Course title: Smart Grid			
Course code: ENR 191	**No. of credits:** 2	**L-T-P:** 28-0-0	**Learning hours:** 28
Pre-requisite course code and title (if any): NA			
Department: Department of Energy and Environment			
Course coordinator: Dr Naqui Anwer	**Course instructor:** Dr Naqui Anwer		
Contact details: naqui.anwer@terisas.ac.in			
Course type: Elective	**Course offered in:** Semester 3		

Course description

The behaviour of existing electrical grid changes very fast and requires dynamic platforms to address the peculiarities related to increased penetration from renewable energy sources, possible inclusion of electric vehicles, ensuring energy security, open access and deregulation. The grid should be resilient enough to behave smartly. The time has come for the existing electric grid to become a smart grid by incorporating dynamic platforms of communication technologies superimposing over the existing electricity infrastructure. The course provides a platform for deep understanding of smart features of an electric grid.

Course objectives

This course provides knowledge about

- Smart electric power grids, including definition, design criteria, technology and IoT.
- Information processing and communications to the power grid.
- Understanding the development of the smart grid,
- Smart grid design, implementation, evaluation and management of smart electricity infrastructure.

Course contents

Module	Topic	L	T	P
1	**Introduction** Indian smart grid policy. Basic concept and definition of smart grid. Smart grid architecture. Smart grid technologies. Properties of smart grid: flexibility, reliability, demand response and other performance parameters. DC smart micro grids.	4	0	0
2	**Communication technologies** Generic model of communication network needed for Smart-grid, two way and real-time communication in power network, Introduction to different communication technologies available in the market (Latest standards. Emphasis on importance of inoperability and standardization of communication protocols), Matrix of different technologies against the smart-grid communication needs in a given utility environment, AMI, AMR & MDA: How it works and how it will help to; reduce peaks manage networks more efficiently and contribute towards smarter grids, Communication Standards IEC6150, Wide Area Situation awareness (WASA), Network stability	8	0	0

3	**Smart meters** Introduction, technology, data management, energy monitoring, smart energy meter, Phasor Measurement Unit (PMU), smart metering infrastructure, data acquisition	4	0	0
4	**Flexible AC transmission system (FACTS)** Congestion management and loadability enhancement, reactive power compensation, concept of series compensation, shunt compensation, FACTS: working principle, classification, series controllers, shunt controllers, series-series controllers, series-parallel controllers.	6	0	0
5	**IoT for power systems** Internet of things for electricity infrastructure and energy management. SCADA, Demand response, AMI, IoT aided smart grid, Big data for power system and introduction to data analytics.	4	0	0
6	**Application of smart grid** Challenges being faced during implementation of smart grid. virtual power plants, Smart Utilities (case studies), Smart Grid Maturity Model (SGMM).	2	0	0
	Total	**28**	**0**	**0**

Evaluation criteria

Test 1: Assignments (after completion of module 1) - 10%
Test 2: Written test (after completion of modules 2 and 3) - 20%
Test 3: Written test (after completion of modules 3 and 4) - 20%
Test 4: Written test (after completion of modules 5 and 6) - 50%

Learning outcomes:

On successful completion of this course, students should be able to:

- Apply advanced knowledge of electrical power system operations and control to analyse the challenges and opportunities due to increased penetration of renewable energy sources. (Test 2 and 3)
- understand and conceptualize the design of smart grid by selecting appropriate communication technologies, implementing smart meter and FACTS. (Test 1, 2 and 3)
- Describe the principles and requirements of the next generation future power network (or smart grid), using the latest trends in IoT for power systems. (Test 4)

Pedagogical approach:

A combination of class-room interactions, group discussion and presentations, tutorials, practical and assignments

Materials

Reference books

James Momoh, “Smart Grid: Fundamentals of design and analysis”, John Wiley & sons Inc, IEEE press 2012.
Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, “Smart

Grid: Technology and Applications", John Wiley & sons inc, 2015.
Fereidoon P. Sioshansi, "Smart Grid: Integrating Renewable, Distributed & Efficient Energy", Academic Press, 2012.
Clark W.Gellings, "The smart grid: Enabling energy efficiency and demand response", Fairmont Press Inc, 2009.

Suggested readings:

M.S.Hossain, N.A.Madlool, N.A.Rahim, J.Selvaraj, A.K.Pandey, Abdul FaheemKhan, "Role of smart grid in renewable energy: An overview", Elsevier Journal of Renewable and Sustainable Energy Reviews, Volume 60, July 2016, pp. 1168-1184.
P. Siano, "Demand response and smart grids—a survey", Elsevier Journal of Renewable and Sustainable Energy Reviews, Volume 30, 2014, pp. 461-478.
Xi Fang, Satyajayant Misra, Guoliang Xue, Dejun Yang, "Smart Grid — The New and Improved Power Grid: A Survey", IEEE Communications Surveys & Tutorials, Volume: 14, Issue: 4, Fourth Quarter 2012
Murat Kuzlu, Manisa Pipattanasomporn, Saifur Rahman, "Communication network requirements for major smart grid applications in HAN, NAN and WAN", Elsevier Journal of Computer Networks, Volume 67, 4 July 2014, pp. 74-88
Yasir Saleem, Noel Crespi, Mubashir Husain Rehmani, Rebecca Copeland, "Internet of Things-aided Smart Grid: Technologies, Architectures, Applications, Prototypes, and Future Research Directions", IEEE transaction on Networking and Internet Architecture, 2017

Journals and Magazines:

IEEE Transactions on Power Systems.
IEEE Transaction on Smart Grid

Additional information (if any): NA

Student responsibilities

Adopt peer learning and knowledge sharing within the class
Attendance, feedback, discipline: as per university rules

Course reviewers:

1. Prof. Biswarup Das, IIT Roorkee
2. Dr. Chandan Kumar, IIT Guwahati