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A CASE FOR THE REVISION OF POWER ENGINEERING SYLLABI AT KENYAN UNIVERSITIES

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ABSTRACT
This paper presents a summary of the current status of Electrical Power Engineering Education at Kenyan universities, followed by a summary of the situation on the same at universities world-wide. Against a backdrop of expected changes in the Kenyan power industry, the paper discusses the industry expectations of a power systems graduate currently and in the future, making a case for the revision of the current power engineering syllabi, concluding with recommendations and strategies for making the required changes.

KEY WORDS
Power engineering education, electric power systems, syllabi, status report

1 Introduction

Electric power engineering education refers to the areas of electrical engineering that deal with the generation, transmission, distribution, and conversion of energy in electrical form. Education may be thought of as a process of change. The design of a curriculum must therefore reflect change. Considering the formulation of a curriculum to be an engineering design problem, it is necessary to articulate design objectives and constraints. Although it is unwise to accept uncritically artificial constraints, clearly there will always be some very real limits. Broadly speaking, the objectives are: (a) To enable students to develop an understanding of the fundamental problems of electric power engineering and their classical solutions; (b) To promote in students the basic managerial, financial, economical, and communication skills necessary to effectively function in industry; (c) To enable students develop competency in mathematics and science commensurate with the requirements of electrical power engineering; (d) To inculcate in students the engineering ethic of service to humanity, through wise and respectful use of natural and human resources; (e)To enable students to develop a competency in the engineering method of problem formulation and solution. Engineering design should be stressed as an important component of the engineering method which refers to a real world problem whose solution results in a practical functional device or system; (f) To produce graduate power engineers competent to serve in industry, utilities, government, or education [1].

Looking at our Kenyan situation, in order to understand to what extent we meet these objectives, it is clear that only the first three objectives are met. Electrical power engineering education in Kenya has remained the same through several years despite the rapid changes in the electrical power industry worldwide. The last curriculum change was done in the eighties. This considered alongside many changes in the computer and communications industry has led to serious loss of student interest in this field. Students claim that it is not interesting, showing much preference for the ’glamorous’ computer related studies. This is absurd considering that computers have already found their way into the power field. Internationally, new industries that were not traditionally in power engineering have entered the arena; computer applications and software development firms now hire power engineers to serve the industry; and a host of auxiliary industries such as automotive, environmental, alternative energy sources, and instrumentation industries are employing power engineers. Potentially, the largest and greatest impact in the long term is the power electronics industry. This area has the potential of radical and major changes in power engineering. Each of these new elements in the career paths of our students have their own requirement, and it is clear that the focus of power engineering needs to be broadened considerably to accommodate these needs [2].

The almost non-existent collaboration between universities and the industry has also led to a misunderstanding in much of the industry of what to expect of an engineering graduate. The university, alongside engineering professional societies, is to blame for this, for not taking its legitimate lead in promoting engineering and the understanding of what it has to offer society. This misunderstanding has in many cases led to the employment of engineering graduates in work meant for technicians.

Recent research in power engineering has made extensive use of versatile mathematical ideas such as Artificial Neural Networks (ANN), Genetic Algorithms (GA), Fuzzy Logic, Ant Swarm Theory, etc. [3], yet these are as yet to even appear in our syllabi. The current trend of deregulation in the power industry worldwide calls for rethinking of how power engineering is taught as monolithic utilities are fast becoming things of the past, with separate entities taking charge of generation, transmission, and distribution of electrical power. This calls for knowledge in power economics, marketing, and so on.

2 Course Content at Kenyan Universities

2.1 Jomo Kenyatta University of Agriculture and Technology

The Kenyan undergraduate engineering programme takes five (5) years. Below is a complete listing of the units (Unit Code & Unit Title) leading to the Degree of Bachelor of Science in Engineering - Electrical & Electronics Engineering (Heavy Current option).

First Year:

HRD2101	Communication skills
SMA2170	Algebra
SPH2170	Physics I
SCH2102	Chemistry I
EME2101	Engineering Drawing I
EME2102	Workshop Practice I
SMA2171	Geometry
SMA2172	Calculus I
SMA2173	Calculus II
SPH2171	Physics II
SCH2108	Chemistry II
EME2103	Material Science I
EEE2110	Workshop Practice II
EME2113	Engineering Drawing II
HRD2102	Development Studies
HRD2103	General Economics

Second Year:

SMA2273	Applied Mathematics I
EEE2202	Analogue Electronics I
EEE2203	Material Science II
EEE2204	Physical Electronics I
EEE2205	Electrical Measurement
SMA2174	Introduction to Computer
SMA2270	Calculus III
EEE2208	Circuit & Network theory I
SMA2271	Ordinary Differential Equations
EEE2210	Analogue Electronics II
EME2211	Mechanical Engineering
EEE2212	Physical Electronics II
EEE2213	Circuit & Network theory II
EEE2214	Electrical Machines I
EEE2215	Electromagnetics I
SMA2175	Computer Programming I
EEE2217	Industrial Attachment I (8 weeks)

Third Year:

SMA2370	Calculus IV
EEE2302	Analogue Electronics III
EEE2303	Circuit & Network Theory III
EEE2304	Electromagnetics II
EEE2305	Digital Electronics I
EEE2306	Electrical Machines II
EEE2315	Thermodynamics
EEE2308	Power Electronics I
SMA2371	Partial Differential Equations
EEE2310	Digital Electronics II
SMA2272	Statistics
EEE2312	Electrical Machines III
EEE2313	Signal Communication I
EEE2314	Transmission Lines
EEE2315	Analogue Electronics IV
SMA2276	Computer Programming II
EEE2317	Industrial Attachment II (8 weeks)

Fourth Year:

SMA2480	Complex Analysis
HRD2114	Research Methodology
EEE 2403	Control Engineering I
EEE2404	Power Electronics II
EEE2405	Analogue Filters
EEE2406	Microprocessor I
EEE2413	Power Systems I
EEE2414	Electrical Machines IV
SMA2407	Instrumentation
SMA2471	Numerical Analysis I
SMA2472	Operations Research
EEE2411	Control Engineering II
EEE2412	Microprocessor II
EEE2416	Power Systems II
EEE2415	Electrical Machines V
EEE2422	Illumination Engineering
EEE2417	Industrial Attachment III (8 weeks)

Fifth Year:

EEE2501	Project (2 Units)
EEE2502	Control Engineering III
EEE2503	Reliability Engineering
HRD2104	Management
HRD2505	Principles of Marketing
EEE2507	Control Engineering IV
EEE2508	Electrical Machine Design
EEE2509	High Voltage Technology
EEE2510	Power System Protection
EEE2511	Power System Analysis I
HRD2115	Accounting and Finance
EEE2512	Energy Studies
EEE2513	Machine Drives
EEE2514	Power System Analysis II
EEE2517	Electroacoustics

2.2 Moi University and University of Nairobi

Moi University (MU) and Jomo Kenyatta University of Agriculture and Technology (JKUAT) were established after the establishment of the University of Nairobi (UoN), with the senior staff at UoN drafting the syllabi at the new universities, along the lines of that at UoN. In fact, a look of the syllabi at these new universities reveals that they are either a copy or copies with cosmetic changes of that at UoN.

3 The State of Electric Power Engineering Education in the Rest of the World

In comparison with all of the areas of electrical and computer engineering, this currently represents about 10% of the overall subject matter. This is based on typical academic programs where faculty and student ratios are approximately that percentage relative to all electrical and computer engineers. A recent survey conducted using the Power-Globe List-server received responses from 67 universities (40 U.S., and 27 non-U.S.) throughout the world. Some of the survey comments on curriculum changes are:

1. Addition of power quality course, modernization of required undergraduate power course.
2. Three new power electronics course and distribution
3. Emphasis on independent study by students.
4. Reduction of machinery hours and addition of a quasi-required power course.
5. Upgrading automation and controls
6. Added a power systems simulation laboratory and a course on public policy.
7. New course on alternative energy distributed generation.
8. Added congestion management, power marketing and deregulation.
9. Added ANN, GA, EP, Fuzzy, Flexible AC Transmission Systems (FACTS), substation automation
10. Added SCADA, FACTS, EMS

4 Critical Evaluation of the Kenyan Situation

The current trend in the rest of the world is that of deregulation. Monolithic utilities are fast becoming things of the past as separate entities take charge of generation, transmission, and distribution.

In the Kenyan context generation is done by the Kenya Electricity Generation Company (KENGEN) and Independent Power Producers (IPPs), such as IberAfrica, Westmont Power (Kenya) Limited., Orpower4 Inc. and Tsavo Power Company Limited, while transmission and distribution, together are done by The Kenya Power and Lighting Company (KPLC). It is likely that this 'half' deregulation in Kenya will be completed and result into a complete separation of the three activities of generation, transmission and distribution. Clearly then, this will impact on the expectations of the power industry on a power engineering graduate; knowledge of power economics and marketing will be a must. Engineers with the ability to attract consumers who have a variety of choices at their disposal and economically deliver power to them will have an edge over those who do not.

Deregulation could result in blackouts as was experienced in the USA [4], possibly because of poor system-wide planning and coordination as a result of different entities managing the different aspects of generation, delivery and marketing of power. Following this experience the idea of distributed generation emerged as a possible solution to this problem, and this makes introduction of this topic in our curriculum worthwhile.

Incidents of poor engineering design that have resulted in loss of life and property are common occurrences in Kenya today, for example construction of houses under distribution lines, unauthorized connection of consumers and so on. In most of these cases it is not that the engineer involved was of poor technical training, in many cases it was because of a need to make quick money by authorizing and commissioning unsafe installations. This brings into sharp focus the need to inculcate in our students deep ethical values and a sense of social responsibility.

The current economic slump in our country calls for training that removes from our students' minds the notion that they undergo training to become employees; they should be prepared and helped to think as creators of jobs. This calls for the introduction of entrepreneurial studies in our curriculum. Students should be made aware of the various ways of earning income, e.g., as an employee, an investor, a business owner and as a self-employed professional. This will make our students understand cash-flow issues and set them on the path to financial independence.

Following the severe capacity shortfalls experienced in Kenya in the years 1999–2001, it has been argued that Kenya's generation capacity is insufficiently diversified, yet the potential exists for additional generation from indigenous resources such as hydro, geothermal, wind and biomass. It has also been suggested that to accelerate the diversification process preferential treatment should be accorded the electricity derived from these sources - the so-called "green electricity". Yet others have argued that the fact that these are environmentally benign energy sources the advantages thereof are sufficient grounds for preferential treatment in the market place. Environmental studies will better prepare our students to appreciate the importance of giving priority to the use of energy sources that do not degrade our environment [5].

The enrolment trend into power engineering courses has seen a downward trend over the years as "more exciting" technologies emerge and take the interest of most students. This need not be the case however as:

- New control algorithms based on intelligent controls incorporating fuzzy logic, neural networks, and genetic algorithms are being slowly introduced.
- Devices based on power electronics are making power transmission safer and more reliable, and the internet is making power marketing more convenient. With companies using the internet to perform operations more efficiently, and with a wide array of products to sell, they need engineers with diverse backgrounds.
- Not only is the electric power industry generating much new technology itself, it is also an important consumer of new technologies produced by other electrical engineering disciplines. This emphasis on technological know-how will require people trained to work in these areas, as well as innovators whose creations must respond to changing requirements for electric power systems [4].
- New industries that were not traditionally in power engineering have entered the arena; computer applications and software development firms now hire power engineers to serve the industry; and a host of auxiliary industries such as automotive, environmental, alternative energy sources, and instrumentation industries are employing power engineers [3].

There is urgent need to create and, where it already exists, enhance university-industry collaboration so as to (i) alter in time our syllabi to correspond to needs in industry, (ii) also reduce the employment of graduates in work meant for technicians, (iii) have industry propose and possibly sponsor student research projects, that could be either just exploratory or address real problems in industry, (iv) provide continuing education for engineers already in industry, (v) provide forums where engineers in industry can meet students for knowledge and experience exchange and career path advice, etc [6]–[8].

At the masters level, there is a special need in the electrical power quality area: this is a subject that relates to maintaining the sinusoidal voltage wave-shape at all load buses, and is also a measure of how each element of the electrical power system from generation to consumption affects the whole system. Increasing reliability and selling power quality related services as unbundled services will be specialized niche needs in industry. Power quality has special importance in an educational program because it teaches modelling and interactions of large-scale systems. Kenya intends to join the South African power pool, making knowledge in the area of power quality a must for our graduates.

Implementation of these suggestions will narrow the gap in the difference between what is taught at our universities and at other universities worldwide, leading to even higher international recognition of our graduates

5 What Changes Should be Made to Our Syllabus?

The changes that should be made to the Kenyan syllabus include introduction of the following courses [3],[9]–[12]:

- Artificial Neural Networks
- Genetic Algorithms
- Fuzzy Logic
- Ant Swarm Theory
- Engineering method of problem formulation and solution
- Power Quality Studies
- Ethics/Social Responsibility
- Power Economics and Marketing
- Distributed Power Generation
- Professional Power Systems Analysis Software
- Entrepreneurship
- Renewable Energy Studies
- FACTS
- SCADA
- Energy Management
- Distribution Systems
- Distribution Systems Automation Studies
- Environmental Studies

6 Transition Strategy

1. In the short-term, retraining of resource persons in the various areas, e.g. ANNs, Genetic Algorithms, Professional Engineering Software, etc. Staff from mathematics department could be used to introduce ANNs. The current problem is that staff from the said department do not seem to understand the required breadth and depth of the specialized mathematical knowledge that they should impart to engineering students. There is also a problem with the order in which concepts are taught, with some mathematical ideas being taught long after they were utilized in the engineering units. This calls for the need of having engineering lecturers teach this specialized mathematics.

2. Equipping the laboratories with the requisite equipment and software.
3. Establishing more industry-university collaboration, for student project suggestions and sponsorships, student and lecturer attachments, for periodic and on-time updating of the syllabus.
4. Establishing active links with international universities.
5. Conducting short continuing education courses for already employed engineers. They could bring to the attention of universities their experiences and observations of what is taking place in industry. They too would be taught about emerging methods and technologies.

7 Conclusions

This paper has presented a detailed outline of the current status of electrical power engineering education at Kenyan universities and compared it with that at other universities worldwide, based on survey comments and curriculum changes made in those universities.

Against a backdrop of expected changes in the Kenyan power industry, the paper discussed the industry expectations of a power systems graduate currently and in the future, making a case for the revision of the current syllabi, and concluding with concrete recommendations and strategies for making the required changes.

By careful implementation of the changes proposed in the various sections of this paper, all the objectives mentioned in the introduction will then be satisfied, and the students taking this course will then be able to fit well in any relevant environment upon graduation. The proposed changes are not restricted to the Kenyan situation only, but should apply to other universities in the world as dictated by their respective conditions.

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