Smart Grid, Industry Trends and Power Engineering Education

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***Abstract*:** This paper discusses smart grid applications as well as the current industry trends and what employers are seeking in power engineers of the 21st century, which will help evolve the smart gird vision of the future. The traditional power engineering curriculum is analyzed, followed by discussion on what the industry is looking for in power engineering education moving forward into the future. Based on industry feedback, key areas of engineering studies have been identified that needs to be incorporated into the existing power engineering curriculum to better align with industry demand. The study presented in this paper concludes that an updated bachelor's in power engineering program that feeds into a master's program specializing in smart grid technology and energy resources, could be a viable way to train the future workforce and help evolve the smart grid.

I. Introduction

The power and energy industry in the 21st century is going through an evolutionary period. New developing technologies are changing the way we generate, transmit and deliver electric power. The electric power industry has many new power grid applications in the forefront. The concept referred to as Power Control Automation, combines and makes use of state of the art technologies from the areas of network communications, power electronics and control systems. Smart grid is the platform that is the primary driver in providing more reliable and cost-efficient electrical power while conserving energy resources in today's new digital era. Moreover, the Smart Grid is a way to address an aging energy infrastructure that needs to be upgraded or replaced. It is also a way to address energy efficiency by increasing consumer awareness about the connection between electricity use and the environment. The concept of Smart Grid is based on the integration of the electric grid, communication network and data acquisition technologies to monitor and control the generation, distribution, storage and consumption of electrical power.

The workforce demand in the electrical power industry is also evolving. In order to be a successful proficient power engineer in the 21st century, one must have multiple skills in cross disciplinary areas. The industry is demanding power engineering education to broaden in a cross function of areas such as networking, control systems, power electronics, data analytics along with information security and business, that will contribute to match the technical engineering ingenuity with the dynamics of the smart grid. The smart grid has many obstacles to overcome, such as, pricing structure, agreement on information protocol, continuing standardization of components, development of low cost smart home appliances and numerous commercial issues.

The academia is witnessing the evolution in the electric power industry and is looking into ways to evolve its curriculum to train productive and qualified power engineers. The academia needs to do further research to understand the industry trends and gather information as to what has changed and what are currently common best practices in the industry. The challenge faced by academia is to come up with an updated curriculum at both the undergraduate and graduate level

that provides the knowledge base of fundamental concepts along with nurturing expertise in cross functional disciplines[1].

Currently in the industry there are quite a few visionary manufacturers who are contributing into smart grid applications; some of the names include GE, Siemens, Schneider Electric, ABB, Motorola, Schweitzer Engineering Laboratories, Cisco, and Powell Electric.. Many of these manufacturers currently have applications in place that will highly support the smart grid vision today but need to mature to a common platform to seamlessly integrate electrical power and network communications as one system. Many manufacturers also have these kinds of integration applications working but only within their own product line and own proprietary software and protocols[2]. There are many national and local government agencies along with private sectors that have begun to develop pilot studies on smart grids applications and have started to model smart grid concepts to learn more of its limitations and conditions before full deployment of the smart grid[3]. The industry has begun to see more standards and best practices mandated to exploit this common vision while keeping public safety a key factor in the design of the Smart Grid.

In view of the above, this paper discusses smart grid applications as well as the current industry trends and what employers are seeking in power engineers of the 21st century, which will help evolve the smart gird vision of the future. The traditional power engineering curriculum is analyzed, followed by discussion on what the industry is looking for in power engineering education moving forward into the future. Based on industry feedback, key areas of engineering studies have been identified that needs to be incorporated into the existing power engineering curriculum to better align with industry demand.

II. The Smart Grid

The Smart Grid is the integration of the electric power grid, communication network, software and hardware to monitor and control the generation, distribution, storage and consumption of energy[4]. The following is a listing of the key components the Smart Grid infrastructure is envisioned to have:

- Advance Metering Infrastructure
- Asset/ System optimization (AO)
- Cyber and Physical security systems.
- Demand Response (DR)
- Distributed Control System (DCS)
- Distribution Automation
- Distribution Generation
- Electric Vehicle
- Energy Management and SCADA
- Energy Storage
- Intelligent Electronic Devices

- Micro grids
- Network Equipment/ Servers
- Transmission enhancement applications (TA)

Utilizing the above listed smart grid components, information gathered from smart devices, known as intelligent electronic devices (IED), will predict near-term demand profile changes leading to the best choice reconfiguration strategy. This creates a solution that mitigates fault and provides electricity free of sags, spikes, disturbances, and interruptions[5].

In addition, the Smart Grid is a way to address an aging energy infrastructure that needs to be upgraded or replaced. It's a way to address energy efficiency to bring increased awareness to consumers about the connection between electricity use and the environment. Also it is a way to bring increased national security to our energy system drawing on greater amounts of home grown electricity that is more resistant to natural disasters and attacks[6].

II.1 Smart Grid Applications in Use Today

New utility electrical meters also known as smart meters, advanced meters, or digital meters seem to have been the stepping stone into the direction of the smart grid. Utility companies have begun to replace all their analog meters with digital advanced meters. Installed in place of old mechanical meters, these meters operate digitally, and allow for automated and complex transfers of information between customer home and the energy provider. For instance, smart meters will deliver signals from the energy provider that can help the consumer cut energy costs. Smart meters also provide utilities with more precise information about how much electricity is being used throughout their service areas. Although smart meter applications are being produced by companies and are in place today but the communication and full functioning potential are still being defined. A lot of manufacturers mentioned earlier are also manufacturing there smart devices or (IED) with smart grid in mind so they are leaving transition points in their designs to easily integrate or commission into future smart grid applications and conversions.

The communication infrastructure currently has many high speed communication networks established that will support the smart grid such as: Zig-Bee, Wi-Fi and WLAN. These networks and other home meshing networks can be the backbone for communication to the smart grid from a public perspective. Communication currently is a constraint since it will require a private communication network to send and receive data onto the smart grid but the foundation platform has been established. Researchers are still working on implementing a high speed reliable private two-way communication network[7].

In addition to the applications listed above, worldwide, there are already over one hundred substations that have been commissioned and are running applications and IED to eliminate or significantly reduce wiring between the relays, the control house and the breakers. The wire reductions are replaced with the communication infrastructure fulfilling the protection and

control applications by exchanging messages over Ethernet (e.g. breaker position and protective trips)[8]. This proves that we will begin to witness more change in the energy and power world leading to digital devices and smart grid.

II.2 *Smart Grid Vision for the Future*

The Smart Grid will consist of massive numbers of parts, controls, computers, power lines, new technologies and equipment. It will take some time for all the technologies to be perfected, equipment installed, and systems tested before it comes fully online. And it won't happen all at once, the smart grid is evolving, piece by piece over the next decade or so. Once mature, the Smart Grid will likely bring the same kind of transformation that the Internet has already brought to the way we live, work, play, and learn[9].

Overall, the Smart Grid will open the door to many new possibilities for utility companies and their customers to reach agreements on ways to save energy. The financial incentives available could encourage a wide range of new consumer options. Consumers may be willing to pay a bit extra for a smart appliance, for instance, if it can also become a new source of revenue for them. Utility incentives could also encourage people to install a home generation system, such as a small wind turbine or solar power system. The result is a win-win-win: a win for the consumer, for the power provider, and for the community[10].

III. Power Engineering Education and the Industry

Power Engineering tends to be an important topic in the 21st century. With the energy and power industry in an evolving state we are learning that there is a shortage of qualified power engineers especially with the high number of baby boomers reaching the retiring age. The power engineering workforce is becoming undersized in comparison to the growing demand and the legacy of the existing power systems experience needs to be conserved in order to successfully transition into the new era of power technology[11]. The academia is seeking ways to improve its power engineering curriculum and bring awareness in the power and energy industry to produce more graduates. The following section presents the traditional power engineering curriculum and discusses what the industry is looking for in power engineering education moving forward into the future.

III.1 Traditional Power Engineering Education

Power engineering core curriculum in the past has been composed of the fundamental core classes as illustrated in Fig.1. While the technology in power and energy is evolving, it's time to look at the industry for trends and to adapt the power engineering curriculum to meet the demand of the industry. By making power engineering education more relevant to future industry needs, a new graduate will be more skilled, will be quickly able to adapt to the future work environment, contribute towards the goals of the potential employer.

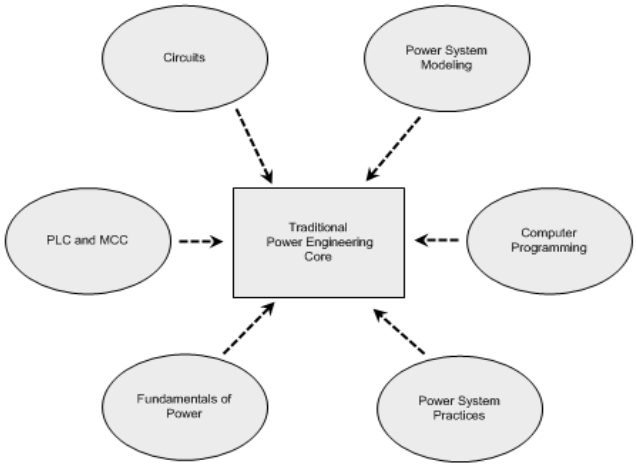

Fig. 1 Traditional Power Engineering Core Studies

However, teaching the fundamentals of power systems including the theoretical concepts is necessary as is done in traditional curriculums. The academia will need to modify/update courses to include new topics. This will take some research and evaluation since the curriculum already is at a stretch and there is not much room to add courses without increasing the required credit hours for an undergraduate degree. A specialized Masters program or graduate certification courses are viable options that can cover smart grid theories and high level concepts[12].

III.2 Demand of Power Engineering Education with Updated Curriculum

In order to be a successful proficient power engineer in the 21st century, an engineer must have multiple skills and be able to multi task and produce good quality products. With today's technology there is a rise in many cross functional engineering discipline needs. A power engineer of the future must be a well-rounded engineer who understands broader fundamentals of cross engineering disciplines and is also has the proficiency to manage projects, write reports and have good communication skills. The industry is seeking power engineering education to broaden in a cross function of engineering studies such as networking, control systems and power electronics in order to transition to the smart grid[13].

III.3 What Industry and Workforce is seeking in Power Engineering Education.

With the innovation of technology and new power components, the industry is seeking significantly more cross function of knowledge in power engineering. Fig.2 illustrates some areas of studies that will broaden the education of power engineering. These courses will allow them to learn of the new trends and technology many manufacturers and facilities are applying in smart grid and new power concepts from generation, transmission and distribution system designs.

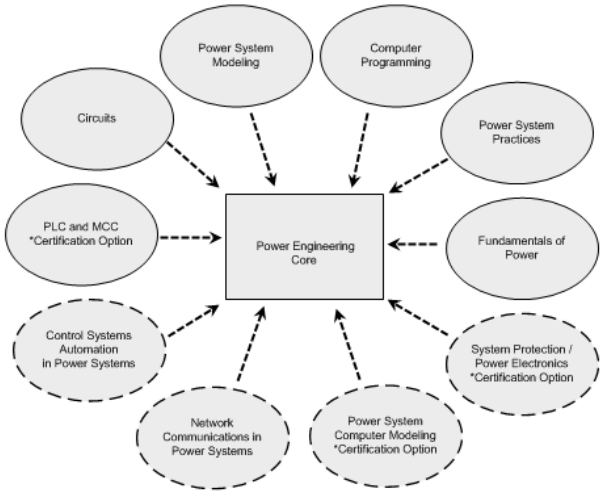

Fig. 2 Updated Power Engineering Core Studies

The academia should do further research and seek formal alumni's to help understand the industry trends and gather information as to what has changed and what are currently common best practices in the industry in power engineering and applications towards smart grid. The power engineering academia should also reach out to manufacturers and look at getting students certified in some of the industry's common software and hardware applications, along with teaching new advanced theoretical power concepts currently in place. As technology changes this will also become a challenge to the academia but proper communications and faculty research with the industry could allow updates to these power engineering studies.

Currently the power industry is looking for expertise in the following specialties and subtopics in its future and current employees:

Control System Automation in Power Systems

- Distributed Control System/Safety Instrumented System
- Sensors and Measurement Instrumentation
- Programmable Logic Controllers
- Multi objective optimization

Network Communications in Power Systems

- Data Acquisition
- Modbus, DNP3,SNMP, WAN, ZigBee , WiFi,LAN
- Programming language java, C+, Visual Basics
- Mobile and Ad Hoc Networking
- Information security management, Cyber security
- Hybrid communication systems for smart grids

Power System Computer Modeling

- ETap Power System sizing

- Lab view modeling and system analysis
- Matlab embedded system design analysis

System Protection /Power Electronics

- Relay, generation and transmission line protection
- Intelligent Recovery and Restoration components
- Supervisory Control and Data Acquisition
- Advanced power electronics systems (FACTS & HVDC)

Business practices in clean energy smart grid environment

- Energy regulations market and environment

Some of the Universities currently developing courses on smart grid at the undergraduate and graduate level for various majors like Electrical engineering, computer science, mechanical engineering and information and security systems are Washington State University, Wichita State University, Purdue University, UC Berkeley, University of Clemson, Illinois Institute of Technology, Texas Tech University, University of Colorado and University of Pittsburgh. West Virginia State University's Law college has initiated an energy curriculum on smart grid. University of Houston, along with offering undergraduate and graduate courses on smart grid is also providing certification courses for the professional engineers already in the field.

The industry has a need for power engineers in the generation business and in all of the business units within the smart grid divisions as well. The industry is seeking for individuals who could work as consultants in their business, work with customers in conducting systems to help the development of best solutions for their business needs. Energy Automation also seeks power engineers to have a focus on software development for management of the power grid, involving programming that can look for different theories and take a consultant approach as opposed to project management approach. The industry also seeks individuals with a Master's degree that have a stronger theoretical knowledge for supervisory and managerial positions in smart grid applications. After a successful completion of a course in Wichita State University in Kansas in the spring of 2012, the instructors felt that the biggest challenge in interdisciplinary classes such as those on smart grids will be achieving depth while satisfying the requirements of the breadth. By the end of the course that was offered, it was apparent that students had not really gone into much depth on any aspect of the material and most of the class time was spent bridging deficiencies in the students background knowledge[14]. Hence, the academia could consider developing a bachelors program that feeds into a master's in power engineering specializing in smart grid technology and energy resources. As mentioned earlier, the power fundamentals and theoretical concepts have to be covered at the bachelor's level, which leaves little room for advanced topics in the already dense courses shown in Fig. 1. A master's program could possibly have further impact by facilitating extensive research within the degree program, which can be sponsored by the industry.

IV. Conclusion

The smart grid is facing many challenges and offers great opportunities in the field of power engineering. This paper provides a glance into the industry trends and technologies that the smart

grid is envisioned to have, as well as what the industry is seeking in power engineering education to support the continuing innovation of the smart grid. The smart grid has many obstacles to overcome, such as, pricing structure, agreement on information protocol, continuing standardization of components, development of low cost smart home appliances and commercial issues such as buying and selling electrical power. The Engineering groups and designers will need to be well informed and educated in a cross function of traditional and new engineering studies to continue to evolve the smart grid and its current applications. The academia will also need to be involved and work towards an updated curriculum in which a bachelor's in power engineering could possibly have a continuing master's program specializing in smart grid technology and energy resources, that will help train the future workforce and help evolve the smart grid.

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VI. Bibilography

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