POWER ENGINEERING EDUCATION FOR RESTRUCTURED PHILIPPINE ELECTRIC INDUSTRY

E. B. Cano
Holy Angel University, Philippines

I. INTRODUCTION

The Philippine electricity industry has been restructured by virtue of the Republic Act No.9136 (R. A. 9136), which is the Electric Power Industry Reform Act of 2001. The centralized operational approach has changed to a competitive framework. This kind of set-up is new to the country. Generation, transmission and distribution of electric energy are now more of a market environment. Generation companies, Gencos, are used to be owned by the state together with the power transmission company, Transco. In the separation of these two components, Gencos will be sold to private corporations and investors. Transco is to be privatized and work as a single entity. Distribution utilities, Discos, will retain their regulated environment and will have private companies and public cooperatives to run Discos. Another important part of electricity deregulation in the Philippines is the establishment and operation of the Philippine Electricity Market Corporation (PEM). Energy will be traded by power producers and consumers more like a stock market at the Wholesale Electricity Spot Market (WESM).

As mandated by R.A. 9136, the Energy Regulatory Commission (ERC) will promulgate and enforce the Philippine Grid Code (PGC) [2], Philippine Distribution Code (PDC) [3] and WESM rules [4]. Various compliance plans are required by the ERC from the industry players to ensure proper deregulation process.

With the changes happening in the electricity industry, the power engineering education should rightly come with self-transformation. To enable the future power engineers who will handle jobs and positions in the deregulated industry the academe should respond and assess the modifications and improvements that need to be done. Power engineering education feeds the power engineering profession [5].

This paper describes the power engineering education model developed in Holy Angel University (HAU), Angeles City, Philippines. The model is based on three binding facts of power engineering education in the Philippines.

1. The restructuring of Philippine electricity industry, as described above.
2. Electrical engineering undergraduate education in the Philippines is the “power engineering” education.
3. And the Philippines is a developing country.

In the Philippines, undergraduate education for electric power, electronics and communications and computer systems are separated. Unlike international courses, Philippine universities and colleges offer Bachelor of Science in Electrical Engineering (BSEE), Bachelor of Science in Electronics and Communications (BSECE) and Bachelor of Science in Computer Engineering (BSCoE) as prescribed by the Commission of Higher Education (CHED). This actuality points the BSEE as the power engineering course. In this paper, when we refer to power engineering in the Philippines we are pertaining to BSEE.

Being in a developing country, the power engineering education in the Philippines must adapt to the status and level of economic standing of students and of the country. Bearing this in mind, the presented power engineering education model aligns to the country’s economic standpoint.

This paper is outlined in the following: review of existing educational standards and electricity codes, presentation of the power engineering education model, analysis of the presented model and concluding remarks and recommendations.

II. STANDARDS AND CODES

To properly provide for the needs of the deregulated electricity industry, an assessment of an educational standard and electricity codes were assessed. This will be the guiding baseline of the model for power engineering education.

1. Technical Panel for Engineering, Architecture and Maritime Education (TPEAME) for Electrical Engineering - this policy provides the suggested minimum requirements for BSEE. It aims to prepare graduates of BSEE for fields of specialization in Power Engineering and

Distribution Engineering [1]. The standard sets the academic requirements with total of 137 units of technical courses and 33 units of non-technical subjects. The table below details the academic requirements.

TABLE 1- TPEAME Minimum Requirements for BSEE

Courses	Minimum Credit Units
Mathematics	26
Physical Sciences	12
Engineering Sciences	31
Professional Courses	68
Languages and Social Sciences	33
TOTAL	**170**

Looking at the subjects required for the professional courses, Table 2 details below.

TABLE 2- TPEAME Professional Courses for BSEE

Professional Courses	Credit Units
Basic Circuits	8
Electric Machines	11
Power Systems	3
Communications	3
Electronics	13
Computer Systems	3
Electrical System Design	8
Control Systems	3
EE Laws	3
Seminars/Trainings	1
Electives	12
TOTAL	**68**

It is noticeable from Table 2 that Power Systems has only three (3) units where as the course's purpose is to shape future power engineers.

2. Philippine Grid Code (PGC) [2] – this code was propagated to provide standards for the transmission services of electrical energy. The PGC establishes the basic rules, requirements, procedures, and standards that govern the operation, maintenance, and development of the high voltage backbone transmission system in the Philippines [2]. The PGC is structured into ten (10) chapters. It is supposedly the "bible" of the Transco personnel. The contents of the PGC are presented as follows:

Chapter	Description
1	Grid Code General Conditions
2	Grid Management
3	Performance Standards
4	Financial Standards
5	Grid Connection
6	Grid Planning
7	Grid Operation
8	Scheduling and Dispatch
9	Grid Revenue Metering
10	Transitory Provisions

The PGC is one document of power transmission design and analysis. Planning, operations, metering, scheduling and dispatch are important part of the PGC where power engineers should be involved.

3. Philippine Distribution Code (PDC) [3] – this code is aimed at giving direction to Discos in regulation of their management, planning, operations and metering. The PDC will likewise govern the distribution utilities in preparing distribution system analysis and design. The PDC is structured as follows:

Chapter	Description
1	Distribution Code General Conditions
2	Distribution Management
3	Performance Standards
4	Financial Standards
5	Distribution Connection
6	Distribution Planning
7	Distribution Operation
8	Distribution Revenue Metering
9	Transitory Provisions

4. Wholesale Electricity Spot Market (WESM) Rules [4] – the market rules provide detailed requirements for trading electric energy. Nodal pricing for the power system grid is outlined together with the market technical and economic procedures. The rules for the Philippine Electricity market is organized into eleven (11) chapters which are:

Chapter	Description
1	Introduction
2	Registration
3	The Market
4	Metering
5	Market Information and Confidentiality
6	Intervention and Market Suspension
7	Enforcement and Disputes
8	Rules Change Process
9	Interpretation
10	Transitory Provisions
11	Glossary

III. POWER ENGINEERING EDUCATION MODEL

The model developed in HAU has the significant aspects: Curriculum Development, Laboratory Development, Faculty Development, Community

Extension and Research. The areas were enhanced considering the three binding facts mentioned in the first part of the paper.

A. Curriculum Development

To parallel the BSEE courses to the present needs of the deregulated electricity industry, several important professional technical subjects were integrated in the curriculum. Also, keeping in mind the economic situation of the students a ladder type yet situational applicable course requirements are added. Table 3 presents the revision to the improved curriculum.

TABLE 3 – Revision to the BSEE Professional and Technical Courses

Course	Description	Credit Units
Electric Power Distribution	Distribution system modeling, analysis: three phase load flow, fault calculations, voltage regulation, power loss computations, distribution planning and reliability	4
Electric Power Transmission	Transmission system modeling, analysis: load flow, short circuit, stability and controls, planning and operations	4
Advanced Power Systems	Electricity market fundamentals, Nodal pricing, market operations, market auction models, current developments	3
Micro-processor Systems	Logic circuits design, switching theories, assembly language programming, interfacing techniques, power system applications	8
Project Study	Introduction to methods of research, preparing research proposal, survey of literature, research writing, research presentation	2

TABLE 2 continuation

Special Topics in Power Deregulation	Regulation and competition, power system economics, compatibility of PGC, PDC and the WESM rules, emerging issues	6
EE Laboratory Technical Skills	House wiring, estimating, troubleshooting, motor repair and rewinding, motor control techniques, control devices, programmable logic controllers	4

The Power Systems subject in Table 2 is dropped from the BSEE curriculum to include Electric Power Distribution, Electric Power Transmission and Advanced Power Systems. This is to furnish to the understanding of the students with regards to the PGC, PDC and WESM, which cannot be covered by the earlier offered subject with three (3) units. Also, the inclusion of power system computer simulations for these incorporated subjects was heightened. Microprocessor Systems were incorporated for students to have a grasp of automation and interfacing applications in power systems. Project Study requirements were taken in for the purpose of shaping the students in writing and presenting their technical ideas. This also aligns to the research efforts of the course. To understand the present setting of the electricity industry and current issues regarding the industry, Special Topics in Power Deregulation credit units of six (6) were included.

Teaching deregulation is unavoidable in the present circumstances and needs to be started early [6]. The addition of the power deregulation courses in the curriculum was inevitable since few students pursue post graduate studies because of economic reasons. In the Philippines, it is fortunate for students to finish his BSEE course for most of them live within poverty level. In this case, Laboratory Technical Skills, offered from second year to third year, were integrated to make a ladder type BSEE. If the student will have financial problems in completing the BSEE course, he has at least gained technical techniques required to work as an industrial technician. And when the student has enough finances to continue his studies, he can continue without major adjustments.

Given the amendments in the curriculum, the students are prepared to work in a deregulated electricity industry. They can opt not to pursue graduate studies when in financial constraints.

B. Laboratory Development

The Electrical Engineering Laboratory is developed to nourished students' technical skills, understanding of practicalities of power engineering theories. Laboratory classes are held once a week for specified subjects. Teaching and research are simultaneously done in the lab. The laboratory has acquired the following hardwares and softwares:

- Electrical Machines Technology
- Industrial Motor Controls
- Insulation Tester, Power Quality Analyzer, Multimeters
- Mathematical Simulation Software
- Power System Simulation Software

The hardwares were primarily for verification of power engineering theories, technical skills enhancement. The sofwares' purpose was to power system design, analysis and operations for distribution, transmission and industrial settings. The Mathematical simulation software is also utilized for research.

C. Faculty Development

As of writing the BSEE faculty roster boasts five (5) Master of Engineering in Electrical Engineering graduates, two others are on their thesis project development. Seminars and trainings are also in the program so they will have to strike the right balance between research and teaching [7]. Some of the notable seminars and trainings given to BSEE faculty and some industry representatives are listed below:

- Research Directions in Electric Power Engineering
- Current Issues in Electric Power Deregulation
- Wholesale Electricity Spot Market Principles and Practices

D. Community Extension

A novel part of Philippine educational system is extending expertise and services to the community. In power engineering, we have conducted free electrical wiring repair at various places where people are considered to be poor. This extension projects train future power engineers to be humane and able to practice practical skills in electrical construction. Though not directly related to deregulation, this helps promotes power engineering.

Electrical Safety and Efficiency seminars were also conducted with IIEE as part of extension services. Faculty provided presentations for Home and Work Electrical Safety in far flung communities making people aware of the consciousness that misuse of electricity can be lethal. The project being with IIEE strengthens the linkage of the academe and the industry. Such activities are continually conducted and develop to foster good utilization of electricity.

E. Research

This area is at the younger stages. Several student projects have been completed regarding distribution system planning and operations. Titles of the projects are:

- Distribution System Reliability Assessment and Enhancement
- Distribution System Loss Evaluation and Reduction
- Quantification of Distribution System Non-Technical Losses
- Load Forecasting for Distribution System Operations

One BSEE faculty has also presented, at one local research conference, a paper entitled "Risk Assessment for Power Distribution System Operations".

Industry linkages are considered to support research efforts. Several faculty members are involved in the Institute of Integrated Electrical Engineers (IIEE) as they serve as chapter officers. This area needs continual improvement and support not only from the HAU but also from industry and government agencies.

IV. DISCUSSION

The HAU power engineering education model is more applicable to the changes of electricity industry. The developed curriculum includes the existing power system codes. The students are expected to be industry ready as they complete their studies.

The existing laboratory equipment for power engineering education may be good for several aspects of deregulation but needs to be upgraded with electricity market tools like auction and nodal

pricing simulators. This required lab tools could be conceived as research projects.

Faculty development is one important part of teaching deregulation. Faculty needs to be informed and updated with the recent developments and emerging issues of the industry if we want to enhanced instruction and research. Initiatives for industry linkage are an integral element for faculty development and power engineering research.

V. CONCLUSIONS AND RECOMMENDATIONS

This paper has presented a power engineering education for the restructured Philippine electricity industry. Several policies and codes are discussed to conceptualize to power engineering education model. For power engineering education to be responsive to the needs of the electricity deregulation, BSEE curriculum, laboratory development, faculty development and research must be improved and promoted.

Universities offering BSEE in the Philippines must enhance their program in accordance with the changes undergoing in the restructured power industry. It is further recommended that CHED will look into upgrading the TPEAME for BSEE that will suit the present situation of the industry. The CHED must also coordinate their movements with ERC, keeping in mind to serve the needs of the electricity deregulation. Industry must also participate in educating future power engineers for it is them that will gain in the long run.

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