DC) from 2014 to 2023, in order to maximize the system-wide social welfare of the country. Then, the Real Options method is applied for valuing the strategic flexibility embedded into the Yguazu hydropower project in order to find the optimal investment time, initially scheduled for 2018. Finally, results show the risk of the investment portfolios and that is convenient to defer the hydropower project until 2023, in all the scenarios under study.**

***Index Terms*— Power Planning, Flexibility, Brownian Motion, Optimal Power Flow, Real Options, Uncertainties.**

I. Introducción

La transición hacia un sector eléctrico eficiente ha requerido un cambio de paradigma en la operación y planificación del sistema de potencia, con el objetivo de mejorar el grado de competencia en el mercado. La asignación eficiente de inversiones y el tiempo de toma de decisiones en la expansión son cada vez más importantes, por ser el sistema de trasmisión (ST), la piedra angular en el que depende la coordinación entre oferta y demanda de electricidad, bajo niveles predefinidos de confiabilidad del servicio. En este sentido, el ST debe evolucionar apropiadamente para ser capaz de cumplir su papel de transporte de energía, desde la generación a los centros de distribución, en función de las necesidades futuras de la demanda.

El problema principal del ST, consiste en la naturaleza de las inversiones, con características como: economías de escala, irreversibilidad, baja adaptabilidad, uso de capital intensivo, opciones de diferir y elevada exposición a las incertidumbres de largo plazo [1]. Así, una metodología de evaluación de inversiones adecuada, debe ser capaz de incorporar de manera cuantitativa estas particularidades, que pueden ser integradas en tres componentes fundamentales: irreversibilidad, incertidumbres y manejo de riesgo.

Algunas de estas incertidumbres, como por ejemplo, la evolución incierta de la demanda, pueden ser representadas adecuadamente a través de procesos estocásticos. Esto permite considerar escenarios de inversión con opciones de flexibilidad, a diferencia del enfoque fijo de flujo de caja descontado. La flexibilidad ofrece la posibilidad de adaptar rápidamente el plan de inversión de los sistemas de potencia y a bajo costo, a cualquier cambio, previsto o no, en las condiciones que se esperaban en el momento en que se decidió[2] - [3]. Por lo tanto, la estrategia de considerar la flexibilidad en proyectos de inversión podría verse como una técnica de manejo de riesgos, que permite gestionar adecuadamente las incertidumbres, que no están resueltas en el momento de la toma de decisiones[4].

El enfoque de Opciones Reales (OR), proporciona un marco basado en las teorías de opciones financieras, para la valoración de proyectos flexibles bajo incertidumbres aleatorias, con múltiples opciones estratégicas de flexibilidad, tales como: la opción de expandirse en una etapa posterior, posponer la opción y abandonar la inversión en el futuro [5].

En dicho sentido, este artículo propone la aplicación del enfoque de OR para la evaluación técnico-económica de inversiones en el sistema de transmisión, en base a simulaciones de Monte Carlo del beneficio social del mercado eléctrico paraguayo, contempladas en el Plan Maestro de la Administración Nacional de Electricidad (ANDE), para el período 2014-2023.

II. Modelado del Sistema de Potencia

La expansión del Sistema Interconectado Nacional (SIN) del Paraguay, se da en el marco de la ejecución de obras contempladas en el Plan Maestro ANDE 2014-2023, el cual busca acompañar el crecimiento proyectado de la demanda, donde las incertidumbres sobre la demanda presentan un comportamiento estocástico. Su impacto sobre la capacidad de transmisión y, consecuentemente, sobre las unidades

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generadoras, es cuantificado a través de un modelo de simulación del despacho óptimo de carga del SIN. Luego, la diferencia de costos de operación del SEP en los escenarios, donde no se incluyen nuevas obras, y un escenario donde son ejecutadas nuevas obras según el plan maestro, definirá el Beneficio Social Incremental (BSI) del país, lo que permitirá cuantificar el rendimiento de las inversiones del Plan Maestro ANDE. Finalmente, se comparará el BSI obtenido en diferentes escenarios considerados con el valor de la flexibilidad del proyecto de la Central Hidroeléctrica Yguazú, también contemplada en el plan maestro, para, de esta forma, cuantificar el comportamiento neto de las inversiones en el ST.

A. Modelado de la Red

El flujo de potencia óptimo (Optimal Power Flow, OPF, por sus siglas en inglés) del SIN paraguayo, es obtenido a partir de un modelo de red simplificado que contempla las líneas de transmisión (LT) de 500 kV y 220 kV, además de las unidades generadoras existentes. Los datos del SIN utilizados fueron obtenidos de [6], mientras que en la Fig.1 se muestra la red para el año 2023, programado según el plan maestro ANDE.

El análisis contempla como horizonte el mediano plazo, y considera que durante el mismo la topología de la red y la situación de la carga en punta de dicho horizonte no superan el margen de reserva de generación. Además, la obtención del OPF toma como parámetros de control que el suministro de la demanda total proyectada se encuentra sin violaciones a los criterios de tensión y de carga en las líneas de transmisión y equipos de transformación ante condiciones normales de operación del sistema (red completa) [6].

Se evalúan también condiciones de emergencia, considerándose el Criterio N-1, en el que se supone la pérdida de un solo elemento del sistema por vez (red incompleta o alterada). Las contingencias son analizadas principalmente en los corredores de las líneas de transmisión modelados, de forma a estimar el desempeño del sistema ante dichas contingencias.

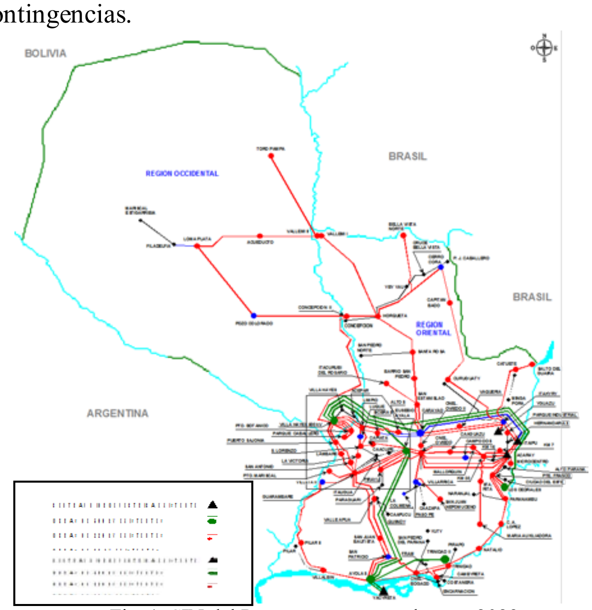

Fig. 1. SIN del Paraguay programado para 2023

B. Modelado del Crecimiento de la Demanda

El crecimiento de la demanda es el principal impulsor de la expansión de los sistemas energéticos. Generalmente, la demanda se considera como inelástica, es decir, existe una ausencia de control por parte de los clientes de su consumo a corto plazo. A pesar de que la carga se considera inelástica, se asume comúnmente que los clientes no estarán dispuestos a consumir energía si el costo de disponer la misma en condiciones de racionamiento o corte, es mayor que el costo tarifario de consumo; este costo es referido como el Costo de Energía No Suministrada (CENS), y es establecido generalmente en términos del administrador del mercado, con el fin de visualizar escenarios con escasez de energía, debido a que la capacidad de generación disponible no es suficiente para abastecer totalmente la demanda[7].

Un modelo estocástico de la demanda consistente debe girar en torno a un componente determinístico, sobre el cual existen fluctuaciones aleatorias. Para evitar una complejidad innecesaria, el componente fijo de crecimiento de la demanda consiste en una tasa tendencial anual que, generalmente se caracteriza como el crecimiento anual promedio obtenido sobre un histórico dado. Las desviaciones aleatorias de la tasa de crecimiento en torno al valor esperado, son interpretadas como un error de previsión de la tasa de crecimiento. De acuerdo con el Teorema del Límite Central, se asume que esta componente aleatoria para el caso de estudio, presenta una Distribución Gaussiana. Atendiendo a la generalización del Proceso de Wiener, esta componente se puede formular como sigue:

$$dz = \varepsilon\sqrt{dt} \tag{1}$$

Donde la variación de la variable z durante un corto intervalo Δt es definido por el producto de la variable aleatoria y la raíz cuadrada de la longitud del periodo. ε es llamado “ruido blando”, es decir, es una variable aleatoria independiente que presenta una distribución gaussiana, con valor esperado igual a 0 y varianza 1. Entonces, el modelo estocástico de la tasa de crecimiento de demanda dR dentro de un intervalo dt, se puede generalizar mediante la formulación del Movimiento Browniano Tendencial, acorde a la siguiente expresión:

$$dR(t) = \mu_{d_i}(t) \cdot dt + \sigma_{d_i}(t) \cdot dz \tag{2}$$

Donde μ_{d_i} es la media no condicional estimada de la tasa de crecimiento para el año t, $\sigma_{d_i}{}^2$ es la varianza no condicional estimada para el intervalo de tiempo dt, y dz es el proceso de Wiener [7].Los parámetros estocásticos utilizados se muestran en la Tabla I.

TABLA I.
Parámetros Estocásticos

País	μ_{d_i}[%]	σ_{d_i}[%]
Paraguay	8,03261	4,2742

C. Flujo de Potencia Optimo del SIN

Como parte de este trabajo, el Ahorro en Costos de Generación (ACG), se utiliza como criterio para evaluar el desempeño económico de la expansión de la red. Por lo tanto, incorporando el modelado del crecimiento de la demanda estocástica para las simulaciones de la operación del SIN, se consideran dos escenarios, sin la ejecución de obras del Plan Maestro ANDE de generación y transmisión por un lado, y con la ejecución de dichas obras por otro lado, con el fin de replicar el comportamiento del sistema y estimar los costos de producción en ambos escenarios.

El cálculo del OPF DC, tiene el objetivo de estimar el costo óptimo de generación. El modelo OPF DC ha sido ampliamente utilizado en numerosos casos de estudio de sistemas eléctricos de potencia, para calcular el despacho de generación basado en ofertas presentadas por los generadores, así como también, considera las limitaciones de la red.

El objetivo general del mencionado modelo es maximizar el BSI, dicho de otro modo, minimizar el costo de generación considerando que la demanda es inelástica. El modelo incorpora los límites de capacidad de las LT, pero hace concesiones respecto a la réplica de algunas características del comportamiento real del sistema, de manera a ganar simplicidad. Por ejemplo, las transacciones comerciales en interconexiones transfronterizas no se pueden evaluar de manera explícita [7].

La ventaja del cálculo del OPF, es que los resultados representan el verdadero potencial de la red, independientemente de su comportamiento real. Para la minimización del costo de generación, el problema de optimización puede afirmarse matemáticamente como sigue:

$$Función\ objetivo = min\left[\sum_i \sum_g C_g\left(P_g^i\right)\right] \quad (3)$$

Sujeto al balance de potencia para el nodo i

$$\sum_g P_g^i - \sum_d P_d^i - \sum_l F_l^i = 0 \quad (4)$$

Sujeto a la producción máxima de cada generador

$$P_g^{i,min} \leq P_g^i \leq P_g^{i,max} \quad (5)$$

Sujeto al flujo de potencia en ambos sentidos de todas las LT conectadas en el nodo i

$$F_l^{min} \leq F_l \leq F_l^{max} \quad (6)$$

Donde C_g es la curva de oferta del generador [USD/h], P_g^i y P_d^i son las potencias [MW] producidas por el generador g y la demanda en el nodo i,F_l es el flujo de potencia para cada línea de transmisión del sistema.

Para este trabajo, el comportamiento estocástico de la operación del SIN puede ser caracterizado mediante un modelo fundamental, ya que los costos de generación anuales están directamente influenciados por el comportamiento estocástico de la demanda, en el corto y mediano plazo. Cabe destacar que la demanda es modelada en el problema del OPF como carga despachable, es decir, con valores negativos en términos de producción de potencia.

Desde un punto de vista económico, se utiliza el flujo de caja estocástico definido por el costo anual de ahorro de generación para cada realización, con el fin de evaluar el rendimiento de la inversiones en el ST, donde los costos de las inversiones requeridas son obtenidas del Plan Maestro de la ANDE.

III. Evaluación Económica de las Inversiones del SEP

El enfoque tradicional que la evaluación de proyectos utiliza es el método del Valor Presente Neto (VPN). Este enfoque de evaluación presenta un buen rendimiento cuando el proyecto está expuesto a una incertidumbre escasa o nula en sus variables de estado y no tiene ninguna opción de flexibilidad estratégica (opción de aplazar, ampliar, cambiar, abandonar, etc.). Sin embargo, la herramienta más apropiada para la evaluación de las inversiones bajo procesos estocásticos es la técnica de Opciones Reales.

A. Flujo de Fondo Descontado Estocástico

El Ahorro en Costos de Generación (ACG), a lo largo del horizonte de inversión se puede calcular mediante la implementación de simulaciones de Monte Carlo. Por lo tanto, el flujo de fondo descontado estocástico del proyecto se define por un conjunto de flujos de fondos obtenidos del OPF y los desembolsos de capital efectuados para el proyecto de expansión. El flujo de fondos resultante de cada simulación de Monte Carlo está compuesto por el BSI anual y los costos de inversión. Así, en este módulo se calcula el valor actual de BSI acumulado en el horizonte de estudio, basado en los ahorros de costos del sistema [2]. Asimismo, en primer lugar, los flujos de fondos del BSI que se originan a causa de la ejecución del proyecto de expansión son descontados por el Costo Promedio Ponderado del Capital (WACC, Weigthed Average Capital Cost, por sus siglas en inglés), de acuerdo con la siguiente expresión:

$$VP\left(BSI_{s,\omega,t_n}\right) = \sum_{t=t_n}^{T}\left(\frac{ACG_{t,\omega}^{S}}{(1+WACC)^t}\right) \quad (7)$$

$$VPN\left(BSI_{s,\omega,t_n}\right) = \sum_{t=t_n}^{T}\left(\frac{ACG_{t,\omega}^{S} - I_{s,t} - CO_{s,t}}{(1+WACC)^t}\right) \quad (8)$$

$$\mathbb{E}\left[VPN\left(BSI_{s,\omega,t_n}\right)\right] = \sum_{\omega=1}^{\Omega}\frac{1}{\Omega}\left(VP\left(BSI_{s,\omega,t_n}\right)\right) \quad (9)$$

Donde $ACG_{t,\omega}^{S}$ y $I_{s,t}$ son los Ahorros en Costos de Generación y los Costos de Inversión respectivamente, las ecuaciones (7) y (8) son el VP y VPN del BSI, ejecutando la estrategia de inversiones en el año t_n y T es el horizonte de inversión. Finalmente, la ecuación (9) define el valor esperado del VPN para Ω realizaciones de Monte Carlo. En cada caso, los sub-índices corresponden al t-ésimo año, i-ésima realización de la simulación de Monte Carlo del sistema de potencia.

B. Programación Dinámica basada en el Valor Esperado

El valor de una inversión flexible, se calcula hallando el tiempo de ejercicio óptimo de las opciones de flexibilidad. La programación dinámica es una herramienta adecuada para llevar a cabo esta tarea. Este enfoque podría ser visualizado gráficamente como un árbol de decisión, y la opción real obliga a una búsqueda del momento óptimo para invertir. En un tiempo t genérico, el modelo estimará el valor presente neto de la inversión teniendo en cuenta la probabilidad de dos escenarios: invertir ahora o mantener la inversión hasta el próximo período.

Por razones de claridad, como ha sido expuesto en [2], el punto de partida del análisis es la evaluación de inversiones en la red de transmisión con la opción de diferir el proyecto Yguazú. Suponiendo que la licencia del proyecto tiene T años de vigencia y el capital necesario para invertir en el año t es I(t), el valor esperado del proyecto de inversión se considera como activo subyacente, $\mathbb{E}[\mathrm{VP(BSI)}]$. La tasa libre de riesgo se denota por r. La política óptima de ejercicio de las opciones se deriva de la comparación del valor intrínseco de la opción de diferimiento, con el valor de mantener viva la opción. El problema se inicia desde el último año y procede de manera recursiva, de atrás hacia adelante, hasta alcanzar el primer año. Durante el último año, el problema se modela como:

$$\begin{aligned} &\text{Ejecutar, si } \mathrm{V(T)} = \mathbb{E}[\mathrm{VP(BSI)}] > I(\mathrm{T}); \\ &\text{No ejecutar, si } \quad \mathrm{V(T)} = \mathbb{E}[\mathrm{VP(BSI)}] \leq \mathrm{I(T)}; \end{aligned} \qquad (10)$$

Consecuentemente, la política óptima de decisión en T es:

$$\mathrm{V^*(T)} = \max[(\mathbb{E}[\mathrm{VP(BSI)}] - \mathrm{I(T)}); 0]; \qquad (11)$$

En todos los años $0 < t < T$, el valor de ejercer la opción de inversión en un tiempo dado es el VPN del proyecto de inversión si la inversión se realiza en el tiempo t, es decir:

$$V^{ex}(t) = \mathbb{E}[VP(BSI)] - I(t); \qquad (12)$$

Por otro lado, el valor de continuación de opción en el instante t-ésima, es decir, el valor del proyecto si la decisión es posponer la ejecución, está dada por:

$$V^{cont}(t) = \frac{V^*(t-1)}{(1+r)} \qquad (13)$$

Donde $\mathrm{V^{cont}(t)}$ es el valor encontrado bajo condiciones óptimas durante los años $\mathrm{t+1, t+2, \ldots, T-1, T}$ descontados al año $\mathrm{t+1}$.

Por lo tanto, en cualquier momento t, la política óptima de ejercicio se deriva del problema de optimización:

$$\mathrm{V^*(T)} = \max[(\mathbb{E}[\mathrm{VP(BSI,t)}] - \mathrm{I(T)}); \frac{\mathrm{V^*(t-1)}}{(1+\mathrm{r})}]; \qquad (14)$$

La última relación de optimización extiende la clásica regla del VPN. La política de decisión extendida es: "En el año t, el tomador de decisiones no debe invertir en el proyecto de inversión (esperar por lo menos un año) a menos que el valor esperado del valor presente neto de la inversión es mayor que el valor de continuación"[2]. Si la opción no se ejerce en el año t, el titular de la opción tendrá dos opciones en el próximo año: la opción de ejercicio o la espera de una mejor oportunidad (aplazar la inversión). Así, el enfoque proporciona el momento óptimo de inversión y el valor de dicha ejecución optima $V^*(0)$.

IV. SIMULACIONES Y RESULTADOS

El caso de estudio pretende ilustrar la metodología propuesta, con el objetivo de analizar los riesgos en diferentes escenarios de las inversiones del plan de expansión del ST paraguayo, considerando la flexibilidad de la CH Yguazú. El análisis es realizado a través del modelo matemático propuesto, considerando el comportamiento estocástico de la tasa de crecimiento de la demanda eléctrica durante el horizonte de inversión mencionado. En la Fig. 2, se puede observar un ejemplo de pasos de iteraciones de la tasa de crecimiento de la demanda, donde la componente tendencial es igual al crecimiento anual histórico promedio de 10 años de la potencia eléctrica de demanda máxima en el Paraguay, con una varianza obtenida considerando dicho comportamiento histórico. [8]

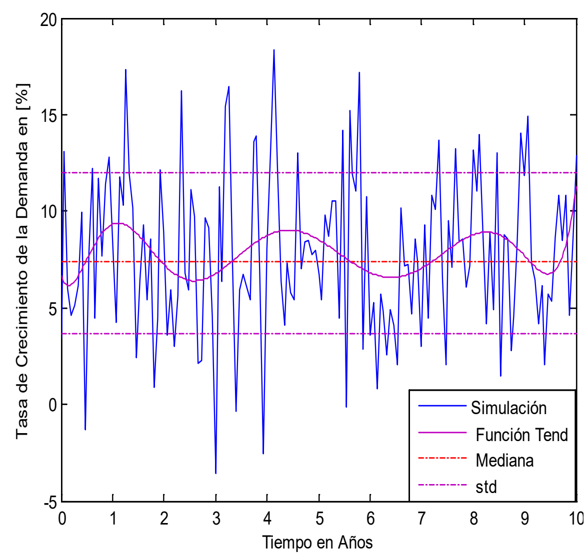

Fig. 2. Comportamiento Estocástico de la demanda.

El costo de generación de la CH Yguazú es considerado en dos escenarios, ya que es una variable no aleatoria; en este caso los costos mínimo y máximo considerados son 15 USD/MWh y 66 USD/MWh. En situaciones de déficit de energía, el precio del déficit es fijado en el valor de VOLL (Value of Lost Load, Valor de Pérdida de Carga, por sus siglas en inglés), el cual es considerado igual a 2940 USD/MWh [9]. Además, la evaluación económica considera una tasa de inflación anual del 4%, y una tasa de descuento WACC del 9% sobre el horizonte, desde el año 2014 al 2023.

Con el fin de determinar el costo de operación para el período de carga pico en el horizonte de inversión se realizan simulaciones de OPF-DC, en un modelo equivalente del SIN paraguayo, para los escenarios sin y con obras de inversión.

Además, se consideran contingencias, teniendo en cuenta el criterio N-1para las LT. Para la validación del modelo utilizado, se realizó una comparación de los flujos de potencia AC (PF-AC), con las simulaciones del presente trabajo, observándose resultados similares. Igualmente, se tomó en cuenta el criterio de convergencia del método de Monte Carlo, lo cual está definido con un error relativo máximo del 1%, con un intervalo de confianza del 90%[10]. Para el régimen normal de funcionamiento del sistema, son necesarias 2000 simulaciones de OPF en cada año de estudio, para satisfacer la convergencia de la esperanza del VPN bajo dicho criterio.

El OPF-DC se calcula utilizando el software Matpower 6.0, el cual es un paquete de simulación del SEP en ambiente MATLAB[11].

Consecuentemente, se obtiene el riesgo inherente de las inversiones del SEP paraguayo, es decir, la probabilidad donde los VPN son menores a ceros (Tabla II), considerando los escenarios en régimen normal y en régimen de contingencia simple, criterio N-1, de las LT.

TABLA II.
BSI Y RIESGO DEL PLAN MAESTRO ANDE 2014-2023

Estudio	$\mathbb{E}[VPN(BSI)]$ (MUSD)	RIESGO (%)
Régimen Normal	2307,3	6,45
Régimen de Contingencia	2106,6	7,4

A. Evaluación de Opciones Reales

Seguidamente, es realizada la evaluación basada en el enfoque de Opciones Reales, valorando la opción de diferimiento de la inversión en el proyecto Yguazú, y así, apreciar la esperanza del VPN de las inversiones del plan de expansión de la ANDE y en el tiempo óptimo para el proyecto en base al BSI, tal como se muestra en la Tabla III.

TABLA III.
FLEXIBILIDAD DE LA CH YGUAZÚ

	2017	**2018 (Plan ANDE)**	**2019**	**2020**
$\mathbb{E}[VPN(BSI)]$ (MUSD)	2292,6	2307,3	2321,1	2333,1
	2021	**2022**	**2023**	**No Invertir**
	2339,5	2330	2332,6	2586,6

Los resultados muestran que posponiendo la ejecución de la CH Yguazú un año, desde 2017 hasta 2023, y aunque el VPN de las inversiones del SEP tenga valores positivos, la estrategia óptima de inversión consiste en enfocarse solo en el ST, abandonando finalmente la ejecución del proyecto Yguazú. Además, el ahorro económico sin la ejecución del proyecto Yguazú para el Plan Maestro ANDE es de 279 MUSD.

V. CONCLUSIONES

En este trabajo, la aplicación de un nuevo marco metodológico ha sido presentada, basada en simulaciones estocásticas y la teoría de OR, para analizar el riesgo asociado a la toma de decisiones en las inversiones del ST paraguayo, considerando la flexibilidad del proyecto de la CH Yguazú, la cual está embebida en el Plan Maestro ANDE y programada inicialmente para el 2018.

El enfoque propuesto es capaz de replicar el comportamiento estocástico del crecimiento de la demanda pico, considerando un horizonte de estudio de 10 años, y dos escenarios de evaluación, con y sin la aplicación de obras contempladas en el plan de expansión de la ANDE, con el fin de presentar resultados que permitan definir una política de inversión óptima, contemplando la flexibilidad, de manera a maximizar el beneficio social del país.

Se concluye que, para el SIN paraguayo, las obras contempladas en el Plan Maestro ANDE 2014-2023, sin considerar la flexibilidad de la CH Yguazú, desde el punto de vista técnico-económico y en régimen normal de operación, están justificadas. Con este estudio se obtuvo un beneficio económico social para el país de 2307 [MUSD] y un riesgo de tan solo 6,45%, el cual representa la probabilidad de que las inversiones del plan no serán factibles, en el caso de que la tasa de crecimiento estocástico de la demanda pico se encuentre muy por debajo de la media tendencial, y más aún si existen retrocesos, es decir, valores negativos en la tasa de crecimiento. Para el caso de régimen de operación en contingencia, aplicando el criterio N-1 a las LT, se obtuvo un riesgo de 7,4%. Para dicho caso se ha obtenido un beneficio económico social de 2106 [MUSD], aunque el riesgo haya aumentado, las probabilidades de que todas las LT salgan fuera de servicio por vez, en cada año de estudio, son muy bajas.

Finalmente, se ha cuantificado el valor de la flexibilidad de la inversión en la CH Yguazú. Los resultados muestran que es conveniente abandonar el proyecto, ya que para dicho escenario se obtuvo el máximo BSI, de 2586 MUSD y por tanto el menor riesgo de tan solo 3,5%, consecuentemente se obtendría un ahorro económico para el país de 279 MUSD. Con ello se justifica que la mejor estrategia de inversión resulta en enfocarse solamente en las inversiones de expansión del ST paraguayo.

La principal contribución de este trabajo, es un modelo analítico para la toma de decisiones en la planificación de expansión del sistema de potencia, donde aspectos como la incertidumbre aleatoria del crecimiento de la demanda, e incertidumbre no aleatoria como el costo de generación, deben ser cuidadosamente tomados en cuenta, para la evaluación de inversiones en el sistema de potencia, y así, evitar toma de decisiones sub-optimas.

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VII. Biografías

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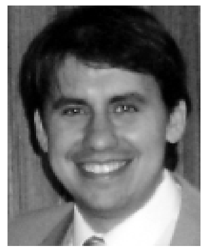

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Analysis of electrical systems in the petrochemical industry in Mexico. Part 1: load flow and short circuit recommendations acording to standards

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***Abstract*- This article presents the current status of the electrical system of the refineries in Mexico. Emphasis is made on the technical modifications in the primary electrical equipment and impacts on the national energy system. The Refining Industry in Mexico has been carrying out transformations and modernizations in the electrical systems to impact on their availability of the system. A previous diagnosis of energy conditions in electric and power systems of refineries in México, and radical changes proposed to implement new electric power distribution systems to establish the culture of Operational Reliability are described. The process of petroleum refining in Mexico has required a robust modernized infrastructure. A list of actions and recommendations that have been made to optimize load flow and short circuit analysis is also presented. The results of this article (Part 1) mainly show the changes required in the Mexican Refining Industry for a possible interconnection of each refinery to new cogeneration plants.**

Keywords— assets, clean fuels, conceptual design, electric grid, electric systems, energy, interrupting capacity, load flow, maintenance, petroleum, safety, reliability, short circuit.

I. Introduction

Electricity will be one of the most important commodities of the future. Energy consumption in different countries depends on oil demand as the bearer of "primary energy"; that is, that oil is the raw material that impacts the most on economic growth.

In Mexico, energy is generated in the order of 875 MW in the three subsidiaries of the Petrochemical Industry in Mexico (PIM), as shown in Table 1. The PIM is a state owned consortium of the Mexican Government and has increased its energy demand in the last decade [1].

Since 2003, PIM has modernized its electrical systems with the acquisition of new primary electrical equipment; such as, electric generators, power transformers, power circuits, switchgear, and has made considerable investments in associated equipment and control instrumentation.

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The integration of the new assets will be implemented in compliance with international standards on electrical systems. Also, integration of new primary electrical equipment in petrochemical plants requires an analysis to determine whether the design short circuit currents of the electrical systems will be sustained throughout the entire grid.

In this paper we present the experiences and realities that for ten years the Electrical Research Institute (ERI) has faced in providing reliability to the Petrochemical Industries in Mexico (PIM), with the development of individual solutions for each issue that it has encountered, and the collaboration between specialists from different disciplines of PIM and project solutions not yet executed and implemented in full for this period.

TABLE I. Average energy demand of petrochemical industries in Mexico [1]

Petrochemical Consortium	Identification of the petrochemical	Energy Demand (MW)	**Energy demand by industry (MW)**
National Refining Industry (NRI)	Cadereyta (RHRLS)	92	512
	Madero (RFIM)	95	
	Minatitlán (RLC)	90	
	Salamanca (RIAMA)	70	
	Salina Cruz (RADJ)	75	
	Tula (REMHI)	90	
Gas and Petrochemical Industry (GPI)	Área Coatzacoalcos	10	161.5
	Burgos y Reynosa	7.5	
	Cactus	40	
	Ciudad Pemex	38	
	La Venta	4	
	Nuevo Pemex	50	
	Poza Rica	12	
Petrochemical Industry (PQI)	Cangrejera	92	203
	Cosoleacaque	7	
	Escolín	2	
	Independencia	6	
	Morelos	71	
	Pajaritos	19	
	TR Pajaritos	6	

Also, in this paper a guide of recommendations that have been made from the “load flow and short circuit” analysis of electrical systems, focused mainly in the petrochemical industry in Mexico is presented. The purpose of this paper (Part 1) is to show that the current conditions of each electrical system must be verified, and thus determine the degree of safety and operational reliability of the facilities, equipment and operating personnel.

II. Background Information

A. *Electrical system analysis of the PIM*

The need to continually perform electrical studies to determine the current status of the electric power system commonly emphasized in books and specialized literature. The petrochemical industry in Mexico, has completed more than 100 electrical studies including those in the NRI, the GPI and PQI, not to mention that Mexico has an infrastructure for the exploitation of hydrocarbons in the Gulf of Mexico with 248 offshore platforms according to [2] and [3], where they have also made more than a 100 electrical studies at “steady state” reported by the ERI in the last 15 years [4].

Electrical safety guide lines recommend performing studies classified into: “steady state” and “dynamic state”. Studies in "steady state" are to be observed, evaluated and assessed under normal operating conditions and contingencies at a given moment of time, analyzing information about the chargeability, load flow, short circuit, protection coordination and arc-flash of power system. Decisions on operations will be based on predictions according to the results.

Moreover, studies on "dynamic state", allows identifying patterns of behavior of the electric system in a given interval of time, after the occurrence of an event in the electric system. These studies will allow us to know changes in the magnitudes of the electrical variables in the occurrence of events, such as faults, connection or disconnection of equipment, sudden loss of generation, among others. With this information it is possible to implement predictive and corrective actions that will contribute to the continuity of supplied energy and thus contribute to preview situation of Operational Reliability.

B. *Petrochemical Industries in Mexico*

The PIM is one of the largest in Latin America, produces about 2.5 million barrels of oil and 6 million cubic feet of natural gas, has 6 refineries, 8 petrochemical complexes and 7 gas processing complexes that allow petroleum producer to deliver it to the various industrial sectors. It also has 83 on land and sea terminals to supply more than 10,000 service stations in Mexico [5].

C. *Electrical Research Institute (ERI)*

The Electrical Research Institute (ERI) is a government organization created in 1975 for research and technological development of the country. Since 1999 it collaborated with the PIM for: a) the development of conceptual engineering, b) economic feasibility studies, c) specifications of electrical and control equipment, d) user requirements indicating operating conditions, e) bidding, f) electrical systems analysis, and g) particular solutions implementation through technical assistance during construction, supply and commissioning of the new equipment.

The ERI was requested by PIM to define the specifications to be met by its electrical distribution systems, control and instrumentation systems of the future, considering optimization criteria. The collaboration of the two companies has focused on the past decade on determining the actual conditions of operational reliability through analysis of the electrical system at steady state, as shown in Figure 1.

D. *Joint collaboration: PIM & ERI*

The ERI in conjunction with PIM has helped define the most suitable electrical schemes based on the experience of the specialists of both institutions; the implementation of the projects being substantiated as indicated in reference [4].

Consequently PIM and ERI have pursued during this decade, the statement of the National Development Plan 2007-2012, which states: "*To ensure a reliable supply, high quality, at a competitive price, of energy inputs that consumers demand*."

In contrast, there have been factors influencing not to achieve the reliability of electrical systems in the NRI, such as lack of investment resources, high operating costs, and low implementation capacity, as well as the lack of autonomy and independence to design business strategies, and improve the gasoline distribution chain.

Since 1999, the ERI have conducted a series of studies and analyzes in "steady state" for PIM, e.g. in the NRI have made substantial progress to secure the operating conditions of the current electrical system and availability for integration of new electrical equipment, ensuring the production of fuels to comply with PIM safety guidelines.

The importance of the analysis of the power system of the PIM is highly significant because the following objectives are sought together with the ERI:

- *General objective.* Contribute to the operational reliability of the National Refining Industry (NRI) with concrete actions in the technical field of planning to optimize power systems and position NRI within the "world ranking" of oil companies.

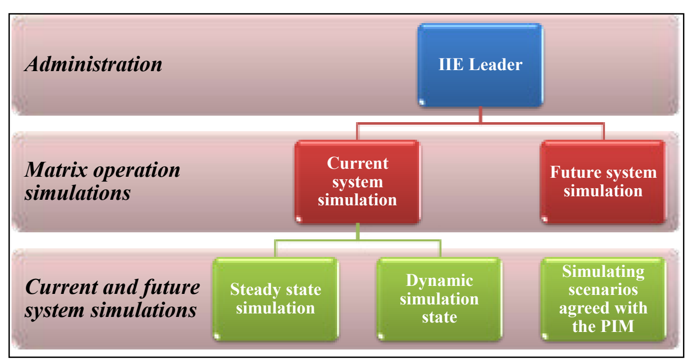

Fig. 1. Simulations recommended for analysis to diagnose current conditions of the electric system in the PIM (IIE=ERI).

- *Specific objectives.* a) Strengthen local working groups in the NRI generating project empathy to achieve concrete actions in the area of main electrical maintenance services, and b) Strategic planning actions to promote a smooth operational reliability based on the modernization of the electrical systems and their associated equipment.

In a medium voltage electrical system, an analysis of short circuit takes place every five years; this is mainly for the safety of personnel and installations of the electrical system. This recommendation applies to the electrical systems of mining, cement, paper and petrochemicals. The petrochemical industry in Mexico; for example, recommended such studies in stable state [6] to oil facilities in the country as a common practice each period of five years.

Therefore, Table 2 shows an example of progress in carrying out simulations since the operational reliability becomes important in 2008 by PIM according to [7].

Nowadays in PIM, there is a technical guide that allows administrators to commit to operational reliability through the application of consistent practices throughout time, so that it is integrated as one of the fundamental values of the culture of PIM. The scope of the guide is based on having an interaction between commitment and leadership as shown in Figure 2; as well as continuous improvement practices to the commitment of the elements that make up the operational reliability marked in Table 3.

Operational reliability is based on the life cycle of the assets, their designs and the applicable regulations, is the unification of human reliabilities objectives, of process, equipment and design, aimed at maximizing the profitability of the company.

The operational reliability model is composed of 14 best practices, the same as those that interact and create value throughout the organization, representing the conceptual and normative framework, the latter containing an axis comprising at least five documents relating to operational reliability in PIM.

TABLE II. PROGRESS OF STUDIES AND ANALYSIS SIMULATIONS OF CURRENT AND FUTURE ELECTRIC SYSTEM OF THE NRI IN MEXICO

Circumstances analysis	Refinery location of the NRI					
	RHRLS	RFIM	RLC	RIAMA	RADJ	REMHI
Load Flow	☑ 2012	☑ 2015	☑ 2011	☑ 2015	☑ 2014	☑ 2015
Short Circuit	☑ 2012	☑ 2015	☑ 2011	☑ 2015	☑ 2014	☑ 2015
Protection Coordination	☑ 2012	☑ 2015	☑ 2011	☑ 2015	☑ 2015	☑ 2015
Arc-Flash	☑ 2012	☑ 2015	☒	☑ 2015	☑ 2015	☑ 2015
Transient Stability	☒	☑ 2015	☒	☑ 2015	☑ 2015	☑ 2015

☑ Elaborated ☒ Unprocessed

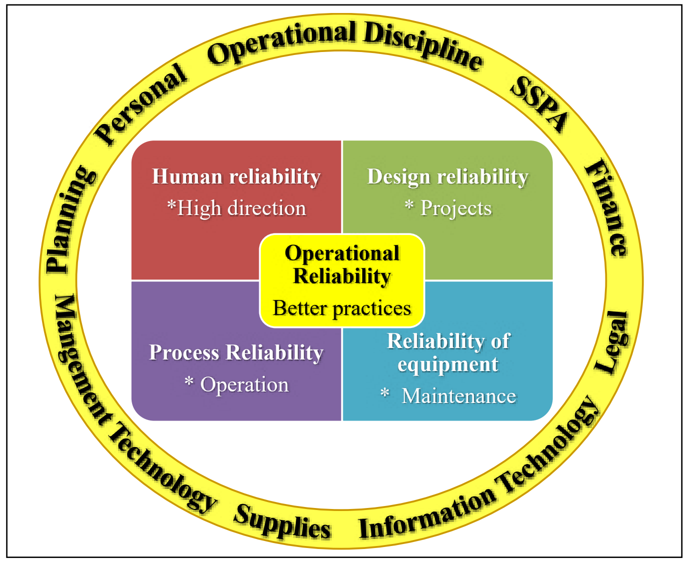

Fig. 2. Diagram showing the interaction of staff PIM commitment to best practice and leadership [Source: 8]

TABLE III. PRACTICES THAT ARE INTENDED TO ALLOW STAFF INTERACTION TO A STRONG COMMITMENT AND LEADERSHIP IN OPERATIONAL RELIABILITY

	Establish a culture of operational reliability	**To maintain compliance with applicable standards**	**Competition Establish process reliability**	**Promote the involvement of staff**
Elements	Establishing Reliability fundamental value	Ensure consistent implementation of standards system	Set goals	Ensure consistent implementation
	Provide strong leadership	Identify when required compliance standards	Define responsible	Involve relevant staff
	Establish and reinforce high standards of performance	Involve relevant staff	Identify benefits	
	Documenting Culture of Reliability	Practices to ensure that compliance standards are effective	Promoting organizational learning	

Source: [8]

Currently, the PIM is implementing a RCAM guide with the 14 best practices. It also is conducting analysis of the electric system to change and implement new projects in parallel according to [9], such as:

1. Integration of an electrical generator in the range of 31 to 38 MW capacity for refineries with energy deficit.
2. Upgrading from 13.8 kV to 34.5 kV synchronization bus for refineries.
3. Integration of an electrical generator in the range of 31MW to 38 MW capacity for refineries with greater load demands in the future CFPQ plants (Clean Fuel Projects Quality).
4. Electrical distribution in switchgear for CFPQ.
5. High resistance grounding of the three generation sources as suggested in [10]
6. Integration of new systems into the Advanced Operational Control System (SCOA: Sistema de Control Operacional Avanzado for the Spanish acronym) as suggested in [11].

Currently, the implementation of electrical reconfiguration projects develops gradually by installing synchronization buses at 34.5 kV and 115 kV in the "MHI" and "HRLS" refineries respectively. On the other hand, by 2017 it has to be implemented in NRI a variety of projects, such as migrating synchronization bus to 34.5 kV of the "ADJ Refinery". There are six refineries in the NRI, and enough technical capacity of NRI specialists for the implementation of such projects. In addition, work is been carry out in conjunction with the ERI, so that PIM can tackle and substantially improve their performance and thus comply with SENER (Ministry of Energy) proposal in the National Development Plan (PND 2007-2012), see Table IV. The collaboration and technical support by the ERI to PIM has an increased tendency for the future; henceforth the NRI can guarantee operational reliability which is one of the most important traits in the oil industry.

III. Recommendations for the Study & Analysis of Electrical Systems in the Petrochemical Industry

The analysis in each refinery in the last ten years have considered and proposed new schemes of action in the requirements for the electric system reconfiguration, such as migrating its distribution energy level from 13.8 kV to 34.5 kV, and in others cases up to 115 kV. Also, the integration of new power equipment, and generation units have been considered, which allow self-supply of electrical power to reach an average of 120 MW for a 34.5 kV level and 320 MW for a 115 level kV as a distribution medium.

It is noteworthy that the Petrochemical Industry in Mexico has obtained a tendency that can migrate its electrical systems through a series of recommendations formulated in these years to make the analysis of the petrochemical electrical systems.

The electrical systems designs of the 70's were different designs than those of the present, and today we take into account a fundamental parameter known as *"Prevention through design"* or *"PtD"*. This term is used in countries like England and Australia wherein governments are asking engineering designing companies, to engineer a safe construction with priority to eliminate or reduce injuries and fatalities during a commissioning [12].

So now the *"Operational Reliability"*, needs to be consolidated with 2 axes mentioned in Table III: 1) to develop a culture of reliability and 2) to promote new generations of engineers who join the PIM facilities, whom they are required to meet international standards in relation to the analysis of electrical systems, which are suggested as to what is shown in Table V.

TABLE IV. Collaboration Results Between NRI and the ERI in Relation to the New Electrical Power System Designs

Project Implementation (concept)	NRI					
	HRLS	FIM	MHI	AMA	LC	ADJ
Conceptual engineering	☑	☑	☑	☑	☑	☑
Bidding rules for generators	☑	☑	☑			
Bidding rules for the new load	☑	☑	☑	☑	☑	☑
Grounding w/ high impedance	☑	☑	☑			
Technical and economic feasibility	☑	☑	☑	☑	☑	☑
Electric Upgrading	☑	☑	☑			
Technical assistance in bidding	☑	☑	☑			
User requirements rules for steam boiler						☑
Implementation and execution projects	☑	☑	☑		☑	
Integration of a new additional generator	☑	☑				

TABLE V. Recommendations for "Steady-State" Studies of Petrochemical Industries in Mexico.

Study	Parameter to determine its condition	Observation
Short circuit analysis	Interrupting capacity and safety factor	It's recommended to determine the conditions of current trends electrical systems reconfiguration and modernization
Load Flow analysis	Voltage Drop	It's recommended to determine the conditions of existing electrical systems and contingency
Protection coordination analysis	Current protection curves and curves of future protection	It's recommended to determine if current protection devices are properly adjusted and recommend a possible adaptive protection
Arc-flash analysis	Magnitudes arc-flash and category personal protective equipment (PPE)	It's recommended to determine which type of personal protective equipment (PPE) should use the personnel operating the primary electrical equipment

The following are recommendations to be used in the analysis of electrical systems in the petrochemical industry in Mexico based on international standards for *"Part 1: load flow and short circuit recommendations"* and other article described of *"Part 2: overcurrent and arc-flash recommendations"*.

A. Short circuit analysis: recommendations

In Mexico, studies of short circuit in petrochemical are intended to meet their national standards such as: a) evaluate the short circuit currents to changes and extensions of electrical installations as described in [14], b) know the magnitude of the "interrupting capacity[1]" and the values of fault currents at various key points in the distribution system as described in [15] and c) determine the increased contribution of short circuit current with the contribution of the generators, the public network and the integration of new plants indicated in [16].

Short-circuit current (Isc) in a power system is presented when in contact with each other or grounded, corresponding to different phases of energized conductors. Typically the short circuit currents are very high, between 5 and 20 times the maximum value of the charging current in the fault point. The *"Isc's"* can be classified into asymmetrical (unbalanced) and symmetrical (balanced). Therefore, it is recommended to pay special attention to the following failures in the petrochemical systems in Mexico to: 1) the *"Isc1F"*: single-phase short circuit[2] and 2) the *"Isc3F"*: three-phase short circuit[3].

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[1] *Interrupting capacity:* magnitude of the short circuit current (Icc) supporting a protective device before a failure occurs, by disrupting according to [13].

[2] *"Isc1F":* happens to contact any one phase to the system ground, is the most common short circuit in an electric power system similar to that of petrochemicals in Mexico.

[3] *"Isc3F":* occurs when they contact the three phases at the same point system, is the most severe short in most cases such a short circuit, the reference is to

It is important to mention that: in the petrochemical systems in Mexico, the damage should be minimizing in the presence of a phase failure or *"Isc1F"* to dissipate the energy stored as soon as possible according to the formula (1).

$$\text{Energy} = \int \left[I\, e^{-\frac{t}{\tau}} \right]^{k} dt \qquad (1)$$

Formula (1) shows that the variable "k" is a factor which corresponds to purely resistive heating. During the experimentation and research [17] and [18] predicts that the values of "k" for an electric arc should be in the range of 1 to 2 ohms. The aim is to show that the result of a fault in the electrical system kept to the shortest possible time will cause minimal damage to a source of power generation, for example.

The recommendations in [10] are: the methods for connecting a grounding system in Mexico petrochemical systems, and prevent the presence of "Isc1F" that generates electrical overvoltage, demarcate the mechanical stresses by the energy released (I2Rt) by the fault currents on the other components of the electrical power system, minimize thermal deterioration presence of levels of energy released with destructive failures, etc.

In case of detecting the magnitudes of *"Isc3F"* in a petrochemical system in Mexico, we recommend using as tools reliable software using methods of solution as the *"Newton Raphson"* or *"Newton Raphson Adapted"* to run an analysis of short circuit with the possibility to verify the conditions of single-phase and three-phase fault. Specifically in the magnitudes of *"Isc3F"* generated by the software, it is recommended to be placed in a "matrix form" with normal scenarios and contingency, same should be allow to read an observation made by the specialist whom prepares the analysis and avoid placing "paper" with the results of different cycles, because on several occasions the result stays in a shelf or cabinet, and are not reviewed or analyzed carefully by the user or customer in the petrochemical. It is also recommended by experience, placing conditions of alert of primary electrical equipment that already exceed their interrupting capacity and classified as mentioned in Table 6.

In industrial electrical systems must always have present the concept of ***"safety factor"*** of electrical equipment which should be in suitable or recommended values, so as to avoid degradation of the insulation by the joule effect or better known as *"I^2t"* or long-term exposure to short circuit conditions.

Accumulation of electric current in a material such as a power circuit for example, causes a temperature increase to degrade the insulation thereof, or an increased concentration of this current flow generates the "*Joule effect*[4]".

TABLE VI. GRAPHICAL REPRESENTATION OF SAFETY FACTORS RECOMMENDED IN THE LITERATURE FOR ISC3F ACCORDING TO [19], [20], [21], [22], [23] AND [24]

Safety Factor (S.F.)	Description	Clasificación del F.S.
> 90%	Equipment that exceed the interrupting capacity	Does not comply
> 80 % y < 90%	Equipment that are at the limit of their interrupting capacity	Exceeds standards
< 80 %	Equipment that are within the limit interrupting capacity	Conforms to standards

B. *Load flow analysis: recommendations*

The load flow analysis, also known as power flows, becomes relevant, since it allows taking the necessary corrective actions so that the *"values of tolerance voltage"* that are within the appropriate limits according to international standards, and are in low or medium voltage electrical power system.

Similarly, petrochemical plants in Mexico intend to meet as indicated their national standards such as: a) assess the safety of electrical installations to changes and extensions of electrical installations as described in [14], b) determine the reference conditions of the network, resulting from amendments made to an electrical system as indicated in [15] and c) know the values of tolerance of the rated voltage for use according to the maximum electrical voltage and the maximum allowable drop in the user installation in medium voltage systems as described in [25].

The voltage drop in the electrical systems is undoubtedly a phenomenon that occurs in any residential or industrial electrical system. It cannot be avoided; however, one can manage to avoid risks and comply with the established norms and standards.

As shown in Figure 3, solutions can range from new sources of supply, such as installing new transformers exchangers, bypassing load to provide more power, calibrate the size of the conductors. On the other hand increasing the number of conductors per phase, to regulate high currents causes large voltage drops.

The implementation of the recommendations mentioned in Figure 3, for example, suggests using appropriate gauges driver with suitable materials to decrease the resistance, then the current flows easily and the voltage drop is decreased. Moreover, in many industries there are common starting devices used by some electrical equipment, remember that if there is a constant flow the resistance increases in the same proportion as the voltage increases. The protection device applied to controlled, equipment manage to limit the inrush current, also avoiding excessive voltage stress

The effects and situations mentioned can be prevented if the aspects mentioned in this article, and regulatory requirements

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design and manufacture the primary electrical equipment.

4 *"I^2t":* the source short and different types of faults that occur, it requires understanding the conceptual description of the effect of current flow. The concentration or increasing energy in the isolation of a power circuit for example, degrade the properties of the insulating material.

established by current standards are met, and taken into account from the start of the design of the electrical system.

The mentioned methods will undoubtedly help to avoid significant voltage drops, and help in making decisions when problems related to the voltage drop arise. The phenomenon of "voltage drop" in industrial electrical systems for future generations of engineers, who join the operation of industrial plants, is to promote understanding and importance in future generations of skilled engineers whom operate the petrochemical industry in Mexico.

In the petrochemical industry in Mexico (PIM) it is recommended to be applied as endorsed in Table VII. This shows possible warning conditions of primary electrical equipment already exceeding the tolerance values for voltage drops as a result of load flow analysis.

The recommendations of the authors of this article according to their experience in industrial electrical systems, it is used as a primary data to **maintain the margin of ± 3%** in main distribution switchgear for derivative feeders and their respective buses are within the international standards, see Table VIII for comparison with standards and so it is suggested to optimize operational reliability in the PIM.

IV. Conclusions

In a world where global fuel demand is almost equal to the overall capacity, each time a plant is out of operation there is an alarm. So reliability is the most important feature in the oil industry.

The energy reforms in Mexico accelerated the implementation of subsequent projects studies and analysis of the electrical system progress. Also, it visualizes partial changes required to the electrical system with financial tables linking electrical reconfiguration projects to modernize the electrical system and prepare for future connection of cogeneration in Mexico.

The experience and knowledge of the operating personnel of PIM together with future electrical designs proposed by ERI is necessary to complement the training of staff to operate the plants.

Today, new working groups are focusing on the changes that happen and the lessons learned from ERI and PIM are reflected in the efforts to benefit the country's energy development.

The experiences of analyzes of industrial electric systems over 15 years for the petrochemical industry in Mexico is focused in that systems must be robust, secure, flexible and able to maintain continuous production of fuels. Also, optimize operational reliability before a possible change or contingency state of the electric power system.

In this Part 1: showed of *"Short circuit and load flow analyses"*, in this case are transcendental know the magnitude of the "interrupting capacity" and "voltage drop" in the group of studies in electrical power systems. In PIM they are vital to determine of the primary electrical equipment installed in the 70's, for example.

In Mexico, studies of load flow in petrochemical plants seek and require to ensure that the tolerance values of the voltage is within the appropriate limits to reduce the effects caused by exceeding the limit voltage in each industrial electrical system, either in a refinery, a petrochemical or a maritime platform.

TABLE VII. Graphic representation of the values of tolerance voltage in switchgear.

Voltage Drop (V.D.)	Description	Classification "Voltage Drop"
> 5 %	Equipment that exceed the value of the voltage tolerance	Does not comply
> 3 % y < 5%	Equipment that are at the limit of tolerance in the voltage	Tolerance limit
< 3 %	Equipment that are within the tolerance limit suggested by the rules	Conforms to standards

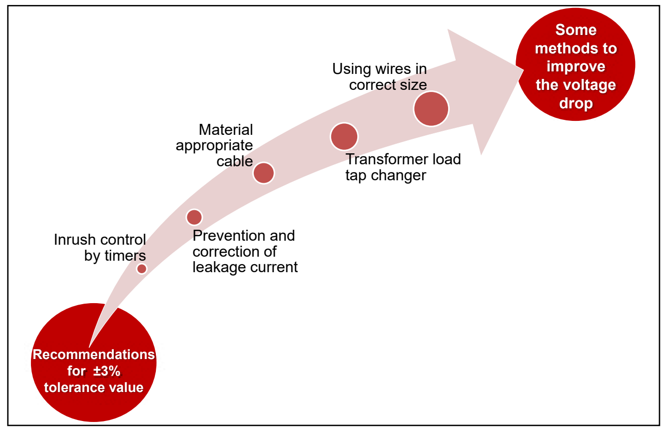

Fig. 3. Some recommendations for improving the voltage drop in industrial power system similar to the PIM.

TABLE VIII. Compare with regulations related voltage drop [19], [25], [26] and [27]

Values of tolerance voltage suggested by national and international standards			
International		National	
IEEE Std 242-1986	IEEE Std 141-1993	NOM-001 SEDE-2012	NMX J098 ANCE 1999
± 5% of the nominal values.	+5 a -10% below the maximum voltage for which the system components are designed	**± 5%** in feeders and derivatives to the furthest contact circuits. 3% in the farthest outlet for heating loads, strength or combinations of these	***+5% y -10%*** of the nominal value of the system voltage
Tolerance values of voltage drop recommended by international standards do not agree in their recommendations. However, the authors recommend be drastic in practice and **use a tolerance of ±3%** in the main bus bar, since downstream also be a voltage drop and the value of this should not exceed stipulated by the rules			

Similarly, in Mexico petrochemical plants are required to prevent falls and that surges arise, to contribute to the safety of operating personnel and installed electrical equipment, and to maintain continuous production of fuels with a high degree of operational reliability.

The trend of changes in the electrical system depends on the results of each analysis to propose an electrical reconfiguration, replacement equipment or recommend preventive actions for the new electrical system of the next generation of specialist personnel related to the subjects of Mexico, such is the case of connecting cogeneration plants with capacities over 300 MW rather than the public grid; however, it may be possible to make interconnections of the National Refining Industry with such plants and making steady state analysis of each of the electrical systems to confirm that the power connections are proper condition.

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BIOGRAPHIES

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Framework Proposal for Optimal Campus Transition to Smart Energy Management System and Prefactibility Project for ESPOL 2.0

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***Abstract*—Ecuadorian universities will have in the future an increasingly high demand of research students that necessitates multi-purpose technological infrastructures with high technology equipment. Thus, it is compulsory to rethink the planning and expansion schemes on which the university assets are updated and adopt a novel model of education platform known as UNIVERSITY 2.0. This approach requires the definition of a referential administrative framework to make the transition between current and future processes to be focused on IT solutions, efficiency, optimal track and use of resources, energy departments, etc., all defined as open divisions that could align the campus as an autonomous city. Hence, integrated technological solutions for all careers will conform the operational platform from which entrepreneur initiatives will deploy industry solutions. This paper presents the framework to line up local universities towards future challenges.**

***Index Terms*—smart grids, renewable energy sources, distributed management, information and communication technologies, open educational resources.**

I. Introduction

Universities are of utmost importance in society because they educate future professionals and lead the next technological step for human development. For this reason, university campuses are evolving from traditional teaching institutions to intelligent autonomous centers. As the demand and technology are under exponential growth a balanced harmony is required to serve users appropriately.

Ecuadorian universities will face soon an increasing demand of students and will need appropriate technological infrastructure. Hence, it will be compelling to conceive novel planning schemes to transform its facilities into powerful integrated assets known as Smart Campus. This transition implementation in ESPOL is intended to prepare a framework for intelligent universities and similar initiatives. This project aims the development of a regulatory framework for university transformation into a smart campus. In the case of ESPOL, it is meant to turn it into ESPOL 2.0. This vision will integrate field components convoluted at every aspect of academic and management activity. It also suggests approaches to analyze common problems in assets, energy conversion and utilization, efficiency, losses and waste treatment, and several others to improve campus performance and outcome.

II. Literature Review

Among several urban development models Smart City has been recognized as the ideal candidate for today's social-economic challenges [1]. It comprises intelligent operation, adaptability, flexibility, robustness, and resiliency features mainly. These factors will contribute to a change of paradigm in urban planning. This novel conception will require investors and authorities to evaluate advancements in the following fields: Economy, People, Governance, Mobility, Environment and Living. These definitions are based upon their interaction in the education sector. The Energy field is embedded in the Environment field because energy issues wherever they occur will generate impacts on the environment. These fields perform activities or solutions in a coordinated and integral manner to provide complete services [2] through intelligent solutions [3] to user. In [4] and [5] holistic models for smart cities have been developed utilizing Internet of Things (IoT) as the basis platform such that services improve the user's quality of life. Energy infrastructure is one of the most important features in Smart Cities and is imperative to include them to the smart grids platform. In fact, transformation requires modernization of energy systems, educational programs for improved energy consumption and related costs, and provision of a secure and reliable renewable resources integration. The intelligent system of a smart city is known as Smart Grid. The relationship between smart city and Smart Grid models can be found in [6].

The Smart Grids environment consists of the following components: renewable energy, intelligent energy management systems, smart metering, electric vehicles (EV), smart load control, and Energy Storage. The smart grid roles, impacts and challenges can be split in renewable energy issues as described in [7] and [8], intelligent energy management systems modelling as shown in [9] and [10], intelligent measurement systems [11], and electric vehicles penetration as studied in [12] and [13]. Some public and private North-American universities have developed and implemented Smart Grids into their strategic plans for research purposes and to achieve sustainability and energy autonomy within their campus. For instance, the University of Maryland (UMD) power grid is a live laboratory of Smart Grid technology, including renewable energy generation, state-of-the-art controls, vehicle charging stations and a EV fleet, integrated to its 50 MW microgrid [14]. Indeed, initiatives have outcome interesting results. The University of California at Los Angeles (UCLA) has an Energy Research Center that is conducting research on the integration of Electric Vehicles (grid to vehicle G2V and vehicle to grid V2G), automated demand response (ADR), microgrids within campus, and integration of distributed and renewable generation with energy storage in its Smart Grid [15]. North Carolina State University (NCSU) developed a master plan [16] detailing a feasibility study on the implementation of a Smart Grid for what they call The Centennial Campus. The University of California at San Diego (UCSD) has one of the most advanced microgrids in the world and supply the demand of 45,000 users among students, professors, and administrative staff, managing automated buildings, smart meters, and energy storage [17]. Other universities leading the development or implementation of Smart Grids are Princeton University, University of Texas at Austin (UTA), and Colorado State University (CSU). Despite this, in most of the cases universities do not have holistic development plans that integrate their smart energy grid with the rest of campus management areas.

Because Latin-America cities and universities have similar challenges, [18] and [19] have determined that the philosophy of smart city can be adapted and replicated to universities, hence, turning campuses to intelligent centers operating in a global and integral manner. This model adapted to universities is known as Smart Campus [18], [20].

III. METHODOLOGY

For the framework application in ESPOL the methodology proposed in [18] was extensively utilized. However, the strategy definition phase was modified to include all programs and projects in the implementation of the model in college. The methodology consists of the following phases:

- Preliminary planning
- Field identification
- Data acquisition
- Data analysis
- Problems classification
- Strategies definition

The phases are detailed below.

A. Preliminary planning

To carry out a project correctly, it is necessary to have a broad knowledge of the areas to be intervened. Therefore, the evaluation is started by a preliminary analysis, with the aim of identifying the most important aspects, such as environment, economy, accommodation, people, etc. Considering these aspects, it will be possible to arrange planning and management correctly for what will be done in the following phases. With this analysis, the affected areas, users, necessities, and project feasibility will be determined. Then, the useful data will be classified into fields.

B. Field identification

The data obtained from the preliminary planning are categorized in main areas introducing aspects, strategies and interventions concepts to identify fields. This practice is based on the six axes of Smart City [1], which have been adapted to the campus. Then, the Smart Campus framework is based on the following fields: People and Living, Economy, Environment, Energy and Mobility. As contrary to the smart city axes, Smart Campus lacks the category of Governance, since it is considered as a cross-disciplinary implicit aspect to all the fields of action. The fields to be used in the Smart Campus are presented in Fig. 1. The detailed definition of each field of action can be found in [18].

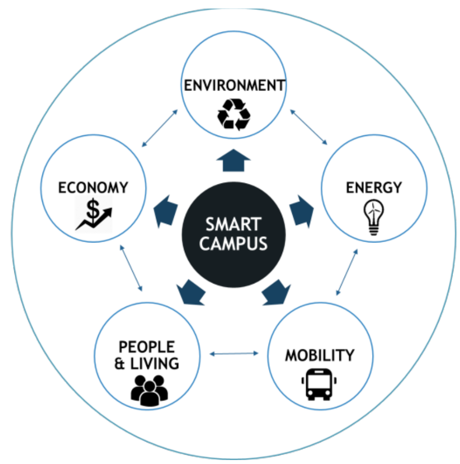

Figure 1. Smart Campus Fields

C. Data acquisition

Data acquisition is intended to define and feed a database whose information is transparent and shared between stakeholders and users through research and surveys. Inside the data collection it emerges activities such as information and data analysis, data accessibility and retrieval, and reliability check. Data selection not only depends on the project scope, but also on relevance, accessibility and effectiveness. Important information is related to historic, structural, operational, demographic, and academic characteristics. Data is normalized firstly and then analyzed.

D. Data analysis

Collecting huge amounts of information reflects different points of view, strength, deficiencies and correlations that not always are identified directly. Therefore, a solution is weighing the data obtained with different indexes. Creating an index involves analyzing a large amount of information that usually proceeds as the following: field, sub-field (optional), index, variable and weighting. To evaluate campus sustainability there have been proposed performance indexes. Each evaluation correlates sustainability concept from several perspectives, focusing only on energy, environment, technology role, and human potential aspects. From the field identification, a scheme to evaluate the institution performance on people and living is shown in Table I. This table shows probable indexes and variables for data analysis of the campus in the field of People and Living.

TABLE I. PEOPLE AND LIVING

Field	Sub-field	Index	Variables
PEOPLE AND LIVING	Students	Students with degrees	Graduated/Admitted
	Academic	Teaching	Students/Professors
			Student unions
		Technical Skills	Yearly seminars
		Primary	Courses/Classrooms
			Libraries per faculty
		Secondary	Accommodation
			Water purifier
		Safety	CCTV
			Private companies
		Technology	Wi-Fi coverage/Total area
	Management	Planning	Annual strategic plans
	Information	Education	Programs
		Availability	Emails, social networks

To evaluate the variables established in Table I and to diagnose their pros and cons, Table II is used to score its effectiveness (1: completely inefficient, 2: inefficient, 3: regular, 4: efficient, 5: completely efficient).

TABLE II. VARIABLE WEIGHING

Variable	Weigh	Pros	Cons
Graduated/Admitted	3	Number of students that obtained a degree	None
Students/Professors	4	Ecuadorian Class A institution	None
Student unions	5	Student motivation for volunteering	None
Yearly seminars	5	Academic and social seminars and tutorials	None
Courses/Classrooms	5	Infrastructure adequacy	None
…	…	…	…

E. *Problems classification*

The results of the data analysis should be interpreted not only to depict the state-of-the-art of the affected areas, but also to underline their shortcomings and strengths. This phase is crucial for the strategies interpretation because it conducts a comprehension exercise to allow understanding improvements or determining existing resources. In addition, this phase allows priority selection of the problems to be solved.

F. *Strategies definition*

The last phase relies in the recognition of appropriate strategies for each field to improve the quality of life of users, optimize energy usage, maximize asset lifecycle, and ensure the availability of services and information. An adequate strategy identifies and associates every connection influence to each field. For example, a strategy to improve energy efficiency on facilities within the energy field usually influences the economic and environmental prospects. Therefore, a strategy to improve energy efficiency should effectively consider building data, advantages or positive influences, disadvantages or negative influences, and interactions with other fields economy and environment fields. Depicting the incidence tables, it will be possible to sketch influences and relationships of strategies to be implemented in certain field and study correlations to other fields that portrays the Smart Campus. An example of incidence matrix is shown in Table III.

TABLE III. INCIDENCE MATRIX EXAMPLE

Other fields		ENVIRONMENT				
		Indexes				
		Topic 1	Topic 2	Topic 3	…	Topic *n*
		Variables				
		Strategy 1	Strategy 2	Strategy 3	…	Strategy *n*
Field 1	P.I.					
	N.I.					
Field 2	P.I.					
	N.I.					
…	P.I.					
	N.I.					
Field *n*	P.I.					
	N.I.					

P.I.: Positive impact / **N.I.:** Negative impact

Each field has its corresponding table, where the other fields have been divided in several indexes containing different variables. System indexes assess campus performance already proposed in the data analysis phase. On each table the variables have been related to other fields, thus highlighting the impacts between them.

IV. CASE OF STUDY

The study case promotes the application of an initial framework to transform ESPOL into a Smart Campus. Faculties have been established as affected areas and students, professors, academic staff, and visitors are considered as users consequently. The fields identified in the university are energy, economy, people and living, environment, and mobility. The information used in this project were provided by current maintenance office, infrastructure department, renewable energy resources laboratory LABFREE, and transportation company TRANSESPOL. Concerning the university performance assessment in all fields, economic, environmental, energy and others indexes were utilized. Table V illustrates the weighting, pros and cons of the energy variables outlined in Table IV. The energy field is one of the most unattended area in ESPOL, so that in this work the actions or strategies pertinent to the area will be presented. Indeed, it is observed that there is an enormous opportunity for renewable resources, smart metering, efficiency initiatives, state estimation devices and sensors, and other integrated solutions in all buildings and facilities. Moreover, it is imperative to envisage a supervision and control center from which all management systems are integrated such as the energy management system, admission management system, efficiency programs, innovation initiatives, etc., all converged on a cloud platform from which other external facilities could be monitored and even controlled also, for instance, electrical utilities, industries, projects, academic collaborations, real-time prototyping, consultant services, expert advice, etc.

TABLE IV. ENERGY INDEXES OF SMART CAMPUS

Field	Sub-Field	Index	Variables
ENERGY	Production	Non-renewable	Generation groups
		Renewable	Photovoltaic panels (PV)
			Wind turbines
	Distribution	Networks	Electricity
			Water
	Demand	Facilities	Energy usage and losses
			Air conditioning efficiency
		Lighting	Sensors network
			LEDs
	Management	Planning	Energy Management System
	Information	Data Mining	Generation and demand per faculty

TABLE V. ENERGY FIELD EVALUATION

Variable	Weigh	Pros	Cons
Generation groups	4	Reserve supply	Fossil fuels usage
PV panels	1	None	10 PV panels only
Wind turbines (WT)	1	None	2 WT only
Electricity	3	Utility supply for campus	Network maintenance
Water	5	Complete infrastructure	None
Electrical energy metering	2	None	Unmeasured facilities
Air conditioning efficiency	2	None	Inefficient system
Sensors	1	None	Uncontrolled facilities
LEDs	2	LED powered bikeway	Facilities lighted up with fluorescents
Energy management system	1	None	Unmanaged distribution system
Generation and demand per faculty	1	None	Unavailable information

According to the identified problems presented on campus in the energy field, the following strategies are recommended:

- PV panels rooftop installation.
- Smart metering deployment in campus buildings.
- Medium voltage distribution network upgrade.
- Sensing devices in the facilities.
- LED lighting installation in classrooms.
- Management Center.

A. PV panels rooftop installation

PV panels can support up 70% of campus demand. The rooftop area required will be less than 50% of the surface available. Besides, PV panels implementation will also have environmental, economic and energy impacts. Table VI depicts the PV panels annual energy supplied and the annual CO_2 tons saved.

B. Smart metering deployment in campus buildings

Regulation and optimization of energy consumption is an essential condition for sustainable development. Thus, smart meter and state estimation devices should be deployed throughout every energy or resources intake. Then, real-time optimization and management control of resources is possible.

TABLE VI. PV PANEL INSTALLATION

Faculty	Area [m^2]	Peak power [kW_p]	PV panels	Annual supplied energy [MWh]	Annual tons. CO_2 saved
FIEC	6073	343.92	1600	0.6592	231.38
FIMCP	3548	176.14	800	0.3296	115.69
FIMCBOR	9236	166.75	750	0.3090	108.46
FICT	2059	178.62	810	0.3337	117.13
TOTAL	**20916**	**865.43**	**3960**	**1.6315**	**572.66**

C. Medium voltage distribution network upgrade

Load growth split electrical networks in radial feeders but it usually does not carry an accurate order. The distribution system enhancement corresponds to a medium voltage main feeder conductor upgrade, redesign of the electrical network to promote smart grid AC/DC transition and flexible power electronic equipment, and appropriate rating for future expansions and facilities.

D. Sensing devices in the facilities

A broad range of autonomous sensing devices and Internet of Things on a cloud computing platform will stimulate intelligence development and innovative solution competition. This technological advancement will overcome the control and data acquisition needs of unattended facilities throughout campus buildings. For instance, controlling amount of artificial light depending on solar radiation coming through windows will boost losses reduction and users comfort and experience.

E. LED lighting installation in classrooms

Energy efficiency will maximize the output coming from the academic process of learning. LED lamps will improve lightning efficiency and electrical energy consumption. Properly designed and implemented, LED bulbs have the potential to almost double its lifetime if compared to fluorescent lamps. In addition, unlike most compact fluorescent lamps, LED bulbs do not contain mercury or phosphorus, thus their disposal or recycling is less problematic.

F. Management Center

The Management Center is a project portfolio consisting of numerous programs and projects. Altogether, these projects will be the heart of ESPOL integral management plan. The energy management system is one of the components that interacts with every other campus systems and processes. It incorporates renewable resources, losses reduction plans, electric transportation, industrial processes, communication systems, and real-time simulation, monitoring and operation on campus. The energy management system includes an extensive repository that collects pertinent information collected on different sources and arrange it properly to be available to students, researchers, professors, and managers, all users of the rest of management systems. The energy management system framework includes demand management, front-end, and back-end domains. It will have a control center EMS-SCADA and could be remotely accessed from local control offices. Fig. 2 depicts the energy management system diagram, and Fig. 3 illustrates the ESPOL control system architecture.

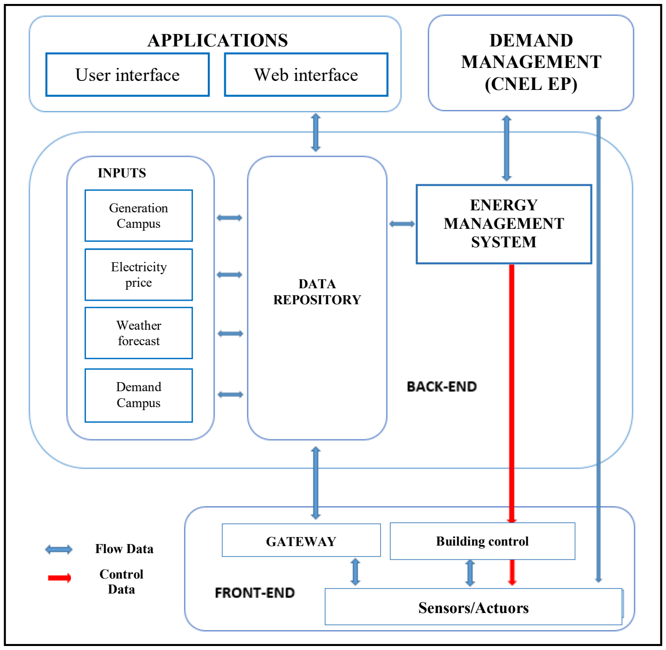

Figure 2. Energy Management System

The ESPOL energy management system office center should have the following characteristics:

- Latest generation SCADA, research or industry-developed, based on real-time operating system in redundant configuration (Hot - Standby).
- Communication topology of campus network will be ring Ethernet communication over optic-fiber, with wireless access points.
- Several operation offices from which the system can be remotely controlled and monitored.
- The energy management system SCADA will be open-source, expandable, scalable, user friendly and easy to configure, with adequacy to include future expansions and upgrades, as well as new functionalities and research algorithms or platforms.
- The power management system shall exchange information from the control systems of each element of the campus network, through standard communication protocols as DNP3.0, MODBUS, CIP, HART, PROFIBUS, OPC, ZIGBEE, LONTALK, IEC 60870-5, IEC 61850, CAN, ANSI C12.18, etc.

The local control offices at ESPOL campus should have the following characteristics:

- Distributed control systems for distributed generation and loads based on programmable controller technologies, gateways, microprocessor based devices, remote terminal units, distributed computers, rugged computers, OPC servers, merging units, etc.
- Human-machine interface HMI (human-machine interface) and Graphical user interfaces to complete supervision and control activities across the campus.
- Expandability to test and assess novel algorithms for engineering, innovation, financing, and social development.
- State-of-the-art servers with open programming languages and standard communication protocols.

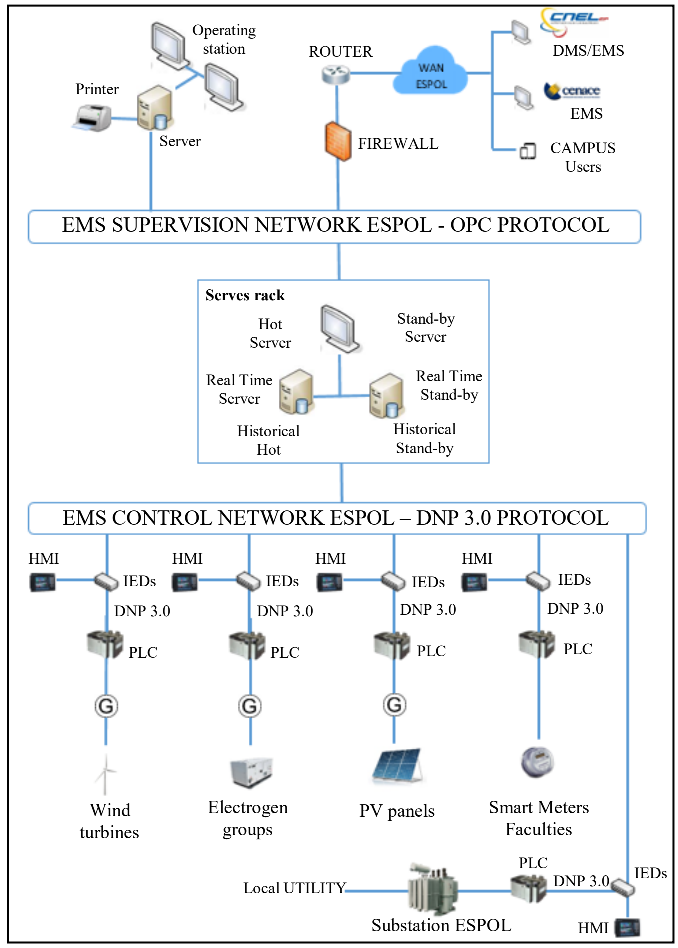

Figure 3. ESPOL control system architecture

V. CONCLUSIONS AND RECOMMENDATIONS

There is great potential to enhance efficiency and energy utilization across campus because current upgrades programs include initiatives for smart grid deployment. Therefore, energy should be the first field to be outlined in upgrade programs. LED lighting systems, sensors and PV panels should be deployed to improve energy savings and contributed to emission reduction. It is compelling to invite industries and produce public-private alliances to attain technological advancements with private investment. Due to the fact that PV panels will not cover all rooftop area, there is adequacy for future expansion on existing facilities. On the other hand, sensing devices and smart meters could be designed and built in ESPOL electronic and fabrication laboratories. The authors of this project strongly recommends to consider this framework in planning activities and future amendments.

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By: kathryn Villafuerte y Tania Abrego

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My path on IEEE

My path in this organization began in late 2013, when along with two friends I went to the office of my university's IEEE Student Branch in Bogota, to ask about activities being developed there in that time. In the beginning of 2014, we were convinced that with IEEE, through its power and energy PES Chapter, we could perform activities never done before in my university.

We identified the problems we had in our school. The lack of software and equipment use tutorials, technical visits to energy sector enterprises, and lectures on state-of-the-art topics were some of the issues we aimed to attend. We were able to attend them, thanks to the support and trust that IEEE and PES logos create. Teachers and enterprise representatives seeing IEEE members interested in a visit, a lecture, a tutorial, or any other kind of activity were prone to help kindly; there were many times in which these teachers and enterprise representatives were also IEEE members, having developed when they were at college the same activities we were developing.

"Most of the time, people ask me about the benefits of being an IEEE member. I think the right question is: What are you losing for not being an IEEE member?"

However, things weren't always easy. Sometimes, academic workload made sleep hours to reduce, bureaucracy in my university hampered several activities and our lack of experience made us cancel some of our initial plans. Some volunteers decided to leave when they perceived that, sometimes, these obstacles were the common denominator of most projects in our PES Chapter.

But in those moments that you decide if you want your passage through the university to be the one of a conventional student who just attended classes, or on the contrary, you want to take passage to prove you can surpass obstacles and stand out. I had the fortune and honor of being the head of my chapter and lead a lot of activities, which let me visit different kinds of power plants and last generation substations, know different regions of my country, and get in touch with iconic enterprises, admirable professionals and incredible academics.

I took some colleagues to see the sea for the first time, to explore remote regions, and unimaginable landscapes we couldn't admire if we weren't leading activities different than the ones planned by my university. Because of these activities we led, IEEE sponsored my presence to different PES events, in which I visited three continents and five countries, and met students and teachers from around the world, friends with whom I work together to encourage more students to join the Institute.

Most of the time, people ask me about the benefits of being an IEEE member. I think the right question is: What are you losing for not being an IEEE member?

About the author: Felipe Gaitan is an electrical engineer student from the Universidad Distrital, in Bogotá. He works as an engineering assistant at IEB Ingeniería Especializada, is a member of the PES Membership Development Committee for Latin America and is Associate Editor of IEEE


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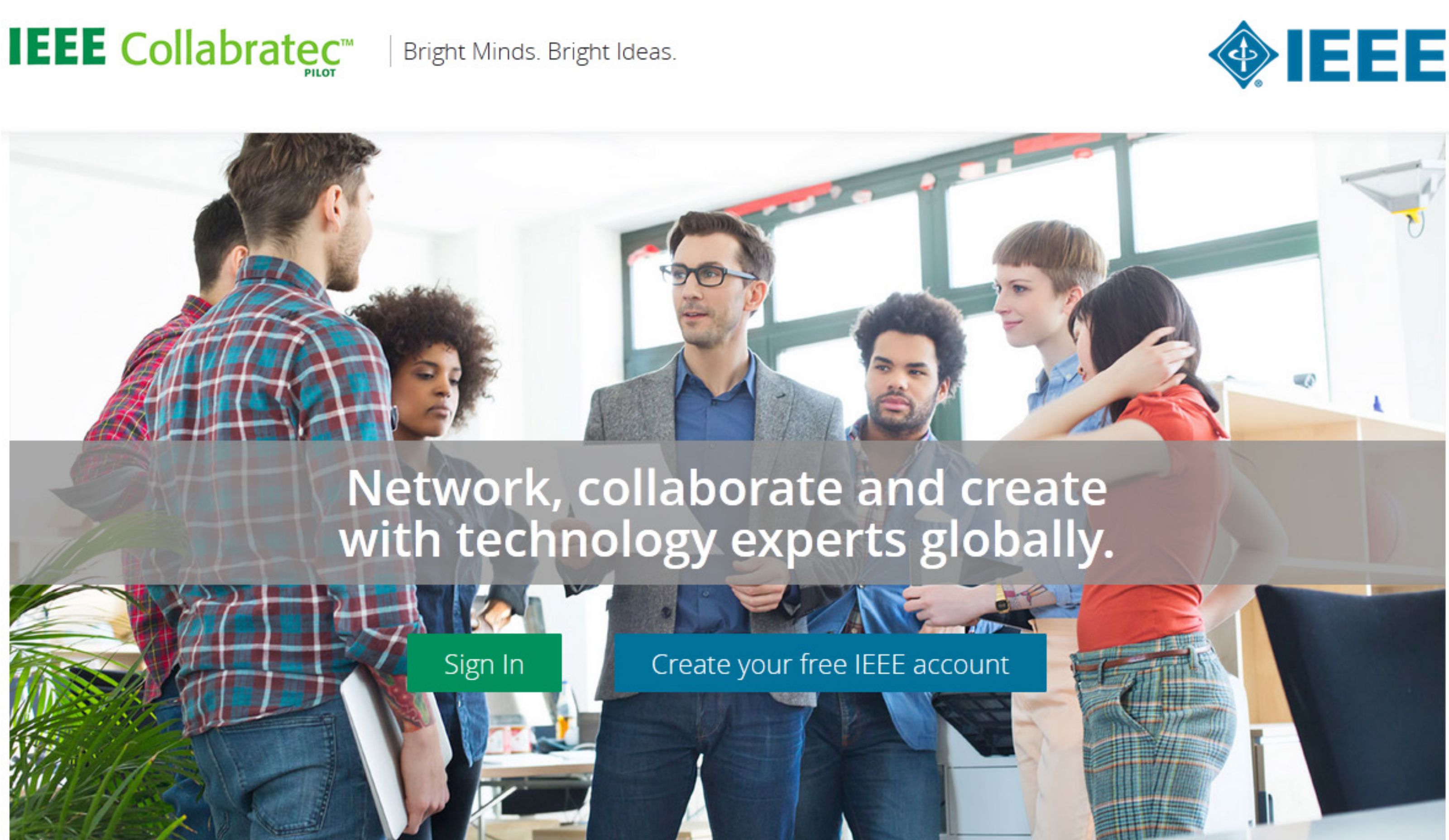
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