

### CONCEPTS OF SMART GRID TECHNOLOGIES

|                                        |                     |                                 |       |                      |                                              |
|----------------------------------------|---------------------|---------------------------------|-------|----------------------|----------------------------------------------|
| <b>Course Code</b>                     | 23EE2701B           | <b>Year</b>                     | IV    | <b>Semester(s)</b>   | I                                            |
| <b>Course Category</b>                 | Open Elective – III | <b>Branch</b>                   |       | <b>Course Type</b>   | Theory                                       |
| <b>Credits</b>                         | 3                   | <b>L-T-P</b>                    | 3-0-0 | <b>Prerequisites</b> | Power Systems, Renewable Energy Technologies |
| <b>Continuous Internal Evaluation:</b> | 30                  | <b>Semester End Evaluation:</b> | 70    | <b>Total Marks:</b>  | 100                                          |

| Course Outcomes                                                       |                                                                                                                                                                 |
|-----------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Upon successful completion of the course, the student will be able to |                                                                                                                                                                 |
| <b>CO1</b>                                                            | <b>Discuss</b> the evolution, technologies, operations, and communication networks of smart grid. (L2)                                                          |
| <b>CO2</b>                                                            | <b>Apply</b> the concepts of smart grid functions, real-time pricing, smart meters, AMR, PHEV, and home automation systems in smart grid operations.(L3)        |
| <b>CO3</b>                                                            | <b>Develop</b> substation automation, energy storage systems, microgrid protection and control, and ICT communication networks in a smart grid environment.(L3) |
| <b>CO4</b>                                                            | <b>Examine</b> the smart grid evolution, international policies, and the impact of smart metering, PHEV, AMR, and home automation technologies.(L4)             |
| <b>CO5</b>                                                            | <b>Determine</b> the effectiveness of energy storage systems, microgrid protection, power quality, and ICT networks in supporting smart grid performance.(L4)   |

| Contribution of Course Outcomes towards achievement of Program Outcomes & Strength of correlations (3:High, 2: Medium, 1:Low) |     |     |     |     |     |     |     |     |     |      |      |      |      |
|-------------------------------------------------------------------------------------------------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|
|                                                                                                                               | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO1 | PSO2 |
| <b>CO1</b>                                                                                                                    | 3   | 1   | –   | –   | –   | –   | –   | –   | –   | –    | 2    | 2    | 1    |
| <b>CO2</b>                                                                                                                    | 3   | 2   | 1   | –   | 2   | –   | –   | –   | –   | –    | 1    | 3    | 1    |
| <b>CO3</b>                                                                                                                    | 3   | 2   | 2   | 1   | 2   | –   | –   | –   | –   | –    | –    | 3    | 2    |
| <b>CO4</b>                                                                                                                    | 3   | 3   | 1   | 2   | –   | 2   | –   | –   | –   | –    | 2    | 2    | 1    |
| <b>CO5</b>                                                                                                                    | 3   | 3   | 2   | 3   | 2   | 1   | –   | –   | –   | –    | 1    | 3    | 3    |

| SYLLABUS |                                                                                                                 |                          |
|----------|-----------------------------------------------------------------------------------------------------------------|--------------------------|
| Unit No. | Contents                                                                                                        | Mapped CO                |
| I        | <b>Introduction to Smart Grid</b><br>Evolution of Electric Grid - Concept of Smart Grid - Definitions - Need of | <b>CO1</b><br><b>CO2</b> |

|     |                                                                                                                                                                                                                                                                                                                                                                                                                  |                            |
|-----|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------|
|     | Smart Grid - Functions of Smart Grid - Opportunities & Barriers of Smart Grid - Difference between conventional & smart grid - Concept of Resilient & Self-Healing Grid - Present development & International policies on Smart Grid.                                                                                                                                                                            | <b>CO4</b>                 |
| II  | <b>Smart Grid Technologies: Part 1</b><br>Introduction to Smart Meters - Real Time Pricing - Smart Appliances - Automatic Meter Reading(AMR) - Outage Management System(OMS) - Plug in Hybrid Electric Vehicles(PHEV) - Vehicle to Grid - Smart Sensors - Home & Building Automation - Phase Shifting Transformers - Net Metering.                                                                               | <b>CO1<br/>CO2<br/>CO4</b> |
| III | <b>Smart Grid Technologies: Part 2</b><br>Smart Substations - Substation Automation - Feeder Automation. Geographic Information System(GIS) - Intelligent Electronic Devices (IED) & their application for monitoring & protection.<br>Smart storage like Battery Energy Storage Systems (BESS) - Super Conducting Magnetic Energy Storage Systems (SMES) - Pumped Hydro - Compressed Air Energy Storage (CAES). | <b>CO1<br/>CO3<br/>CO5</b> |
| IV  | <b>Micro grids and Distributed Energy Resources</b><br>Concept of micro grid - need & applications of microgrid - formation of microgrid - Issues of interconnection - protection & control of microgrid - Integration of renewable energy sources<br>- Demand Response.                                                                                                                                         | <b>CO1<br/>CO3<br/>CO5</b> |
| V   | <b>Information and Communication Technology for Smart Grid</b><br>Advanced Metering Infrastructure (AMI) - Home Area Network (HAN) - Neighborhood Area Network (NAN) - Wide Area Network (WAN).                                                                                                                                                                                                                  | <b>CO1<br/>CO3<br/>CO5</b> |

| <b>Learning Resources</b> |                                                                                                                                                                  |
|---------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Text Books:</b>        |                                                                                                                                                                  |
| 1.                        | Integration of Green and Renewable Energy in Electric Power Systems - by Ali Keyhani - Mohammad N. Marwali - Min Dai Wiley - 2009.                               |
| 2.                        | The Smart Grid: Enabling Energy Efficiency and Demand Response - by Clark W.Gellings - Fairmont Press - 2009.                                                    |
| 3.                        | Smart Grid: Technology and Applications - by Janaka B. Ekanayake - Nick Jenkins - Kithsiri Liyanage - Jianzhong Wu - Akihiko Yokoyama - Wiley publishers - 2012. |
| 4.                        | Smart Grids by Jean-Claude Sabonnadière - NouredineHadjsaïd - Wiley publishers – 2013.                                                                           |
| 5.                        | Smart Power: Climate Changes - the Smart Grid - and the Future of Electric Utilities by Peter S. Fox Penner - Island Press; 1 <sup>st</sup> edition - 8 Jun 2010 |
| 6.                        | Microgrids and Active Distribution Networks by S. Chowdhury - S. P. Chowdhury - P.Crossley - Institution of Engineering and Technology - 30 Jun 2009             |

**Reference Books:**

1. The Advanced Smart Grid: Edge Power Driving Sustainability:1 by Andres Carvallo - John Cooper - Artech House Publishers July 2011
2. Control and Automation of Electric Power Distribution Systems (Power Engineering) by James Northcote - Green - Robert G. Wilson - CRC Press - 2017.
3. Substation Automation (Power Electronics and Power Systems) by Mladen Kezunovic - Mark G. Adamiak - Alexander P. Apostolov - Jeffrey George Gilbert - Springer - 2010.
4. Electrical Power System Quality by R. C. Dugan - Mark F. McGranahan - Surya Santoso - H. Wayne Beaty - McGraw Hill Publication - 2nd Edition.

**E-Resources:**

1. <https://nptel.ac.in/courses/108107113>
2. <https://online-learning.tudelft.nl/courses/smart-grids-the-basics/>