Generally speaking, nations that have excelled in science and engineering are the most economically successful. Success in science and engineering is nearly always underpinned by a robust education system that caters to teaching and research. Therefore, it is fair to say that a good, practical engineering education is the single most important factor for a nation’s sustainable development and economic prosperity. This is particularly critical today as we are living through times of unprecedented social, economic, and technological change. Artificial intelligence and robotics have emerged as the next frontier of technological evolution.

The electric power industry is experiencing fundamental changes brought about by the need to produce our electrical energy in a more sustainable manner not only in environmental terms but also in economic terms. While the basic science and engineering principles are not changing, there is no question that the underlying themes that were the staple of electric power systems engineering courses will require redevelopment and updating. This article aims to tease out some of the key drivers for change in the way engineering, and electrical power system engineering in particular, is taught.

**Trends in Power Systems Engineering Education**

**Smart Grids**

For the last decade, electrical power systems in developed countries have been in a state of transition from traditional power systems, dominated largely by fossil-fuel-driven generation, to more sustainable power systems that are increasingly reliant on renewable energy, mainly wind and solar. This irreversible transition is largely motivated by the need to generate sustainable electricity without causing adverse environmental impacts, such as climate change. Similar changes are also taking place in developing countries, which, unencumbered by legacy systems, are well positioned to provide the ideal test beds for the design and operation of new power systems.

The term *smart grid* is used to refer to power systems of the future, and, for the most part, they comprise renewable energy sources with variable output. Because of variable output and the operational requirements of typical ac power systems, such as real-time supply and demand balancing, an essential part of the smart grid is storage, both short and long term. Demand-side participation in the energy market is also a key component of smart grids. Information and communication technologies (ICTs) are critical to the design and operation of smart grids.

**The Changing Nature of Generation**

Most power systems today are driven by high-inertia ac generators. Power system steady-state and transient-stability analyses use generator models and parameters for hydro and thermal power plants. Most electrical power engineering undergraduate and postgraduate curricula are based on these fundamental assumptions. These assumptions are beginning to be challenged as more wind and solar generation systems are connected to power systems via converters. This has consequences for system inertia and, hence, system transient stability and system protection. Moreover, wind and solar generation have zero marginal costs as opposed to fossil fuel generation. Therefore, new methodologies, principles, and techniques for the planning, design, and operation of power systems dominated by this type of generation will have to be developed and incorporated in standard electrical engineering curricula.

**The Changing Nature of Loads**

The nature of loads on power systems is poised to change significantly with lighting technologies trending toward light-emitting diodes and with the emergence of dynamic loads, such as electric cars, which can produce and consume energy. Operators of dynamic loads are called *prosumers*, a term that entered the power system lexicon a few years ago. More critically, the introduction of the electric car will make domestic, industrial, and commercial loads more dynamic, with spatial and temporal features that are much more pronounced than the features we are seeing today. We are witnessing a firm commitment to the decarbonization of transportation, with electric cars emerging as the winner. Virtually all leading car manufacturers have dedicated programs for developing electric cars. These changes must be incorporated into new power system engineering curricula.
ICTs
Because ICTs are central to the smart grid concept, it is crucial for power system engineers to acquire a better understanding of them. Most devices will incorporate some programmable features as society progresses toward the Internet of Things. This will unlock the opportunity to use all types of loads as potentially flexible resources to be deployed in system-operation optimization to enhance the security of energy supply within constraints imposed by variable output renewable generation.

A Deep Dive into Electrical Engineering Curriculum
The changes we are witnessing in the power sector will require a fundamental review of current undergraduate and postgraduate electrical engineering curricula to keep pace. There is a sense that we may already be behind the curve. Perhaps it is time to delve deep into electrical power systems curricula to modernize and prepare for future power systems.

Engineering Skills Gap
There is ample evidence of a skills gap in engineering. In the United Kingdom, for example, according to a recent survey covering the years 2017 to 2024, “The electrical engineering workforce is projected to grow by 6.1% over the period to 2024, creating 2,700 jobs and, at the same time, 23.7% of the workforce is projected to retire, creating 10,400 more job openings.” In light of these expected developments, it is very likely that this gap is understated in the area of power systems engineering.

To address this issue, it is time to consider how online teaching platforms can be implemented to effectively teach engineering in a credible manner. Currently, there are numerous online resources that cover a broad range of engineering topics. There are still many issues, however, that must be resolved if we are to provide engineering education using online platforms. These issues include the credibility of the programs, since the current accreditation frameworks may not be suited for this form of delivery and, more importantly, for examination. For engineering programs, the matter of how to deal with laboratories remains a challenge.

The Case of Africa
The situation is even more critical for Africa. According to the United Nations’ “World Population Prospects: The 2015 Revision, Key Findings and Advance Tables,” Africa’s population is projected to double to nearly 2.5 billion by 2050. Without innovation in the delivery of education, it will not be possible to account for this rapidly growing population, whose young people are projected to represent 37% of the entire world’s youths by the same date. According to the United Nations Educational, Scientific, and Cultural Organization Director General Irina Bokova, “In Namibia, Zimbabwe, and Tanzania, there is one qualified engineer for a population of 6,000 people, compared to one engineer per 200 people in China,” and “it is estimated that some 2.5 million new engineers and technicians will be needed in subSaharan Africa alone if we are to achieve the millennium development goals pertaining to access to clean water and sanitation for Africa.”

Under the current models of engineering education in most African countries and in many countries around the world, engineering graduates are equipped with knowledge but lack the necessary skills to adequately perform their jobs as professional engineers. As a result, graduates must undergo a period of postgraduate training of approximately two years. This training is intended to provide them with the knowledge, skills, and attitudes necessary for them to perform their job competently. Unfortunately, this model of engineering education and training is not working very well. Often, private engineering firms are reluctant to hire new graduates, instead opting for experienced engineers to fill positions. With the scarcity of employment opportunities, many graduates are left without a job and no opportunity for structured training. This is wasteful not only because it is very expensive to educate engineers but also because these highly educated engineers often leave the profession altogether. There are no accurate statistics to quantify the problem, but anecdotal evidence suggests this is a serious problem that must be addressed.

Because most engineering curricula do not include modules on entrepreneurship and developing employable skills, the graduates who fail to find work have a slim chance of transitioning to professional status. This matter has not escaped the attention of major stakeholders, including national governments, the African Union, and international development cooperating partners. For example, the African Union, under Agenda 2063’s call to action, has placed an emphasis on science and engineering education. To accomplish Agenda 2063’s call to action, it will be essential to foster close collaboration between engineering faculties and industries.

The Education Partnerships in Africa (EPA) project in Zambia is an example of such a collaboration. The EPA project was initially funded by the British government and aimed at fostering collaborations between institutions of higher education in Zambia and the United Kingdom as well as local and international industries to improve the quality of engineering education in Zambia. The project has been underpinned by a memorandum of understanding between the University of Manchester in the United Kingdom and the University of Zambia. Much has been achieved under this project over the nine years that it has been running. Notably, the electricity companies in Zambia, i.e., ZESCO, CEC and Lunsemfwa Hydro, have contributed to the refurbishment of infrastructure and the procurement of lab equipment for the University of Zambia and Copperbelt University as well as the construction...
In 2016, ABB and the German government provided €1.2 million to the EPA project, to enhance the substation, support pedagogical development, and develop a two-year international internship program for graduates from the two universities. The project will run for three years, up until the end of 2019.

Arising from the experience gained from the EPA project, here are some recommendations that will enhance the quality and relevance of engineering education in Africa:

✔ Engineering faculties must establish links with local and international engineering firms and stakeholders in the education of engineers.

✔ Engineering faculties must establish vibrant industry advisory boards. This is important to ensure timely feedback from industries on the relevance and quality of engineering education. This can also lead to support in funding laboratories and other infrastructure investments as well as projects and student internships.

✔ Engineering curricula must be reviewed and enhanced to include elements of entrepreneurship as well as aspects of engineering training by providing opportunities for skills and attitude development, ensuring that graduates acquire the minimum skills necessary to be employable or self-employed.

✔ Robust quality assurance systems and processes, which must be periodically validated through accreditation of the engineering programs by local, regional, or international accreditation bodies, must be ensured. Due to the rapid population growth, there is inevitably a high demand for education. Because governments are unable to meet the demand for school, college, and university places, the private sector is filling the gap. While this is a welcome development, it is important to provide clear governance structures as well as an efficient regulatory framework to prevent poor-quality education from being provided by private sector entities.

✔ Where the traditional engineering education models persist, it is essential to establish strong links between industries and local universities to ensure that all students have the opportunity to acquire at least two years of practical industry training after graduation. This may require developing incentive programs to attract companies to take on engineering interns.

✔ Professional engineering institutions should be developed and supported. Professional institutions have an important regulatory role to play, including accreditation of engineering degree programs. International professional organizations are important allies that support developing and strengthening local professional institutions. The IEEE, through its Africa committee, is supporting engineering workforce development in Africa and aims to work with local professional institutions to accomplish this goal.

**Conclusions**

The electricity supply industry is undergoing fundamental changes as it transitions from fossil fuel-driven energy supply systems to largely renewable energy-based power systems. The concept of the smart grid is widely used to describe the type of power systems that are emerging. The time is now to undertake a fundamental review and update the electrical engineering curriculum to ensure future engineers will be equipped with the knowledge, skills, and attitudes to plan, design, and operate the smart grids of the future. The role of the Internet will become increasingly important as we endeavor to provide a cost-effective, high-quality engineering education to a larger cohort of students. The issues that will need to be addressed in the online delivery of engineering education are accreditation, credible examination systems, and how to best provide labs. The incorporation of entrepreneurship and a focus on employability skills are now recognized as essential in providing engineering education. Through one of its main strategic goals focusing on engineering workforce development, the IEEE, with its Africa committee, is fully engaged in supporting engineering schools in Africa to improve the quality of engineering education.

**For Further Reading**


