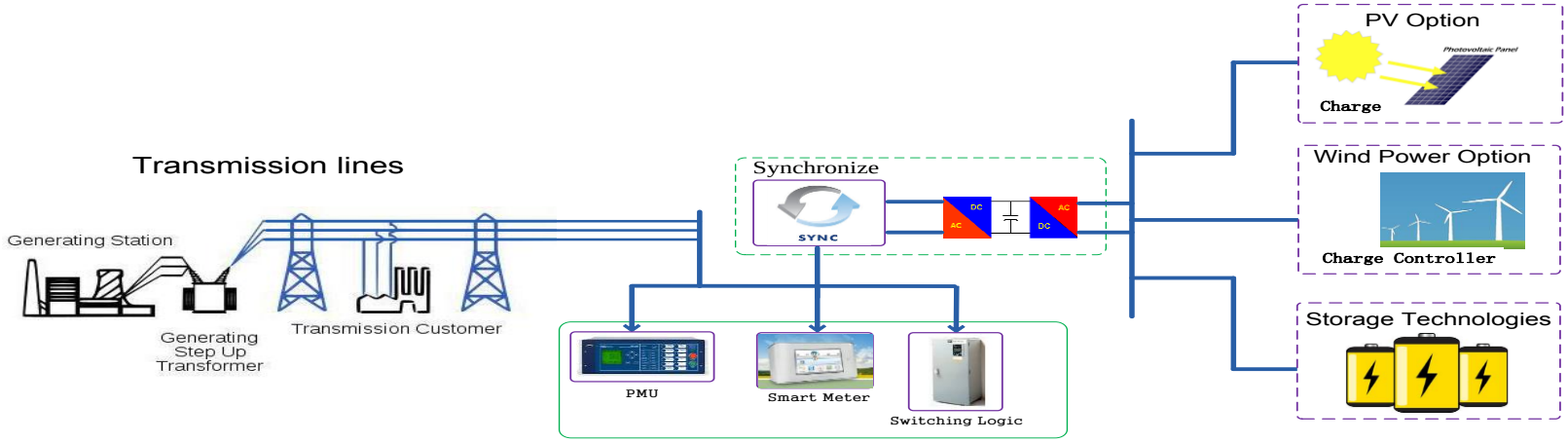
Energy Processing for Smart Grid (4.4)



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- Ph.D., Electrical Engineering, Howard University 1983
- M.S.S.E., Systems Engineering, University of Pennsylvania, 1980
- M.S.E.E., Electrical Engineering, Carnegie Mellon University, 1976
- Professor and Director of the Center for Energy Systems and Control (CESaC)
- Former Director of ECE Department at NSF
- Author of several papers and books including "*Smart Grid: Fundamentals of Design and Analysis*", and a best-seller, "*Electrical Power System Applications of Optimization 2nd Ed."*
- Fellow of IEEE

Education Need and Target Audience

- Objective: Develop a University course on energy processing for the smart grid.
- Need: The overall need is to re-energize the interest in power system engineering. Educational material is needed for teaching renewable energy, storage facility, energy processing, measurement techniques, and smart grid technologies/systems.
- Audience: This university course is for undergraduates and first year graduate students in the field of power engineering.
- Status: The course is currently being taught with the new materials.

Learning Objectives

To develop competency in problem solving, design, analysis of technical challenges in the development of technologies for deployment of energy processing and smart grid network. The course covers the following topics:

1. Fundamentals of Energy Conversion Principles
2. Tracking and Evaluation of the Renewable Energy Resources
3. Storage Techniques/ Options
4. Fundamentals of Smart Grid
5. Energy System Controls
6. Real Time Measurement for Smart Grid
7. Communication, Protocol, Standards, Security, and Protection of Smart Grid Devices

Description of Energy Processing for Smart Grid Course

1. Fundamentals of Energy Conversion Principles

Content
- Three Phase Power
- Load Types
- Magnetic circuits
- Transformers
- Classical Machines
- AC/DC Machines
- Converters & Inverters
- (Modeling and Characteristics)

Student Assessment
- Students will be assigned homework and tested on their knowledge based on the content of the module. Students will also do research paper on emerging trend related to the module's contents.

Module Duration
- 2 weeks

Reference
- Text books
- Published papers

2. Evaluation of Renewable Energy Resources

Content
- Renewable energy resources including solar, wind, hydro, biomass, etc
- Modeling, and
- Characteristics Evaluations in terms of: efficiency, reliability, cost, interconnectivity, etc

Student Assessment
- Students will be assigned homework and tested on their knowledge based on the content of the module. Students will also do research paper on emerging trend related to the module's contents.

Module Duration
- 3-6 weeks

Reference
- Text books
- Published papers

Description of Energy Processing for Smart Grid Course Cont.

3. Storage Techniques/ Options

Content

- Study of various storage techniques including batteries, pump hydro, flywheel, etc.
- Study includes areas such as
- Energy storage characteristics
- Efficiency
- Cost
- Reliability, and
- Environmental impact

Student Assessment

- Students will be assigned homework and tested on their knowledge based on the content of the module. Students will also do research paper on emerging trends related to the module's contents.

Module Duration

- 2 weeks

Reference

- Text books
- Research papers
- Published papers

4. Fundamentals of Smart Grid

Content

- Overview of Smart Grid concepts, fundamentals, and design
- Types of devices
- Advancements in electricity grid
- Measurement tools
- Matrix of performance
- Security Issues
- Communication requirements

Student Assessment

- Students will be assigned homework and tested on their knowledge based on the content of the module. Students will also perform experiments and do research papers on emerging trend related to the module's contents.

Module Duration

- 3 weeks

Reference

- Text books
- Published papers

Description of Energy Processing for Smart Grid Course Cont.

5. Energy System Controls

Content

- Local & Wide area control
- Smart Grid performance Matrix
- (Voltage & frequency load control)
- Real time control
- (Phase Measurement Unit-PMU)
- State Estimations
- Devices

Student Assessment

- Students will be assigned homework and tested on their knowledge based on the content of the module. Students will also do research paper on emerging trends related to the module's contents.

Module Duration

- 3-6 weeks

Reference

- Text books
- Published papers
- Advanced Books in Power Systems, Stability, and Control

6. Real Time Measurement for Smart Grid

Content

- Concepts and Applications of Phasor Measurement Unit, Smart Meters, Instrumentals, Protection devices, and Intelligent Electronic Devices-IEDs.

- **Communications**
- Remote Terminal Unit-RTU, SCADA, Energy Management Systems-EMS, Distribution Management System-DMS

- **Advancements**
- Modern Substations, Distribution Automation

Student Assessment

- Students will be assigned homework and tested on their knowledge based on the content of the module. Students will also do research paper on emerging trends related to the module's contents.

Module Duration

- 3-6 weeks

Description of Energy Processing for Smart Grid Course Cont.

7. Communication, Protocol, Standards, Security, and Protection of Smart Grid Devices

Content

- Data Encryption and Decryption
- Protection
- Computation Analysis
- Communication controls
- Security Options

Student Participation

- Students will be assigned homework and tested on their knowledge based on the content of the module. Students will also perform experiments and do research papers on emerging trend related to the module's contents.

Module Duration

- 3-6 weeks

Reference

- Text books, research papers, and published papers

Featured Textbooks

1) Title: **Electric Power Distribution, Automation, Protection And Control**
Author: James A. Momoh
Year Published: 2008

2) Title: **Smart Grid-Fundamentals of Design and Analysis**
Author: James A. Momoh
Year Published: 2012

Fundamentals of Energy Systems Course

- There was a need at Howard Univ. to redesign an introductory course for juniors.
- This course was developed from a subset of the materials from the proposed Energy Processing for Smart Grid course.
- The course has been approved by Howard and juniors are taking it this semester.
- The following slides describe the course.

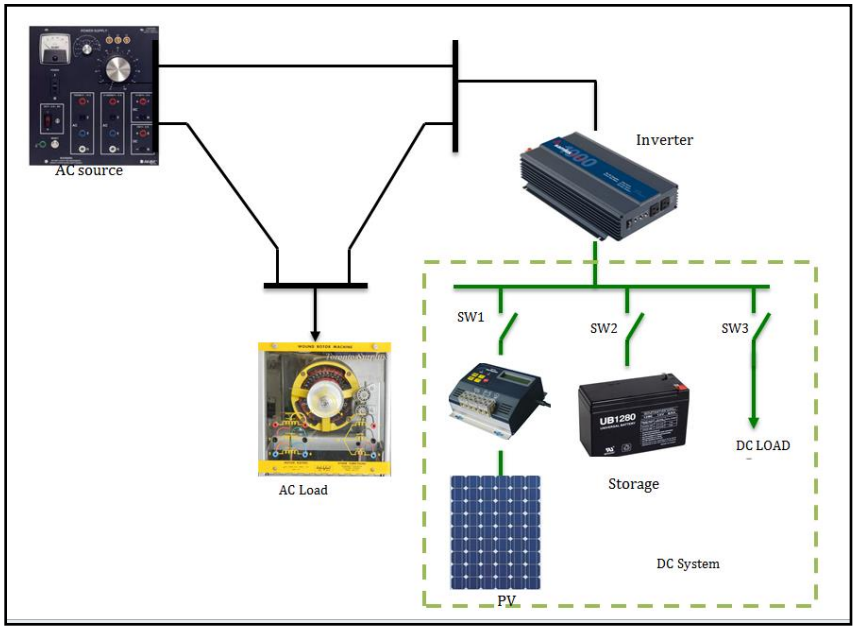
Description of Fundamentals of Energy Systems Course

- Introduction to Power Systems, Single phase and three phase circuit analysis
- Understand magnetic circuit analysis, magnetic properties of materials, transformer theory and applications.
- Review basic primary energy sources and applications to central power generation
- Understand the fundamentals and applications of solar and wind energy technologies I
- Introduction to Power Electronics Converters (Inverters and Converters]
- Understand the principles of operation and design of three phase AC machines
- Understand the principles of operation and design of induction and DC Machines.
- Review of Smart Grid Fundamentals
- Understand the fundamentals of Transmission model and power flow analysis
- Understand the use of PSpice and MATLAB in energy conversion performance analysis and power flow packages

Description of Fundamentals of Energy Systems Course

Laboratory

- Measurement Techniques tools such as watt meters, and Smart Meters Lab for power networks
- Introduction to the power simulation tools such as PSpice, MATLAB and other power flow tools.
- Experiment on different renewable energy resources and different load types
- Machine dynamics and control for AC, DC and induction machines and transformers
- Introduction to power electronics converters
- Smart grid design experiment



Experimental Layout for Micro Grid

Student Feedback to Date

- Students now appreciate current trends in the provision of energy, especially as related to the integration of renewable energy and storage facilities into the power network.

- Students have also come to appreciate the interdisciplinary component of the development of the future energy system.

- Finally, students appreciate more the knowledge gained from previous classes that they have taken because they are able to see the direct application of that knowledge to power network development.

Future Plans

During the coming summer we plan to do the following:

- Provide integrated problem solving and laboratory exercise covering the topics discussed in different modules,
- We plan assemble the lecture materials as a text book and make it available online,
- We plan to use the material developed to initiates projects in our pre-college for engineering systems program, senior projects, and graduate research.
- We plan develop IEEE papers for wider dissemination, and
- We intend to develop new research and education topics in areas of application of smart grid for customer appliances.

Accessing the Materials

Lecture notes will be collated into a book that will be published and available for purchase from bookstores.

An online e-book version will also be available when the course materials are fully developed and posted on the Center for Energy System and Control website: http://cesac.howard.edu/.

Further detail of the course can be requested from the author via email.

Current references in support of the course are spooled from:

•Textbooks

1)Title: **Electric Power Distribution, Automation, Protection And Control**
Author: **James A. Momoh**
Year Published: **2008**

2)Title: **Smart Grid-Fundamentals of Design and Analysis**
Author: **James A. Momoh**
Year Published: 2012

•Published papers

The completed course material syllabus will be available to other schools via the internet.