

eLearning for Electric Distribution Planning Engineers

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Abstract—This paper presents the experience in an eLearning training project that is being implemented for electrical planning engineers from the national Mexican utility Comision Federal de Electricidad (CFE) Distribution. This modality is implemented and will be used in the utility for training purposes to help personnel in their daily technical activities. One important advantage of this training project is that once it is implemented and applied, financial resources will be saved by CFE Distribution Company because online training will be used in all the country; the infrastructure for the eLearning training will be uploaded in computational servers installed in the National CFE Distribution Training Department, in Ciudad de Mexico, and can be used in workplaces of 16 Distribution Divisions and 150 Zones of CFE Distribution. In this way, workers will not need to travel to the National Training Department, saving enormous efforts, financial, and human resources.

Keywords—Moodle, eLearning, corporate training, electrical planning engineer.

I. INTRODUCTION

EVERY successful organization has its human capital as a solid main base, for this reason companies do great efforts and interest in its selection; also, companies invest large amounts of money in training. It is recognized and is a fact that such investments add value to the human capacities of the company. Keeping a technical updated staff, as well as the interest that the future candidates will have, it is usually the real challenge and to fulfill it, this requires increasing their skills and updating their knowledge through the *training* process.

Nowadays, the terms training and information systems are changing the way that organizations work. Information systems help to speed up processes; therefore, the organizations that implement them achieve competitive advantages by adopting them in their functions. Because of the previous statements, 98% of all companies are planning to use eLearning by 2020 [1, p.2].

Training refers to the methods used within the organization, to provide people the needed skills to carry out their work. It includes from small courses on terminology, to courses that allow the user to understand the new system operation. It can be in a theoretical or practical basis, or better yet, combining the two of them. Also, the development of a custom eLearning

project is an exciting opportunity for a learning and development management. It is an opportunity to create content that is uniquely suited to meet organizational needs and perhaps, new delivery models [2, p.1].

In Mexico, the power electric company, CFE-Distribution provides the public electricity distribution service, to residential and industrial customers, with international standards, quality, safety, and reliability, through its key processes:

- Client services
- Measurement, connection, and services
- Planning or construction
- Operation and maintenance

This is achieved with the talent of more than 49,000 workers, in the 16 Distribution Divisions, 150 Zones, and more than 900 areas of the country, where they work permanently, to have efficient General Distribution Networks [3].

To strengthen the technical knowledge for the best performance in daily work activities, the CFE-Distribution Planning Area has the need to train its distribution planning engineers. To satisfy the above, the utility CFE-Distribution requested to the National Institute of Electricity and Clean Energies (INEEL), specifically to the Transmission and Distribution Department to present a proposal to carry out this training.

The training requested by CFE-Distribution should be by using online learning or eLearning and cover the topics currently required by distribution planning engineers, as well as new requirements of the electric distribution networks that have been incorporated into their work area. In this way, workers will not need to travel to the National Training Department saving in accommodation expenses and traveling time.

It is a challenge to manage training in a classroom environment. Because of that, many corporations are using technology to improve the delivery of their workers training programs. With eLearning, their workers can take a range of training modules that are designed to suit their individual needs [1, p.3].

For the industry, the growth of virtual education over just the past decade is astounding, 98% of organizations are predicted to use eLearning as a part of the learning or training process [4]. Also, virtual education, with its flexibility, has succeeded to create a new era in education that in many cases provides the best alternative to traditional educational [5, p.61].

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II. REQUESTED eLEARNING CHARACTERISTICS

A. New Topics

The new technical topics should cover the daily work of the distribution planning engineers, for example, evaluation of the short-circuit levels and the hosting capacity in the distribution feeders.

B. eLearning Available Infrastructure

Available infrastructure should be used; the CFE Distribution training area has the *Moodle* educational platform, which is open-source type [6], which will be used for the educational training program through eLearning mechanisms.

C. Staff Involvement

The staff of the company, CFE Distribution, must be involved in educational eLearning tasks. The project considers Divisional-planning leaders that will perform training functions of both, *instructors* and *tutors*, for the distribution planning personnel at the Distribution Zone level.

D. Role of the INEEL

The INEEL will generate all the content for the courseware consisted of technical guides or booklets, participants examination, videos containing theoretical technical topics, and videos explaining practical examples of each topic, development of the Moodle template to upload the courseware.

III. PROJECT DESCRIPTION

The project must optimize human and financial resources for the training of CFE-Distribution's planning engineers. Expected project savings due to the development of this eLearning project can be as follows:

- Travelling expenses of the distribution planning engineers from the 16 Distribution Divisions and 150 Zones, where they work permanently, to training offices in Mexico City, since the eLearning training can be carried out from their work offices.
- Reduce efforts and costs for the execution of periodic training courses. This is because the audiovisual content that is prepared can be reused by eLearning at any time and any place.

IV. OBJECTIVES AND GOALS

It is established as the objective of this eLearning project to promote the comprehensive development of human capital in the CFE-Distribution planning area, increasing their skills and competencies through the design of an eLearning modality in the delivery of technical modules.

The goals to accomplish this new eLearning project are as:

- Detecting training needs of CFE - Distribution planning engineers.
- Establishment of a training program according to the detected needs.
- Preparation of training content and implementation in

eLearning environments in the educational platform, *Moodle*, of the CFE Distribution Training Department.

- Integrating evaluation and recognition schemes for the participants in the eLearning training sessions.

V. DESCRIPTION

CFE Distribution Training Department has a tool for online education named *Moodle* and used widely in the world. Moodle will be used for this eLearning project. For this purpose, the capabilities of the tool should be reviewed and documented, defining the learning activities that can be applied in the training modules.

The training will be carried out from two aspects:

- a) A first aspect will be on the technical concepts that the planning engineering staff faces in their daily work, such as the evaluation of the short-circuit levels and the hosting capacity in the distribution networks.
- b) The second training aspect will be on the capabilities of the computational tool Synergi [7] for electrical studies in the utility CFE Distribution.

The utility CFE Distribution recently updated *Moodle*, which is necessary to have a widespread eLearning training in all the country. To comply with the above, each training module must have practical applications of the learned technical concept, using *Synergi* software as the main tool for electrical studies in the CFE Distribution utility.

B. Expected Results

With the accomplishment of these eLearning training, CFE Distribution will achieve:

- a) Understanding and analytical implementation of the assigned planning process tasks, which will result in a better performance.
- b) Optimization in the use of CFE Distribution's training infrastructure, as well as other available tools.
- c) Faster response for the eLearning training of planning engineers in new topics related to the planning distribution area.
- d) CFE Distribution will have an internal training scheme based on its own planning engineering staff.
- e) Better control and management of the distribution planning training program.

INEEL will deliver to CFE Distribution, in printed form and in electronic file, all the technical documentation applicable to the developed modules, as well as the evidence of the imparted courses and attendants' evaluations.

VI. METHODOLOGY

In the Stage 1 of the eLearning training project, it will be developed Modules 1 to 4 as indicated in Table I. This paper contains only the information for Stage 1. The Stage 2 covers Modules 5 to 9 and will be dealt in a future paper. To achieve the objective and goals of this eLearning project, the following methodology was proposed.

Based on the analysis of the CFE Distribution training history, needed topics were determined to cover opportunity areas for personnel training, as well as to establish their

requirements.

The modules and content of the training program were defined jointly between INEEL and CFE Distribution, establishing general objectives for each of them, as well as content development (scripts) of the nine modules that conforms the training program.

The 9 training topics were selected accordingly to the needs of CFE Distribution workers. The topics' titles are as shown in Table I.

TABLE I
SELECTED TOPICS FOR THE eLEARNING TRAINING

Module	Topic Title
1	Modeling of medium and low voltage electrical distribution systems with Synergi.
2	Analysis of instantaneous power flows in medium and low voltage circuits to determine the regulation and instantaneous power losses at the connection points of the RGD in medium and low voltage using Synergi.
3	Failure analysis of medium voltage circuits to determine the short circuit currents and the three-phase and single-phase X / R ratio to ground at the RGD connection points using Synergi.
4	Analysis of the hosting capacity of distributed generation in RGD medium voltage circuits.
5	Reactive power compensation in RGD medium voltage circuits.
6	Long-term demand forecast in the HV / MV transformation elements and MV / MV circuits of the RGD.
7	Planning of the area of influence and load centers of new HV / MV distribution substations.
8	Sample design and analysis for the estimation of total losses in low voltage networks with an acceptable level of confidence and degree of error.
9	Economic analysis of investment projects.

If is required, the INEEL can get the expert support in the adults' learners process (andragogy) to consider their learning conditions and to facilitate the eLearning training.

The eLearning training will be based on the Moodle teaching-learning platform, in accordance with the methodology proposed by the CFE Distribution training Department. However, this eLearning training will have a documentary part using the organization and preparation activities established in the Institutional Competition Standard (NIC).

As part of the project methodology, during the courses, CFE Distribution's planning engineers can accredit any module of the program by presenting an evaluation for one Module or for the corresponding Modules.

CFE Distribution Staff will teach additional modules to those covered by INEEL instructors, or by other instructors selected by CFE Distribution (for example retired engineers). In this process, INEEL will support Divisional trainers or external instructors to clarify doubts or comments on the Modules content.

INEEL will oversee the application of attendants' final evaluation after finishing the training process, as well as issuing the corresponding certificate of modules approval with curricular recognition by the Mexican Ministry of Labor and Social Welfare (STPS).

VII. RESULTS

The activities to carry out the Stage 1 are as follows:

- The technical reference material for those attending the course consists of a study guide for each Module. Currently, the first 4 study guides have been developed (one for each module) and the CFE Distribution personnel has approved 3 study guides corresponding to Modules 1 [8], 3 [9], and 4 [10]. The study guide for Module 2 [11] is in revision by CFE Distribution personnel. Fig. 1 shows the cover page for each of the 4 Modules.



Fig. 1 Study guides of Modules 1 to 4 (Module 2 is still in revision)

- Theoretical PowerPoint presentations for Modules 1 to 4 were developed; these presentations will be used for each

instructor during the recording of 4 to 6 training videos for each Module. Fig. 2 shows slides for Modules 4 and 3.

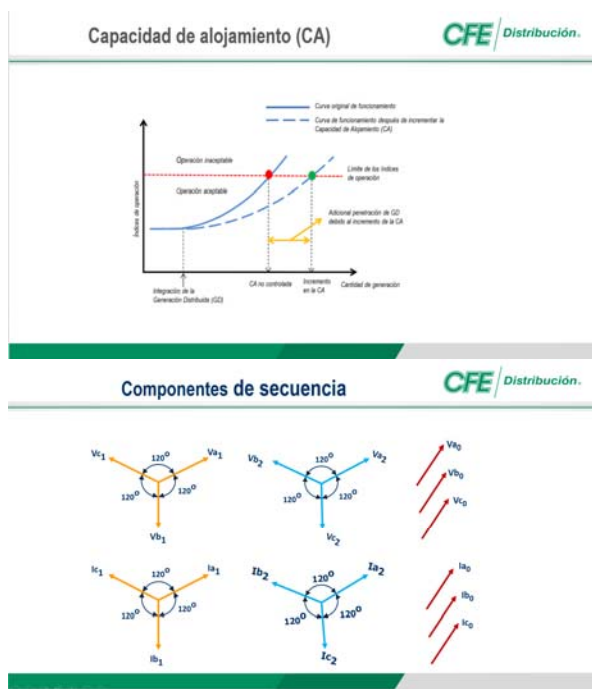


Fig. 2 Slides of Modules 4 and 3



Fig. 3 Instructors filming Modules 3 and 2 at INEEL facilities

c) Training videos for Modules 3 and 4 were recorded; for the rest of the Modules 75% of the training videos were recorded and there are in preparation 25% of the material. Fig. 3 shows the filming of 2 INEEL instructors for Modules 3 and 2. After that, video editing is done for future loading in the Moodle platform. On the other hand,

Fig. 4 shows a “print screen” of the finished edition of the video for Module 3.



Fig. 4 “Print screen” of the video for Module 3

- d) In the case of practical examples, a video of Module 3 was started using the *Free Screen Video Recorder* software [12]. Fig. 5 shows a print screen of the video with a practical example, that is, the use of Synergi software in practical case studies.
- e) To evaluate the learning of each assistant to the eLearning training, a questions set is being developed; the question set for Modules 3 and 4 has been finalized, and the question set for Modules 1 and 2 is being developed. At the end, the complete questions set will be uploaded in the Moodle platform. The course attendee must obtain a minimum of 80 points to pass a Module. The duration of the theoretical examination will be one hour (60 minutes 20 questions = 3 min/question).
- f) The Moodle application was installed on an INEEL server to carry out tests, simulating the CFE Distribution virtual platform. The creation of the local server and its customization to resemble the virtual platform server was completed.

It was developed several module screens that will be included on the Moodle platform in the format used by CFE Distribution; also, a template for Moodle was acquired and installed on that server. With this template, the course structure was designed on the Moodle platform and the material of the Modules will be uploaded as soon as it is finished.

- g) The "*Action Plan for Tutor Candidates*" was developed in which actions aimed for tutoring; also, strategies for tutorial action and the virtual tutor guidelines are included. This document has already been approved by CFE Distribution. Fig. 6 shows the cover page for the *Action Plan for Tutor Candidates* [13].
- h) The development of a training guide for instructors-facilitators (Tutors) with the Moodle platform is in preparation.

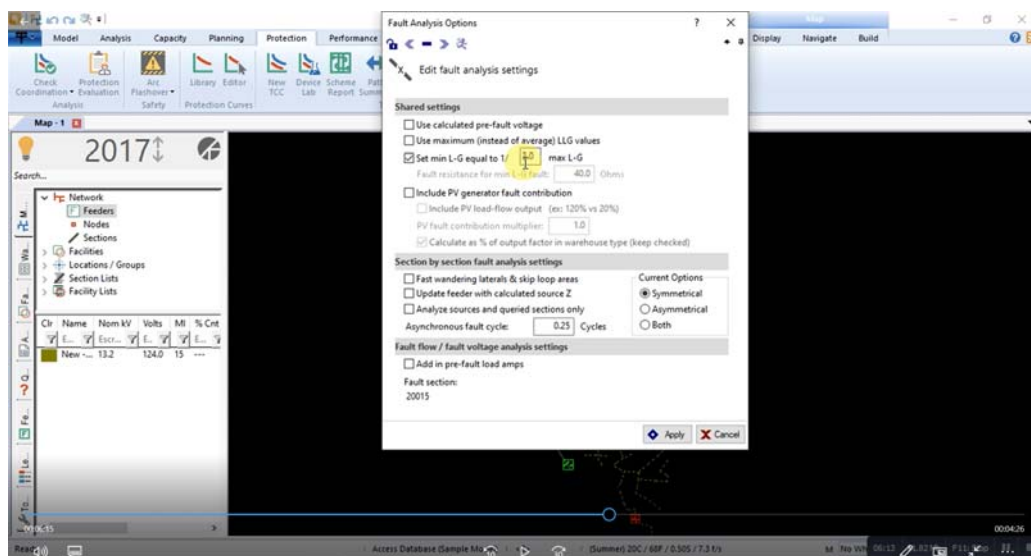


Fig. 5 “Print screen” of a practical case study video for Module 3



Fig. 6 Cover page and content of the *Action Plan for Tutor Candidates*

- i) The duration to attend each module was calculated, and it is approximately 60 minutes; the course attendant is expected to attend 5 to 6 training videos of 10 min each, plus time to complete homework and extra class work (project or research work). For the first 4 Modules of Stage 1, it is required approximately 9 hours per week for 4 weeks. On the other hand, the tutor also requires time to answer questions from those attending the course, to review homework, and for advice on research projects; It is estimated that the tutor requires approximately 6 hours per module.
- j) The characteristics of the personnel that will be a tutor was agreed with CFE Distribution personnel and it was defined that tutors must meet requirements of training, experience, communication, and other skills as shown in Table II.

VIII. CONCLUSION

The main results obtained in the development of the project are presented. An eLearning training project for electric

planning engineers of a Mexican electrical utility is developed. The advance of the study guides for Stage 1 modules has been completed. Likewise, the question banks were developed to evaluate the learning process of the attendants.

TABLE II
CHARACTERISTICS AND REQUIREMENTS THAT TUTORS MUST HAVE

#	Characteristic	Requirement
1	Career	Professional background in: <ul style="list-style-type: none"> • Mechanical Electrical Engineer • Industrial Engineer • Electromechanical Engineer • Electrical Engineer
2	Technical background	Extensive knowledge in the electrical studies
3	Teaching experience	Preferably in areas that he/she will teach or related disciplines
4	Software tools management	Excellent level in the use of Synergi software
5	Communication	Ease of written communication
6	Language	Understanding of technical information in English
7	Other skills	Without fear of taking on new challenges.
8	Time availability	Flexibility in time
9	Active or retired staff	Possibility for retired staff to participate

Polymedia equipment was used for filming modules videos. Procedures and criteria for modules approval for attendants of the virtual courses were determined. Additionally, an Action Plan was prepared for tutors to raise awareness about the tutorial action of the personnel who will participate in that role. These documents were reviewed and approved by CFE Distribution staff.

It is expected that once CFE Distribution is using this eLearning training process, several benefits will be gained, such as financial resources and time, among others.

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REFERENCES

[1] Melody Godsey, eLearning Authoring Tools, "Why eLearning Is The Future Of Corporate Training", eLearning Industry, December 8, 2019. Available Online: <https://elearningindustry.com/why-elearning-is-future-corporate-training>.

[2] Gerald Zandstra, eLearning Authoring Tools, "Developing Custom eLearning For Corporate Training", eLearning Industry, April 15, 2019. Available Online: <https://elearningindustry.com/custom-elearning-development-corporate-training>.

[3] Portal of Comision Federal de Electricidad Distribucion, Available Online: <https://www.cfe.mx/distribucion/Pages/default.aspx>.

[4] Achieve Virtual, Real Indiana Educators, "Infographic: Evolution of Virtual Education," Copyright 2020. Achieve Virtual Academy, 2020,

IN, USA. Available Online: <https://achievetvirtual.org/blog/online-high-school/infographic-evolution-of-virtual-education/>.

[5] Khaled Elbehiery, Hussam Elbehiery, "Entrepreneur Universal Education System: Future Evolution", World Academy of Science, Engineering and Technology, International Journal of Educational and Pedagogical Sciences, Vol:15, No:1, 2021.

[6] Moodle educational platform, Available Online: <https://moodle.org/course/view.php?id=5>.

[7] Synergi Electric modules, Power distribution analysis and optimization, Available Online: <https://www.dnv.com/services/synergi-electric-modules-5008>.

[8] Jose Pepe Rasgado "Modeling of medium and low voltage electrical distribution systems with Synergi", INEEL, Cuernavaca, Morelos, Mexico, 2021. (in Spanish)

[9] Jose Luis Silva, "Failure analysis of medium voltage circuits to determine the short circuit currents and the three-phase and single-phase X / R ratio to ground at the RGD connection points using Synergi", INEEL, Cuernavaca, Morelos, Mexico, 2021. (in Spanish)

[10] Jose Luis Silva, Jose Pepe Rasgado, "Analysis of the hosting capacity of distributed generation in RGD medium voltage circuits", INEEL, Cuernavaca, Morelos, Mexico, 2021. (in Spanish)

[11] Gustavo Candelaria, "Analysis of instantaneous power flows in medium and low voltage circuits to determine the regulation and instantaneous power losses at the connection points of the RGD in medium and low voltage using Synergi", INEEL, Cuernavaca, Morelos, Mexico, 2021. (in Spanish)

[12] Uptodown, Free Screen Video Recorder, Available Online: <https://free-screen-video-recorder.uptodown.com/windows>.

[13] Isaias Ramirez, "Action Plan for Tutor Candidates", INEEL, Cuernavaca, Morelos, Mexico, 2021. (in Spanish)

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