Smart Grid Architecture ESE-909

Background

1. Give brief rundown of the existing program.

- Today's electric grid is a one-way flow of electricity with following characteristic:
  - Centralized, bulk generation, mainly coal and natural gas
  - Has controllable generation and predictable loads
  - Limited automation and situational awareness
  - Lots of customized proprietary systems
  - Lack of customer-side data to manage and reduce energy uses
- What is needed today is to have a “more efficient or advanced grid” in terms of the usage of advanced communication technology, information technology (IT) other advanced technologies with improved efficiencies. Because of all these attributes, the smart grids can be termed as “intelligent grid” or the grid with the brain.
- Smart grids enable bidirectional flows of energy and uses two-way communication and control capabilities that will lead to an array of new functionalities and applications. The smart grid will permit the two-way flow of both electricity and information.
- The move towards the smart grid is fueled by a number of needs. For example, there is the need for improved grid reliability while dealing with an aging infrastructure, and there is the need for environmental compliance and energy conservation. Also, there is the need for improved operational efficiencies and customer service.
- The course on smart grids will provide students knowledge about the architectural design of smart grids. Measurement and communication technologies for smart grids would be discussed in detail. Performance and stability analysis of smart grids and computational tools required for smart grid design would be the core content of this course.

Rationale

2. Rationale for offering/launching the new course.

- The course will give a solid foundation for the national and international development towards the futures renewable electric energy system, and different concepts known under the name Smart Grid, from the perspective of electric power engineering.
- The starting point is the understanding of how design, operation and control of power systems traditionally have been considered, and the course takes a multi-disciplinary approach where power systems and electric power conversion merge together.
- In addition, the course seeks to give perspectives on the Smart Grid trends that motivate it, and a discussion of changes that are already taking place, such as the deployment of smart meters and consequences thereof, as well as the view of the electrical engineering industry on the Smart Grid.

Educational Objectives

3. Objectives of the program under which the proposed course will be conducted

The objectives of this Smart Grids: Philosophy, Design and Analysis course are:

(1) To identify the architectural design of smart grids.

(2) To discuss the need of implementing Smart Grids in Pakistan.

(3) To discuss smart metering infrastructure and demand side management concepts for overcoming energy crisis.

(4) To discuss the issues of renewable integration in smart grids

(5) To identify the role of distribution companies in increasing the energy efficiency.

(6) To discuss the energy storage systems for smart grids.

(7) To discuss the concepts and topology of microgrids

International Practice

4. Specify the universities of repute where the proposed course is being conducted.

i. Oregon State University, USA

ii. Arizona State University, USA

iii. Norwegian University of Science and Technology, NTNU, Norway

Proposed Timeframe of Commencement

5. Specifying semester with year. Summer 2015

Course Contents

6. Give details of the course, on the following lines:

a. Course Code ESE- 909

b. Title Smart Grids: Philosophy, Design and Analysis

c. Credit Hours 3

d. Objective

The outcomes of this Smart Grids: Philosophy, Design and Analysis course are:

(8) To discuss the need of smart grids from Pakistan's Perspective.

(9) To identify the need of installing smart metering infrastructure in Pakistan.

(10) To recognize the benefits of distribution automation in DISCO'S.

(11) To discuss the impact of Distributed Generation on Smart Grids.

(12) To discuss advance SCADA Concepts

(13) To study the topology of Microgrids

(14) To discuss SMART Grids with Energy Management Systems

e. Outcomes

After completing the course, the student shall

- Understand the background for Smart Grid, and the differences between the future Smart Grid and todays power system, as well as have knowledge about important terminology.
- Have knowledge about challenges faced by the Pakistani energy sector in the years ahead, such as challenges regarding the deployment of smart meters.
- Know the electric power engineering basis for Smart Grid.

- Have knowledge about technology for micro grids and the integration of renewable energy such as wind power, solar power, including the characteristics of these sources, in the power system, and technology related to charging of electric vehicles.

f. Contents with suggested contact hours

No.	Topics	Text Book	Contact Hours
1.	**Smart Grid Architectural Design** • Todays grid VS The Smart Grid • Smart Grid Global Initiatives • Power System Enhancement Function of Smart Grid Components • Concept of Micro grid and its Topology	A	6
2.	**Smart Grid Measurement and Communication Technology** • Wide Area Monitoring Systems • Phasor Measurement Units • Advance Metering Infrastructure • Smart Meters and Appliances • GIS and Google Mapping Tools	A	4
3.	**Performance Analysis Tools for Smart Grid Design** • Introduction to Load Flow Studies • Challenges to Load flow in Smart Grid • Weakness of the present load flow methods • Congestion management effect • Load flow for smart grid design • Contingencies and their Classification	A	8
4.	**Stability Analysis Tools for Smart Grids Design** • Introduction to Stability • Voltage Stability Assessment • Voltage Stability Assessment Techniques • Voltage Stability Indexing • Angle Stability Assessment	B	4

	• State Estimation		
5.	**Computational Tools for Smart Grid Design** • Introduction to Computation Tools • Optimization Techniques for Smart Grids • Classical Optimization Methods • Heursistic Optimization Methods • 5. Computational Challenges	A	8
6.	**Pathway for Designing Smart Grid** 1. Barriers and Solution to Smart Grid Development 2. General Level Automation 3. Bulk Power system automation of the smart grid at transmission level 4. Distribution System Automation for Smart Grids	C	8
7.	**Renewable Energy and Storage** • Renewable Energy Resources • Sustainable Energy option for Smart Grids • Penetration and Variability issues for sustainable energy technology • Demand Response Issues • Electric Vehicle and Plug ins Hybrids • Environmental Implications • Storage Technologies • Tax Credits		4
8.	**Case Studies and Test Beds for the SMART Grids** • Demonstration Projects • Microgrid with Renewable Energy • Testbeds and Benchmark Systems • Challenges and Benefits of Smart Transmission System	B	3
	Total		45

g. Recommended Reading (including Textbooks and Reference books).

S. No.	Title	Author(s)	Assigned Code	Remarks

1	**Smart Grid: Fundamentals of Design and Analysis**	James Momoh	A	Text
2	**Smart Grids: Infrastructure, Technology and Solutions**	Borlase	B	Reference
3	**Electric Power Distribution Engineering(Third Edition)**	Turan Gonen	C	Reference