AC 2011-953: INDUSTRY-DRIVEN POWER ENGINEERING CURRICULUM DEVELOPMENT IN ELECTRICAL AND COMPUTER ENGINEERING TECHNOLOGY PROGRAM

Aleksandr Sergeyev, Michigan Technological University

Aleksandr Sergeyev is currently an Assistant Professor in the Electrical Engineering Technology program in the School of Technology at Michigan Technological University. Dr. Aleksandr Sergeyev is earned his bachelor degree in electrical engineering in Moscow University of Electronics and Automation in 1995. He obtained the Master degree in Physics from Michigan Technological University in 2004 and the PhD degree in Electrical Engineering from Michigan Technological University in 2007. Dr. Aleksandr Sergeyev research interests include high energy lasers propagation through the turbulent atmosphere, developing advanced control algorithms for wavefront sensing and mitigating effects of the turbulent atmosphere, digital inline holography, digital signal processing, and laser spectroscopy. He is also involved in developing new eye-tracking experimental techniques for extracting 3-D shape of the object from the movement of human eyes. Dr. Sergeyev is he is a member of American Society for Engineering Education (ASEE) and actively involved in promoting engineering education.

Nasser Alaraje, Michigan Technological University

Dr. Alaraje's research interests focuses on processor architecture, System-on-Chip design methodology, Field-Programmable Logic Array (FPGA) architecture and design methodology, Engineering Technology Education, and hardware description language modeling. Dr. Alaraje is currently the Electrical Engineering Technology program chair as well as a faculty member at Michigan Technological University, he taught and developed courses in Computer Engineering technology area at University of Cincinnati, and Michigan Technological University. Dr. Alaraje is a Fulbright scholar; he is a member of American Society for Engineering Education (ASEE), a member of ASEE Electrical and Computer Engineering Division, a member of ASEE Engineering Technology Division, a member of Institute of Electrical & Electronic Engineers (IEEE), and a member of Electrical and Computer Engineering Technology Department Heads Association (ECETDHA)

Industry-Driven Power Engineering Curriculum Development in Electrical and Computer Engineering Technology Program

Abstract

The power engineering industry has been experiencing a demonstrated shortage of skilled, well-trained, and educated power engineering technologists and technicians to fill positions in the electric power industry. The root cause of this problem is two-fold. First, academic programs in power engineering have not been educating and graduating enough students in power engineering curriculum to address this shortage. Clearly, more needs to be done to encourage additional capacity within programs and inspire more and more diverse students to explore this career path. Second, nearly 75% of current power engineers and technologists are at or near the retirement age and will retire in the next 10 years. As a result, without coordinated and effective efforts, this demonstrated worker shortage will only get worse in the coming years. Industry and academia need to work together to address this problem. The initiative described in this paper will re-shape, expand, and enhance the current power engineering focus area in electrical engineering technology program. New courses in power electronics, power transmission and distribution, and renewable energy will be developed providing electrical engineering technology students the opportunity to learn concepts and hands-on skills and will address the present and future needs of the power energy industry. One key factor of the proposed new courses will be to revamp the curriculum to meet the expectations of power industry by supplying qualified technicians and technologists who have extensive hands-on experience. The cross-disciplinary electric power system training program presented in this paper is very versatile. It is structured in a way to accommodate the needs of enrolled in the Michigan Technological University students, employees of industry looking to improve their knowledge in power areas, as well as students from another universities and colleges pursuing power education. Concept of virtual laboratory is also introduced here and provides addition flexibility in the class's offering strategies. Due to the rapid changes in the technological world, faculty involved in teaching the proposed courses must be informed of advances in technology currently used in the industry. On the other hand, industry wants to have qualified and well-educated employees who are ready to implement their knowledge on day one of their employment. As a result, the initiative of power engineering curriculum development described in this paper is industry-driven.

Introduction

Many electrical engineering technology programs have already started the revamp of their power engineering curriculum to address the shortage of skilled technologists in the power energy industry by introducing courses in power electronics and renewable energy. For example, Texas A & M University is developing a new program in power engineering technology with a focus on the nuclear power industry[3]. A new nuclear power institute was formed in collaboration with community colleges to enhance both two-year and four-year technology programs relevant to the power industry. The new power engineering technology program is a multidisciplinary program with the aim of training the next power engineering technologist workforce.

At the University of Cincinnati's electrical and computer engineering technology program, a new two-year associate degree in power system engineering technology has been developed. The

program started in fall 2006 with ten students; efforts are currently being invested to extend the two-year degree into a four-year Baccalaureate degree in power system engineering technology[2].
At the University of Houston efforts are underway to reverse the traditionally low enrollment of students in the electrical technology program. There, a new electrical power technology program started in fall 2003 and, since the program began, enrollment has increased steadily from 60 students (in prior electrical technology program) in fall 2002, to 91 students in fall 2003, and 109 students in fall 2004. The new electrical power technology program curriculum covers topics in power generation, power transmission and distribution, electrical machinery and machine control, electrical system design, and industry practice[4].
At the State University of New York, college at Buffalo, the power/machines option in the electrical engineering technology program has experienced a major change in order to enhance the program and meet the industry expectations. The new curriculum teaches topics in power systems, electric machines, and power electronics[1].
The Electrical Engineering Technology program at the Michigan Technological University (MTU) is ready to take the challenge and collaborate with local and regional industry to develop a power engineering curriculum to solve the current shortage and future expected growth in power engineering professionals within the State and beyond. The MTU will develop and expand its current power focus area to train a larger and more diverse future power engineering technologist workforce that will meet the changing needs of the industry.

University – Overview

Michigan Tech is a public university committed to providing a quality education in engineering, science, business, technology, communication, and forestry. Fall 2009 enrollment showed a total of over 7,100 students, including over 1000 (~17%) graduate students[5]. Over 62% of the Michigan Technological University students are enrolled in engineering and technology programs[5]. The School of Technology offers programs covering the entire spectrum of technology. The School awards bachelor's degrees in Computer Network & System Administration, Construction Management, Electrical Engineering Technology, Mechanical Engineering Technology, and Surveying Engineering.
The electrical engineering technology program (EET) at Michigan Tech offers a Bachelor of Science in Electrical Engineering Technology. The EET program is application-oriented and focuses on preparing graduates for entry into the workforce upon graduation. Graduates of the program are electrical engineering technologists with career options in micro-controller applications, robotics, industrial automation, instrumentation, and control.

The University Curriculum Content

Recognizing the need for the next-generation of skilled technologists for power engineering fields, the electrical engineering technology program at Michigan Tech will re-shape, enhance, and expand its power engineering focus area. The Power Engineering curriculum development will incorporate the addition of three new courses that will be added to the current two courses, Electrical Machinery and Power Systems. The Electrical Engineering Technology program will re-shape the current power systems course to focus on Power Distribution and introduce three new courses (Power Transmission, Power Electronics, and Alternative Energy Sources). Figure 1 shows the current and proposed power engineering focus area curriculum; the descriptions of the

three new courses are provided below. We were able to add the new three courses without impacting the overall degree plan. The current EET program has a shortage of courses in power engineering; only one course (Power Systems) is currently offered. The EET program will still be structured as a 127 credit hour program with sixty-eight (68) credits of technical courses in Electrical Engineering Technology. This is in line with ABET requirements[6].

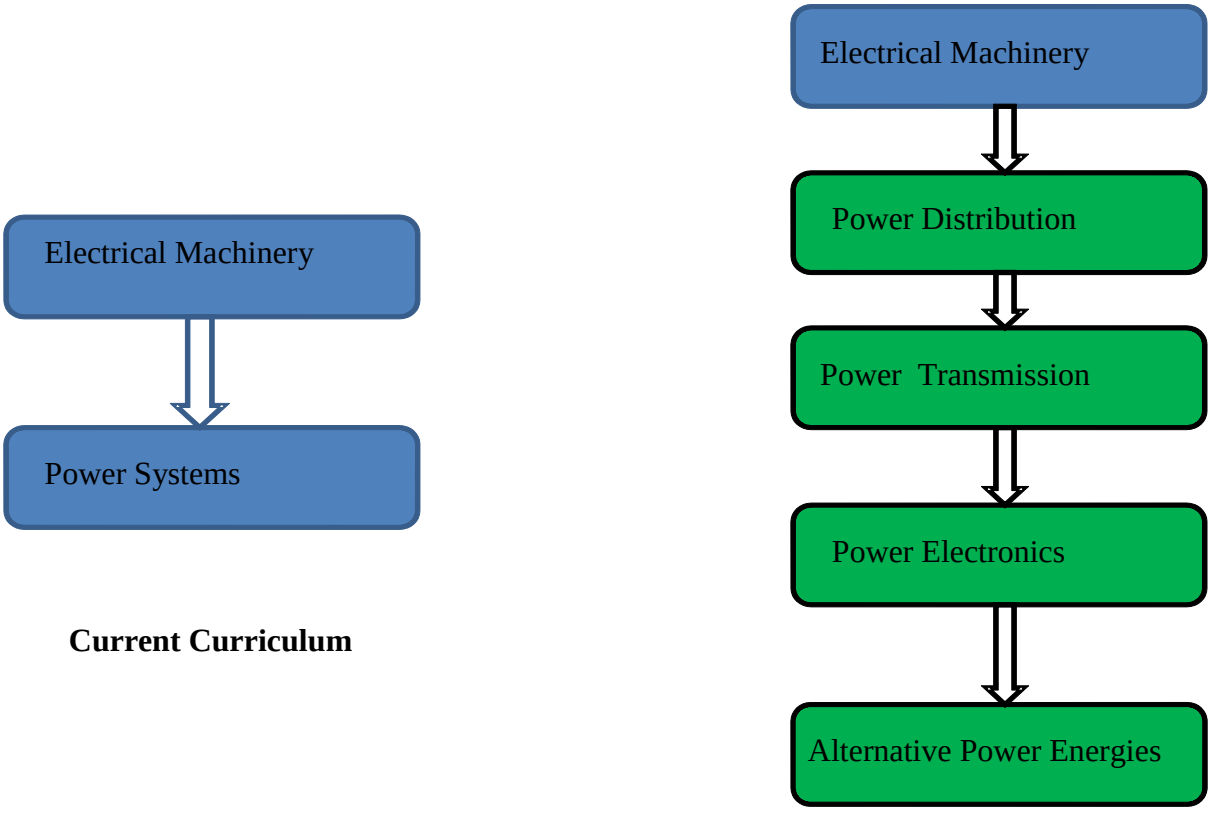

Figure 1: Current and Proposed Power Engineering Curriculum

Summary of the Courses

The *EET 3390 Power Distribution* is a three credit hour course that provides a practical introduction to electrical power distribution. Fundamental concepts for modeling distribution lines, power system generators, power transformers, three-phase power, line faults, distribution system protection, and power system load are thoroughly covered. Simulation of power systems during normal and abnormal conditions is presented.

The *EET 4390 Power Transmission* is a three credit hour course that provides an overview of transmission systems. Topics such as transmission voltage levels, requirements for overall

system stability, transmission line parameters, line faults and protection, and bulk power substations are discussed in depth. The fundamentals of line construction and planning are also covered in the course.

The *EET4391 Power Electronics* is a four credit hour course that presents an introduction to electronic power conversion circuits. It provides an analysis of basic switching circuits and power converter topologies including dc/dc converters, ac/dc rectifiers, dc/ac inverters, and ac/ac frequency converters. It discusses the selection criteria for reactive elements and models for solid-state switching devices and identifies common performance objectives such as efficiency and power factor.

The *EET 4393 Alternative Energy Sources* is a three credit hour course that presents an overview of the world's energy resources and energy consumption trends. Conventional and emerging energy sources and conversion methods are discussed in terms of their long term viability, based on technical and political factors. Major types of renewable energy sources are discussed in the course in great detail. Relevant topics on transportation energy technologies and systems perspectives on transportation energy are also presented in the course**.**

"Power World" Simulation tools:
The theoretical knowledge will be greatly enhanced by implementing the simulation software "PowerWorld", commonly used in the power industry, and providing extensive hands-on experience in the laboratories. The PowerWorld Simulator is an interactive power systems simulation package designed to simulate high voltage power systems operation over time frames ranging from several minutes to several days. The software contains a highly effective power flow analysis package capable of efficiently solving systems. PowerWorld Simulator 14, the most up-to-date power system simulation software package, is licensed for educational use and available from PowerWorld Corporation to educational institutions at no cost.

Laboratories:

Currently there is no laboratory component in Power Systems course however the students receive hands-on training through field trips to the local power plants and paper mills. A laboratory component will be an integral part of all three courses: *EET 3390 Power Distribution, EET 4390 Power Transmission, EET 4393 Alternative Energy Sources.* The MTU will obtain necessary laboratory equipment by seeking for external funds and via donations from the industry.
Laboratory exercises will be developed to provide students with extensive hands-on experience valuable to the industry. Because most electrical power is produced by generators (this applies to power stations as well as to standby power supplies), hydroelectric, and wind generators, the students will be provided with hands-on experience related to three-phase synchronous generator experiments. In addition to basic experiments dealing with three-phase synchronous generators, experiments involving manual and automatic synchronizing circuits, the automatic power factor and power control will be developed. Concepts of renewable and conventional power plants with transmission and distribution systems will be utilized to design and teach laboratories in *EET 3390, EET 4390, and EET 4393.* The developed laboratory experiments will allow the faculty member to cover a wide variety of topics and provide significant hands-on experience in topics

of manually operated synchronizing circuits, automatic synchronizing circuits, automatic power factor control, three-phase lines, generator protection, energy consumption, relays, busbars, and load monitor.
The broad spectrum of topics such as the efficiency of a steam generator, effect of the air feed on the exhaust gas, setting up energy balances, determining the temperature and pressure of saturated steam, determination of steam enthalpy, the heat transfer coefficient, specific steam consumption of the turbine, turbine power for different pressures of live and exhaust steam, and thermal and overall efficiencies will be revealed using the developed laboratory exercises. The laboratory component of *EET 4391* will introduce the fundamental concepts involving single-quadrant and 4-quadrant controllers, single- and three-phase power inverters, AC controllers/three-phase controllers, switched mode power supplies, pulse width modulation (PWM), power semiconductors, uncontrolled and controlled rectifiers, automatic control and speed adjustment.
Implementation of the virtual laboratories is program long term goal. On-line material will be recorded and posted on the specifically designed web site with the permission access for the registered students. Virtual laboratories will be conducted over the internet in real time. The lab assistant physically present in the laboratory and having the access to the equipment will communicate with and assist the students in order to assemble the circuit and complete the laboratory assignment. The lab assistant will serve the purpose of the student's hands. This approach of virtual lab will enable training of industry workers without them having to leave their place of employment, in addition to a broader range of students who might be attending other universities or colleges.

Training plan for students and industry representatives.

Described in this paper cross-disciplinary electric power system training program at the MTU is intended to be very versatile. It will be structured in a way to accommodate the needs of the Michigan Tech enrolled students, employees of industry looking to improve their knowledge in power areas, as well as students from another universities and colleges pursuing power education and electing to take on-line courses on power transmission, distribution, alternative energy, and power electronics. In addition, course materials developed through this project will be disseminated to increase the impact to engineering technology programs at other institutions. The overall training plan for students and industry representatives is outlined in Figure 2.

Currently enrolled Michigan Tech students seeking a degree in power will have two choices on how to complete the requirements associated with the courses of interest:

> **PATH 1**: Students will register for semester-long, on-site courses and laboratories. Both the courses and the laboratories will be taught in-real time by faculty and lab assistants.
>
> **PATH 2**: Students will register for semester-long, on-line courses with the intensive, one-week-long, on-site laboratories. On-line material will be recorded and posted on the specifically designed web site with permission access for the registered students. One week on-site laboratories will be conducted by the faculty and lab assistants in real time.

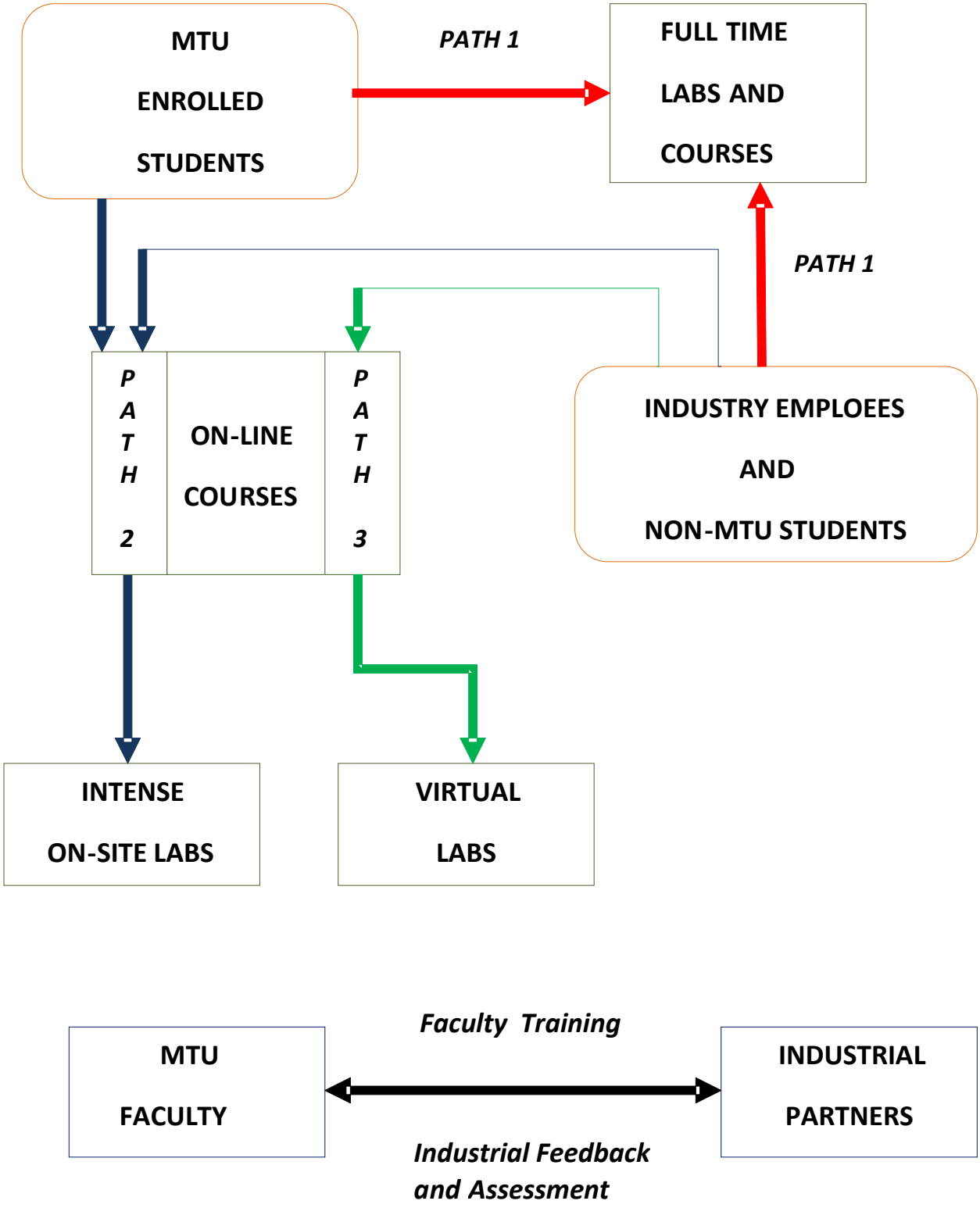

Figure 2: The proposed cross-disciplinary electric power system training program at MTU

Industry employees looking to improve their knowledge in the power area, as well as students from other universities and colleges pursuing power education may elect one of three choices:

PATH 1: Students will register for the semester long on-site courses and laboratories. Both the course and the laboratories will be taught in-real time by faculty and lab assistants.

PATH 2: Students will register for semester long on-line courses with intense, one-week-long, on-site laboratories. On-line material will be recorded and posted on the specifically designed web site with permission access for registered students. One week on-site laboratories will be conducted by the faculty and lab assistants in real time.

PATH 3: Students will register for semester long on-line courses with virtual laboratories. On-line material will be recorded and posted on the specifically designed web site with permission access for registered students. Virtual laboratories will be conducted over the internet in real time. The lab assistant will physically present in the laboratory and have access to the equipment and will communicate with and assist the students in order to assemble the circuit and complete the laboratory assignment. The lab assistant will serve the purpose of the student's hands in real time, enabled by online learning software.

Due to the rapid changes in the technological world, faculty involved in teaching must keep informed of advances in technology currently used in the industry. On the other hand, industry wants to have qualified and well-educated employees who are ready to implement their knowledge on day one of their employment. As a result, while academia needs to be fully aware of the current state-of-the-art knowledge requirements: industry must be driving the curriculum development. We intend to strengthen an existing link between the University and industry in order to stay current. This partnership is a "two-way street" and advantageous for both parties.

Conclusion

Academic programs in the School of Technology Michigan Tech are designed to prepare technical and/or management-oriented professionals for employment in industry, education, government, and business. This curriculum development will reshape, enhance, and expand the power engineering focus area in Electrical Engineering Technology programs, beginning at Michigan Tech**.** Curriculum revision will provide electrical engineering technology students the opportunity to learn concepts and hands-on skills and will address the present and future needs of the power energy industry. The curriculum revision will provide a model for other electrical engineering technology programs and resources developed will be made available to other programs. The primary outcome of this project will be a larger number of better qualified engineering technologist graduates with skills and knowledge that are current and relevant.

References:

1. Ilya Grinberg, "Power Systems Curriculum and Course Structure in Electrical Engineering Technology Program", *2001 ASEE Annual Conference*, Section 1433, 782[1].
2. R. Miller, M. Rabiee, E. Stepp, "Power Engineering Technology Program Development", *2008 ASEE Annual Conference*, Paper 614[1].

3. J. Porter, W. Zhan, J. Alvarado, J. Morgan "Power Engineering Technology: A New Program Targeted at the Nuclear Power Industry", *2008 ASEE Annual Conference*, Paper 487[1].
4. L. Faulkenberry, W. Shireen, "Evolution of the electrical Power Technology Program at the University of Houston", *2006 ASEE Annual Conference*, Paper 1195[1].
5. The Michigan Technological University Admission Office.
6. "Criteria for Accrediting Engineering Technology Programs," *Technology Accreditation Commission, ABET, Inc*., Baltimore, Maryland, 2007.