Workforce Development
Meeting the Educational Challenge of the Smart Sustainable Grid

Chanan Singh

Texas A&M University

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The Backdrop

- A smart grid with heavy penetration of variable energy sources, integrated microgrids, central and distributed energy storage and distributed communication and computational technologies allowing smarter utilization of resources and consumer participation.

- Greater emphasis on reliability, resilience to physical and cyber-attacks, as well as emergence of new loads and generation operating conditions make monitoring, control and protection of electricity grid challenging.

- These factors, together with emphasis on markets, result in a higher uncertainty in the planning and operation of future energy systems.

Workforce for this Grid?

- Workforce needs will happen at various levels : skilled workers, engineers, managers.

- Our concern is with the engineering workforce needed to:

  - design, construct and operate the future grid.
  - to produce innovative ideas and transformative changes to integrate clean and sustainable energy sources.

- *Relevant education of this workforce is critical to the success of the future grid*.

Channels to Education

- All research activities as a part of this initiative as well as others in this area will contribute, to some extent, to the development of the workforce through participation of graduate students in the research projects.

- Education through this channel is deep but relatively speaking more narrowly focused.

- The scope of this thrust is education of a much wider audience as well as giving a more comprehensive view to those engaged in research on particular topics.

State of Art

- The most common source of engineering workforce is the BSEE degree programs where the students take 3 to 4 courses in power systems or a combination of power systems and power electronics.

- The next level is the MSEE: the students can take more courses in their area of interest and have more depth.

- The highest level is the PhD: the students get more knowledge as well as develop evaluation abilities.

- Evaluation level (Bloom's Taxonomy) is the highest level of understanding which allows the individual to argue and debate alternatives and to evaluate arguments.

- Successful orchestration of the smart grid needs workforce at all the three levels in different proportions.

What is Needed?
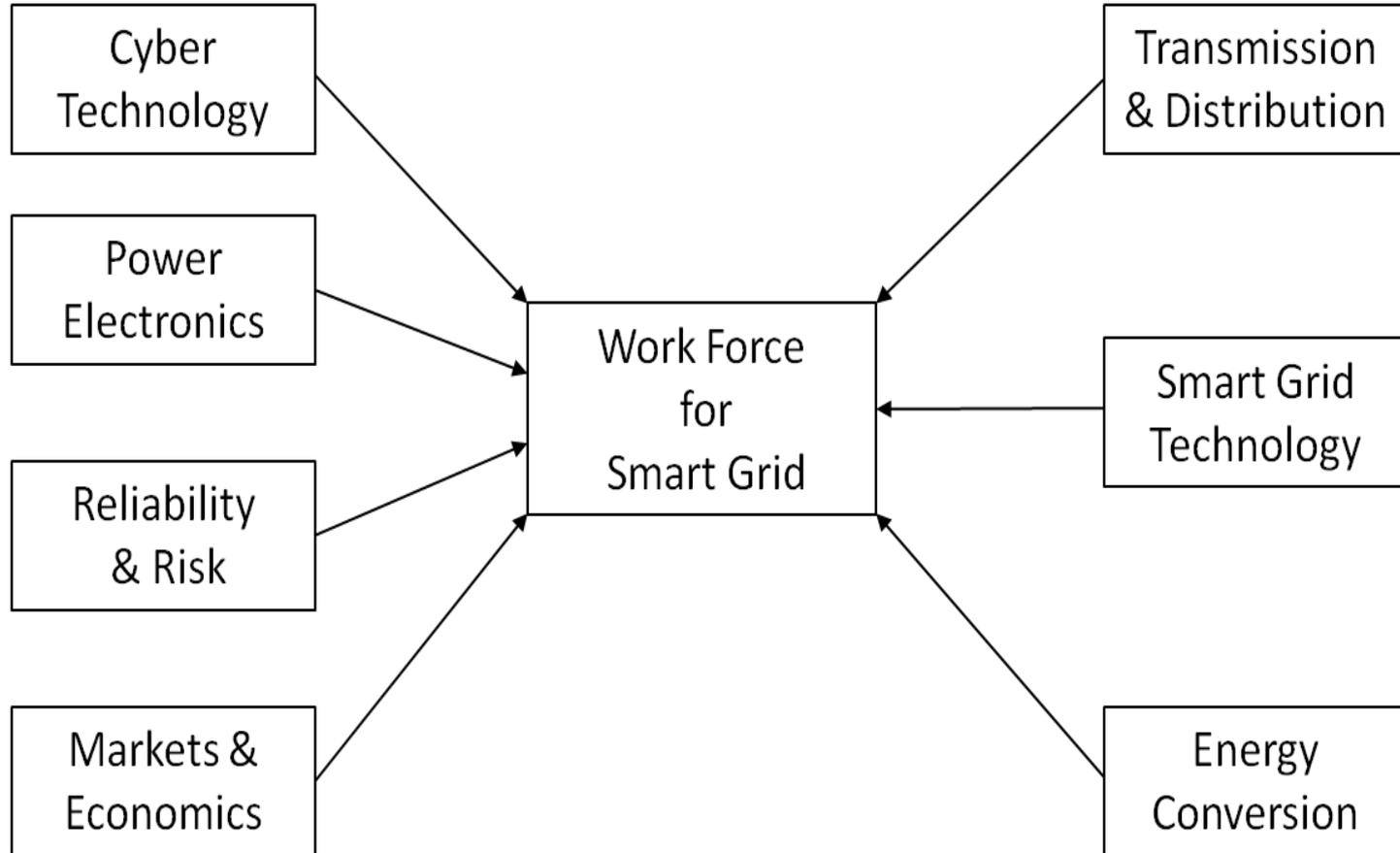
Challenges to this Vision

- U.S. universities tend to give a broad based education to the students at the BSEE level.

- This is expected to open more opportunities and lifelong learning capabilities to the graduates.

- At the BSEE level, the power curriculums need to compete with other specializations and general education requirements for their share of credit hours.

- Power related courses therefore need to design their education within these constraints.

Challenges

- In the environment of restricted hours available, the struggle between the depth and breadth of coverage is always a problem.

- In addition in most schools the pace and rigor of the course is typically geared towards the average student.

- Most of the power system related programs are small and have access to only a narrow set of specialties.

- Even in the larger programs, the expertise of faculty is determined by the research they engage in. Therefore expertise for all the needed technologies may not be available.

Challenges

- Evolution of the future grid is fast-paced and the key technologies are in constant flux. Therefore, the curriculum and training to develop the workforce also needs to be fast-paced, flexible and able to quickly adapt to rapid technological developments, while simultaneously ensuring solid foundation in the fundamentals.

- The interdisciplinary expertise required for smart grid technologies, including measurements, communication, computing, and control, make the required education and training more challenging.

- In addition the students need to be able to work in interdisciplinary teams.

Opportunities

- Collectively, the universities in the PSERC provide a broad spectrum of expertise. This allows a rare opportunity to tap this resource for text books and course material to meet the interdisciplinary needs of education.

- Advances in e-learning technologies, and ubiquitous access to high speed internet provide a tremendous opportunity to address the above challenges.

What Can We Do?

- We can act as an enabling agent.
- Our objective is to develop a collection of educational material, books as well as notes, on relevant topics and on background topics required to understand these concepts, and make them available to those interested.
- This will make it possible to teach a variety of subjects as the availability of such material facilitates offering such courses.
- Through this process of collective and collaborative wisdom, cutting-edge research and insightfulness can be made accessible to practicing engineers, researchers and students.

What are We Doing?

- The issues of breadth and depth need to be balanced.

- Also we need to consider the current gaps in the education of the existing workforce.

- The nature of audience, whether these are school going graduates, working engineers or other energy professionals also needs to be considered.

- We need to utilize the e-learning technologies to provide an as up-to-date education as possible.

- After careful thinking, six specific tasks have been undertaken for this thrust. Some educational materials will be focused on providing the breadth and the others on depth in needed areas.

What are We Doing?

- Tasks focused on covering the breadth of the topics needed:
  - PSERC Academy: A Virtual Library of Thousand Short Videos
  - Smart Grid Education (on Synchrophasors)
    for Students and Professionals
  - Energy Processing for Smart Grid Technology
- Tasks focused on depth:
  - Educational Tools for Reliability Modeling and Evaluation of the Emerging Smart Grid
  - Course in Energy Economics and Policy Critical
  - Infrastructure Security: The Emerging Smart Grid

PSERC Academy

- Not focused on any particular topic but rather provides a mechanism for disseminating rapid advances in an efficient manner.

- The vision is to develop, over a period of 3-5 years, hundreds or even thousands of online videos ranging from introductory material to advanced topics.

- Delivered using a range of methods from simple lectures and derivations of equations to sophisticated multi-media delivery.

- Meant to evolve over time, based on user and expert feedback, changing needs and learning technologies.

Smart Grid Education about Synchrophasors

- Industry-wide projects are creating a need to educate emerging engineers about synchrophasor fundamentals.

- An excellent book already published on the subject but we recognize a need for more elaborate instructional material.

- A group of authors has engaged in development of instructional materials to:

  - Develop comprehensive educational package that will reach out to educators, students, practicing engineers, managers, legislators, and public officials;

  - Write a text book and prepare a set of presentations that may be used for instruction.

Energy Processing for Smart Grid

- Fundamentals of electric machines and transformers , modeling of renewable energy such as wind and solar resources while accounting for variability.

- Ability to model and analyze power electronics building blocks of inverters or converters.

- Ability to understand real time measurements using phasor measurement units (PMU), smart meters and consequently use the measurements to perform real time stability, power flow and optimal power flow of the grid under different contingencies.

Reliability Modeling and Evaluation of the Emerging Smart Grid

- Educational material developed through this task will provide the target audience with the state of the art tools for modeling and analysis of reliability of this complex cyber-physical system.

- This material will be useful for those who need to use these tools as well as those who want to do further research.

- They will be able to use this knowledge to make tradeoffs between reliability, cost, environmental issues and other factors as needed.

Energy Economics and Policy

- The goal is to provide a deep understanding into the economic and technological drivers that led to the regulatory policies and market institutions that have dominated the electricity industry over the last century.

- From such a base, one can explore how advances in both technology and economic policy have made possible new market designs and helped to spur increased wholesale trade.

- A complete view of the potential role of the future grid within the energy sector must also consider the economic characteristics that permeate the energy industries.

Critical Infrastructure Security

- Design and development of a new smart grid course focused on cyber-security.

- Key areas of research focus include designing an interdisciplinary course; locating and creating course materials; teaching in efficient manner and disseminating course material to be adopted by other educational institutes.

- Has four components: smart grid operation and control; communication; data management and computing; and basics of cyber-security.

Concluding Remarks

- Education is an enabling and empowering force.

- It provides knowledge, understanding, and insightfulness to understand problems and situations and make decisions.

- It also empowers the workforce to make further innovations to serve the power systems industry.

- Education can serve the workforce involved in the management and operation of existing technology as well as spur the progress to higher levels of accomplishment in the smart grid, through providing insightful and holistic viewpoints.

Concluding Remarks

- The work done throughout this thrust will thus have a transformative and disruptive influence on the orchestration of the smart grid.

- Work is going on six topics to yield quality educational material.

- With time more topics may need to be addressed and the current ones updated. So resources need to be found to continue this effort.