Course Code : **SGT 703**

Course Title : **Introduction to Smart Grid**

Credit Hours : **3**

Course Description

The transformation from centralized to distributed energy resources brings new challenges for metering, pricing, communication, and distribution. Basically, we will see a power system enhanced with information technology. This course aim is to provide an introduction to the key mechanism of the smart grid such as: Energy generation, Energy distribution networks, communication technologies, Energy sustainability, Smart microgrids, Smart metering and home automation, E-mobility, and information technologies

Course Objectives

Students will be able to:

- Understand the key mechanisms of the smart grid.
- Develop the idea of making the system smarter in order to predict energy demand, enable sufficient production, adjust production on demand and handle problems fast and efficiently.

Course Topics

Week No. 1: Introduction to Smart Grids (motivations, historical background,Basic terms and concepts).
Week No. 2: Fundamentals of Energy Generation.
Week No. 3: Basics of Energy Distribution and Transmission.
Week No. 4: Review of Smart Metering and Sensing.
Week No. 5: Fundamental of Smart Grid Operation.
Week No. 6: Overview of Photovoltaics power generation.
Week No. 7: Overview of wind power generation.
Week No. 8: Fundamental of DC Microgrids.
Week No. 9: Fundamental of AC and hybrid Microgrids.
Week No. 10: Information Technologies for Smart Grids.
Week No. 11: Key Communication Technologies for Smart Grids.
Week No. 12: The way to Home Automation and Energy.
Week No. 13: The need for E-Mobility.
Week No. 14: Function of Storage Systems for Smart Grid.
Week No. 15: Future of Smart Grid and Challenges.

References

- S.K. Salman , *Introduction to the Smart Grid: Concepts, Technologies and Evolution*. IET, 2017.
- J. Momoh, *Smart Grid: Fundamentals of Design and Analysis*. Wiley, 2012.
- A. Keyhani, *Design of Smart Power Grid Renewable Energy Systems*. Wiley, 2016.
- J. Ekanayake, N. Jenkins, K.Liyanage, J. Wu, and A. Yokoyama, *Smart Grid: Technology and Applications*. Wiley, 2012.

Course Code : **SGT 704**

Course Title : **Discrete Mathematics and Optimization**

Credit Hours : **3**

Course Description

The course provides the basics of Optimization methods applied to smart grid design and operation. Graph theory, linear programming, non-linear unconstrained and constrained Optimization, Combinatorial optimization, and Stochastic Programming.

Course Objectives

The student will be able to:

- Develop a set of mathematical tools to face the modeling of real life smart grid design situations.
- Solve complicated optimization problems with the aid of computer simulations.

Course Topics

Week No. 1: Introduction to Optimization Methods.
Week No. 2: Graph Theory: Algorithmic Graph Theory, Networks and Flows.
Week No. 3: Graph Theory ctd.
Week No. 4: Counting: Combinatronics, Pigeonhole Principle.
Week No. 5: Linear Optimization: Theory, Simplex Method (Part 1).
Week No. 6: Linear Optimization: Theory, Simplex Method (Part 2).
Week No. 7: Nonlinear Optimization: Unconstrained Optimization – Descent and Newton Methods (Part 1).
Week No. 8: Nonlinear Optimization: Unconstrained Optimization – Descent and Newton Methods (Part 2).
Week No. 9: Non-Linear Optimization: Constrained Optimization – Karush Kuhn Tucker Conditions (Part 1).
Week No. 10: Non-Linear Optimization: Constrained Optimization – Karush Kuhn Tucker Conditions (Part 2).
Week No. 11: Non-Linear Optimization Algorithms: Numerical Methods.
Week No. 12: Non-Linear Optimization Algorithms: Penalty and Augmented Lagrangian Methods - Interior-point.
Week No. 13: Combinatorial Optimization.
Week No. 14: Stochastic Programming.
Week No. 15: Application of Optimization Methods in Smart Grid.

References

- Antoniou, and W-S. Lu, *Practical Optimization: Algorithms and Engineering Applications*. Springer, 2007.
- M. C. Golumbic, and I. B-A. Hartman, *Graph Theory, Combinatorics and Algorithms: Interdisciplinary Applications*. Springer, 2005.
- J. Zhu, *Optimization of Power System Operation*. Institute of Electrical and Electronics Engineers, 2009.
- J. A. Momoh, *Electric Power System Applications of Optimization*. Marcel Dekker, 2001.
- A. Chakrabortty and M. D. Ili´c, Eds, *Control and Optimization methods for Electric Smart Grids*. Springer, 2012.

Course Code : **SGT 705**

Course Title : **Measurements and Signal Processing**

Credit Hours : **3**

Course Description

This course provides the basic fundamentals to understand the main aspects of common electrical measurements in Smart Grids, the characteristics of used sensors, signal conditioning circuits, and noise and coherent interference mitigation. In addition, it discusses the basics on digital signal processing applied to Smart Grids measurements.

Course Objectives

The student will be able to:

- Know the importance of electrical measurements in the operation of Smart Grids.
- Interpret the measurements' specifications and collect, among the technologies, the most suitable for the applications.
- Apply signal processing to voltage and current measurements to calculate power quality figures of merit.
- Perform the design of the data acquisition chain connecting with the power systems measurements standards.

Course Topics

Week No. 1: Basics of Electrical Measurements in Smart grid.
Week No. 2: Measurement uncertainty (Quantification of Systematic errors, Reduction of systematic errors, Aggregation of errors).
Week No. 3: Calibration of measuring Sensors and Instruments.
Week No. 4: Instrumentation Amplifiers (Signal conditioning).
Week No. 5: Sensor Technologies (Radiation, Temperature, …etc).
Week No. 6: Digital Interfaces in measurement systems.
Week No. 7: Noise and coherent interference measurements and its minimization.
Week No. 8: Data acquisition.
Week No. 9: Digital Filters.
Week No. 10: Discrete and Fast Fourier transforms.
Week No. 11: Synchronized Measurements.
Week No. 12: Smart Sensors (RTUs, IEDs, and PMUs).
Week No. 13: Wide Area Measurements (WAM).
Week No. 14: Case Study I.
Week No. 15: Case Study II.

References

- P. Purkait, *Electrical and electronics measurements and instrumentation*. McGraw Hill Education (India), 2013.
- R. B. Northrop, *Introduction to instrumentation and measurements*. Taylor & Francis, 2005.
- C. W. De Silva, *Sensors and actuators: control systems instrumentation*. CRC Press, 2007.
- Alan S. Morris, Reza Langari, *Measurement and Instrumentation, Theory and Application*. Elsevier, 2011.

Course Code : **SGT 706**

Course Title : **Communication Technologies**

Credit Hours : **3**

Course Description

This course focuses on the principles of telecommunications, the protocols and the standards of the main wired and wireless communication technologies. It then discusses the role of communication networks in smart grids, the main applications and the requirements.

Course Objectives

The student will be able to:

- Understand the role of communication networks in the context of smart grids. Identify the applications and the requirements.
- Use of design and analysis tools, both analytical and numerical.
- Understand the role of communication systems in the context of efficient energy management solutions.

Course Topics

Week No. 1: Introduction to communication system. The end-to-and Smart Grid Communication Model: the IEEE 2030 standard.
Week No. 2: the ISO/OSI network stack.
Week No. 3: Physical Layer principles: channel and noise, cables and interfaces
Week No. 4: Main modulation schemes.
Week No. 5: Channel coding, channel capacity.
Week No. 6: MAC Layer principles: deterministic and contentious based media access control mechanism.
Week No. 7: Cooperative schemes and routing.
Week No. 8: Network Layer principles: Ethernet and TCP-IP.
Week No. 9: Transport layer and Application layer
Week No. 10: Low power wireless protocols: ZigBee, Bluetooth, LPWAN technologies.
Week No. 11: IEEE 802.11 WiFi, WiMAX.
Week No. 12: Cellular Networks standards., LTE
Week No. 13: Last mile protocols: xDSL.
Week No. 14: Power Line Communications basics and standards.
Week No. 15: OTN/WDM, SONET/SDH, FTTx.

References

- L. T. Berger and K. Iniewski,*Smart Grid Applications, Communications, and Security*. Wiley, 2012.
- L. Lampe, A. M. Tonello, T. G. Swart, *Power Line Communications – Principles, Standards and Applications from Multimedia to Smart Grid*. Wiley, 2016.
- L. W. Couch II, *Digital and Analog Communication Systems*. Pearson, 2013.

Course Code : **SGT 710**

Course Title : **Renewable and Distributed Generation**

Credit Hours : **3**

Course Description

Introduction to renewable & distributed generation Solar Energy (solar spectrum, solar radiation measurements, concentrating solar power (CSP) technologies, Photovoltaic cells). Wind Energy, Biomass Energy Fuel cells and Stirlling Engine Energy. Applications of Distribution Generation (DG). Power quality in distributed generation, Design of DG systems.

Course Objectives

The student will be able to:

- Understand the current and future renewable energy sources and DG system development especially in solar, wind, biomass and geothermal energies.
- Show the main technical challenges, which face such types of energy.
- Investigate new and emerging distributed generation technologies

Course Topics

Week No. 1: Introduction to renewable & distributed generation Solar Energy (solar spectrum, solar radiation measurements, concentrating solar power (CSP) technologies).

Week No. 2: Photovoltaic Energy (Basic semiconductor physics for PV, equivalent circuit for a photovoltaic cell, electrical characteristics, shading impacts on PV, silicon technologies, Thin-film technology).

Week No. 3: Photovoltaic Systems (grid-connected systems, stand-alone PV systems, PV-powered water pumping).

Week No. 4: Geothermal Energy.

Week No. 5: Wind Energy (Part I: Historical development of wind power, Types of wind turbines, Power in the wind, Maximum rotor efficiency).

Week No. 6: Wind energy (Part II: Average power in the wind, Specific wind turbine performance calculations, Environmental impacts of wind turbines) marine, and hydro energy (wave energy, micro-hydropower systems, hydraulic turbines).

Week No. 7: Biomass Energy.

Week No. 8: Fuel cells and Stirling Engine Energy.

Week No. 9: Applications of Distribution Generation.

Week No. 10: Power quality in DG systems.

Week No. 11: PV based DG systems.

Week No. 12: Wind energy based DG systems network integration, connection standards, codes and practice.

Week No. 13: A detailed design project of a PV energy conversion based system.

Week No. 14: A detailed design project of a PV water pumping systems.

Week No. 15: A detailed design project of a Wind Energy conversion based system.

References

- B. Everett, G. Boyle, S. Peake, and J. Ramage, *Energy systems and sustainability*. Oxford University Press, 2012.
- G. Boyle, Ed, *Renewable Energy: Power for a Sustainable Future*. Oxford: Oxford University Press, 2012.
- D. M. Buchla, T. E. Kissell, T. L. Floyd, *Renewable Energy: Sources, Processes, and Systems*. Pearson, 2014.
- N. Jenkins, R. Allan, P. Crossley, D. Kirschen and G. Strbac, *Embedded generation*. IET Power and Energy Series, 2000.
- A. Keyhani, *Design of Smart Power Grid Renewable Energy Systems*, Wiley, 2016.

Course Code : **SGT 711**

Course Title : **Advanced Distribution and Substation Automation**

Credit Hours : **3**

Course Description

This course introduces the differences and requirements of distribution system in smart grid and control and protection schemes in distribution substation. Moreover, it covers the advanced techniques of substation automation systems and explains the main components and operation of distribution management system

Course Objectives

The student will be able to:

- Understand the difference and requirement of distribution system in smart grid.
- Be familiar with the control and protection schemes in distribution substation.
- Know the advanced technique of substation automation system.
- Know the main components and operation of distribution management system.

Course Topics

Week 1: Electrical distribution system protection and control
Week 2: Advanced protection in distribution substation (Part 1).
Week 3: Advanced protection in distribution substation (Part 2).
Week 4: Fundamental of power system Automation
Week 5: Substation Automation
Week 6: SCADA in Advanced Distribution system
Week 7: RTU and IED for SCADA application in substation automation. (Part 1)
Week 8: RTU and IED for SCADA application in substation automation. (Part 2)
Week 9: Data communication standard in substation automation
Week 10: Communication system for substation control and automation
Week 11: Distribution Management system (DMS)
Week 12: DMS applications in substation automation
Week 13: Industrial substation automation system products
Week 14: Case study - Part 1: Automation system design for industrial substation
Week 15: Case study – Part 2: Integration of substation automation and DMS for real distribution system Electrical distribution system protection and control

References

- J. Northcote-Green and R. Wilson, *Control and Automation of Electrical Power Distribution syst*em. CRC Taylor & Francis, 2007
- M. S. Thomas and J. D. McDonald, *Power System SCADA and Smart Grids.* CRC Taylor & Francis, 2015.
- C. Wang, J. Wu, J. Ekanayake, and N. Jenkins, *Smart Electricity Distribution Networks*. CRC Taylor & Francis, 2017.
- *Practical Distribution and Substation Automation including Communications for Electrical Power Systems:*IDC Technology, 2010
- P. Karampelas and L. Eknonomou, *Electricity Distribution: Intelligent Solution for Electricity Transmission and Distribution Networks*: Springer, 2016.

Course Code : **SGT 712**

Course Title : **Energy and Distribution Management Systems**
Credit Hours : **3**

Course Description

The course provides the students with the basics of energy and distribution management systems. Fundamentals of generation dispatch, generation control, transmission system security management, and home energy management as major elements of energy management system. Basics of distribution management system; including topologies analysis, load forecasting, monitoring, operation, and outage management system.

Course Objectives

The student will be able to:

- Model, analyze, and develop energy systems and to evaluate energy-efficient policies with the basics of energy auditing and economic analysis.
- Apply energy management standards.
- Develop distribution system models adequate for smart grid management applications.

Course Topics

Week 1: Introduction to energy management system in smart grid technology.
Week 2: Energy system modeling, analysis methods & techniques. in smart grid system.
Week 3: Energy management measurements and performance indicators.
Week 4: Energy efficient and saving techniques in buildings and industrial applications.
Week 5: Home Energy Management Fundamental, Energy audit fundamentals, system standards (ISO50001), and applications in building and industrial facilities.
Week 6: Generation dispatch and distributed control.
Week 7: Transmission system security management.
Week 8: Distribution management system in smart grid technology.
Week 9: Distribution system modelling; power flow and contingency analysis.
Week 10: Distribution system topology analysis.
Week 11: Distribution system monitoring; network topology monitoring, network state monitoring, and distributed energy resources (DER) state monitoring (Part 1).
Week 12: Distribution system monitoring; network topology monitoring, network state monitoring, and distributed energy resources (DER) state monitoring (Part 2).
Week 13: Distribution system operation; network reconfiguration, Volt/VAR management, relay protection re-coordination, and operation of DER.
Week 14: Outage management system (OMS); fault identification, fault diagnosis and fault location, supply restoration, and event analysis and recording (Part 1).
Week 15: Outage management system (OMS); fault identification, fault diagnosis and fault location, supply restoration, and event analysis and recording (Part 2).

References

- F. Kreith, D. Y. Goswami, *Energy Management and Conservation Handbook*. CRC Press, 2017.
- C. B. Smith and K. Parmenter, *Energy Management Principles; Applications, Benefits, Savings*. Elsevier, 2016.
- N. Hadjsaïd, and J. Sabonnadière, Eds.,*Smart Power Grids*. John Wiley & Sons, Inc, 2012.
- J. Momoh, *Smart Grid: Fundamentals of Design and Analysis*. John Wiley & Sons, Inc, 2012.

Course Code : **SGT 713**

Course Title : **Demand Response**

Credit Hours : **3**

Course Description

The course provides the main techniques of Demand Response including Load Control, Pricing, Electricity Markets, Economic Consumer Scheduling, Controlled Thermal Loads, Electric Vehicle Interaction, Ancillary Services and Microgrid Management.

Course Objectives

The student will be able to:

- Understand and apply demand response techniques and load scheduling for efficient and economic operation of smart grid using communication infrastructure.

Course Topics

Week No. 1: Demand response in the context of smart grid.
Week No. 2: Demand Side Management (DSM).
Week No. 3: Types of Controllable Loads.
Week No. 4: Plug in Hybrid Electric Vehicles (PHEV) and Vehicle to Grid (V2G) Technology.
Week No. 5: Thermal loads: Air conditioning and Electric Water heaters.
Week No. 6: Demand response. Direct and Indirect Load Control.
Week No. 7: Electricity market. Day-Ahead (DA), Real-Time (RT), Inclined Block Rate (IBR), and Time-of-Use (TOU) Pricing Schemes.
Week No. 8: Smart Meters and Communication Technologies.
Week No. 9: Economic Consumer Scheduling (ECS).
Week No. 10: Economic Consumer Scheduling considering IBR Pricing.
Week No. 11: User comfort in ECS.
Week No. 12: Demand response challenges (a) Load Synchronization.
Week No. 13: Demand response challenges (b) Privacy and Security.
Week No. 14: Ancillary services: Frequency and Voltage Regulation.
Week No. 15: Microgrid Scheduling and Management.

References

- M. S. Thomas and J. D. McDonald, *Power System SCADA and Smart Grids*. Taylor & Francis Group, 2015.
- N. Hatziargyriou, *Microgrids Architectures and Control*, IEEE Press, Wiley, 2014.
- B. M. Shawkat Ali, *Smart Grids Opportunities, Developments, and Trends*. Springer, 2013.
- H. Mohsenian-Rad, *Communications and Control in Smart Grids*. Lecture notes, Texas Tech University, Spring, 2012.

Course Code : **SGT 714**

Course Title : **Smart Grid Road Mapping and Standards**

Credit Hours : **3**

Course Description

This course introduces the smart grid conceptual model and provides specified standards to design a roadmap to implement, assess and monitor a smart grid system. It also covers performing of the gap analysis required to upgrade a conventional grid into a smart grid including how decisions are taken and identification of the required technologies. Moreover, the course addresses the national policies, challenges, and other experiences toward smart grid roadmaping

Course Objectives

The student will be able to:

- Know different standards in smart grid roadmaping.
- Design an effective roadmap to upgrade a conventional grid according to a specified standard.
- Design of the smart grid implementation time plan.
- Follow specified standards to design a smart grid roadmap.

Course Topics

Week No. 1: Smart grid conceptual model.
Week No. 2: Standards in smart grid roadmaping.
Week No. 3: Smart grid roadmap steps to upgrade the conventional grid.
Week No. 4: Defining the vision statement and the society awareness plan.
Week No. 5: Gap analysis development and evaluation between existing grid status and vision.
Week No. 6: Mapping the technologies required for the smart grid.
Week No. 7: Identify the necessary data and surveys to engage consumers in decision-making.
Week No. 8: Smart grid roadmap assessment.
Week No. 9: Prioritizing and planning of a precise roadmap (Part 1).
Week No. 10: Prioritizing and planning of a precise roadmap (Part 2).
Week No. 11: Design of the smart grid implementation time plan.
Week No. 12: Monitoring and adjusting this roadmap.
Week No. 13: Political support and policies.
Week No. 14: Challenges in developing a smart grid roadmap.
Week No. 15: Exploring other countries experiences in smart grid roadmaping.

References

- Office of the National Coordinator for Smart Grid Interoperability, “NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 1.0,” U.S. Department of Commerce, National Institute of Standards and Technology, 2010.
- A. M. Annaswamy, et al., IEEE Vision for Smart Grid Controls: 2030 and Beyond: Roadmap, 2013.
- IEEE P2030 standard, "Guide for Smart Grid Interoperability of Energy Technology and Information Technology Operation with the Electric Power System (EPS), and End-Use Applications and Loads", 2011
- IEC SG3, 2010, "IEC Smart Grid Standardization Roadmap Edition1.0", June 2010.
- International Energy Agency (IEA), “Technology Roadmap: How2Guide for Smart Grids in Distribution Networks,” Edition: 2015
- International Energy Agency (IAE), “Technology Roadmap: Smart Grids,” 2011

Course Code : **SGT 715**

Course Title : **Adaptive Protection Systems in Smart Grid**

Credit Hours : **3**

Course Description

The course provides profound information about the digital Power system protection and modern applications in smart grid system. The Synchronized measurement technology, infrastructure of wide area measurements are addressed. The course also covers the architecture and applications of a WAMPAC system and developing many protection techniques based on WAMs.

Course Objectives

The student will be able to:

- Know the types of wide-area monitoring system architectures.
- Examine the applications of synchronized measurement technology.
- Design suitable protection system with phasor inputs.
- Manipulate with wide-area monitoring system data.

Course Topics

Week 1: Digital protection system configuration
Week 2: Digital protection algorithms
Week 3: Introduction to Synchronized Measurement Technology
Week 4: Wide-area Monitoring System
Week 5: Architecture of a WAMPAC System
Week 6: Applications and Benefits of Synchronized Measurement Technology
Week 7: Adaptive Protection Systems with Phasor Inputs
Week 8: Microgrid protection
Week 9: Self heeling of protection system
Week 10: Wide-Area Monitoring and Adaptive Protection
Week 11: Wide Area Voltage Protection
Week 12: Wide-Area Monitoring, Protection, and Control of Future Electric Power Networks
Week 13: Fault identification and localization algorithms
Week 14: Case study (Part 1): Smart Grid protection
Week 15: Case study (Part 2): Integration of smart grid protection and control

References

- A. R. Messina, *Wide Area Monitoring of Interconnected Power Systems*. Institution of Engineering and Technology IET, 2015.
- H.Bevrani, M. Watanabe and Y.Mitani, *Power System Monitoring and Control*. Wiley-IEEE Press, 2014.
- Y. Li, , D. Yang, F. Liu, Y. Cao, C. Rehtanz, *Interconnected Power Systems: Wide-Area Dynamic Monitoring and Control Applications*. Berlin Heidelberg: Springer-Verlag, 2016.
- M. M. Eissa and M.Masoud, "A Novel Wide Area Protection Classification Technique for Interconnected Power Grids Based on MATLAB Simulation" in *Scientific and Engineering Applications Using MATLAB*, E. P. Leite, Ed., InTech, 2011, pp.129-154.

Course Code : **SGT 716**

Course Title : **Condition Monitoring and Asset Management in Smart Grid**

Credit Hours : **3**

Course Description

Introduction to to the techniques and standards of asset management in smart grid and to ensure minimum life cycle costs of assets while achieving maximum energy production and system reliability. The course offers the basics of reliability and economic analysis and their application in smart grid context

Course Objectives

The student will be able to:

- Identify different maintenance policies and strategies used in smart grids.
- Identify economic performance indicators used in the economic analysis of assets.
- Design an asset maintenance plan for achieving minimum cost and optimum asset performance.
- Analyze data to improve asset performance and minimize maintenance costs.

Course Topics

Week 1:	Introduction to Reliability and Maintenance Planning and Assets of Smart Grid Systems
Week 2:	Basics of Reliability Theory
Week 3:	Maintenance Planning Policies
Week 4:	Reliability Centered Maintenance (RCM)
Week 5:	Maintenance Standards in Smart Grids (PAS 55 and ISO 55000/1/2)
Week 6:	Condition Based Maintenance (CBM) Planning (Part 1)
Week 7:	Condition Based Maintenance (CBM) Planning (Part 2)
Week 8:	Utilization of Reliability and Condition Monitoring Data for Asset Management
Week 9:	Economic Indicators of Smart Grid
Week 10:	Life Cycle Costing Principles
Week 11:	Replacement Analysis (Part 1)
Week 12:	Replacement Analysis (Part 2)
Week 13:	Asset Performance Assessment
Week 14:	Applications and Case Studies: Condition Monitoring for a Smart Grid (Part 1)
Week 15:	Case Studies: Design of an Asset Management Plan (Part 2)

References

- R. Karki, R.Billinton, A. K.Verma, *Reliability Modeling and Analysis for Smart Power Systems*. Springer, 2014.
- T. Van der Lei., P. Herder, Y.Wijnia, *Asset Management: The State of the Art in Europe from a Life Cycle Perspective*. Springer, 2012.
- G. Liu, M. G. Rasul, M.T.O.Amanullah, and M.M.K. Khan, “Economy of Smart Grid” in *Smart Grids, Green Energy and Technology*, A. B. M. S. Ali (ed.), London: Springer-Verlag, 2013.
- P. Bangalore and L. B.Tjernberg, ‘Condition Monitoring and Asset Management in the Smart Grid’, in *Smart Grid Handbook*, John Wiley & Sons, 2016.

Course Code : **SGT 717**

Course Title : **Microgrid and Virtual Power Plant**

Credit Hours : **3**

Course Description

This course provides master students with a working knowledge of fundamentals, design, analysis, and development of Micro-grid and virtual power plant. The course also offers simulation and control of micro-grid and virtual power plant.

Course Objectives

The student will be able to:

- Know some mathematical tools, and programming software required to design, build, and operate microgrid and virtual power plant systems.
- Construct a dynamic simulation model of different microgrids and virtual power plant configurations.
- Design control and operation of market based VPP using direct Controlled VPP and price signal controlled VPP.

Course Topics

Week No. 1: Introduction to microgrid
Week No. 2: Penetration of DG on power system
Week No. 3: Economic analysis of microgrid
Week No. 4: Hierarchical and control of microgrid
Week No. 5: Modelling and simulation of microgrid.
Week No. 6: Concept of VPP
Week No. 7: VPP elements and operation strategy.
Week No. 8: Integration of VPP in distribution network
Week No. 9: Integration of large scale (LS) VPP in transmission system
Week No. 10: Market participation of VPP
Week No. 11: Control and operation of market based VPP: Direct Controlled MBVPP
Week No. 12: Control and operation of market based VPP: Price Signal Controlled MBVPP
Week No. 13: Modelling and simulation of VPP
Week No. 14: Challenges of VPP implementation
Week No. 15: Case study

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References

- E. A. Setiawan, *Concept and Controllability of Virtual Power Plant*. Kassel University Press, 2007.
- F. Zhang, *Coordinated Control and Optimization of Virtual Power Plants for Energy and Frequency Regulation Services in Electricity Markets*. Texas A & M University, 2012.

Course Code : **SGT 718**

Course Title : **Smart Grid Planning and Operation**

Credit Hours : **3**

Course Description

This course aims to cover a generic framework for planning and operation of smart grid that handles newly immerged challenges and cope with specified targets of societies and future electricity demand. The course sails among introducing basic SG operational elements, enhancing operational functional objectives, optimizing operational performance, maintaining system safety and integrity, and lastly, ensuring system operability.

Course Objectives

The student will be able to:

- Perform Mathematical formulation of smart grid planning problems with consideration of uncertainty and variability.
- Analyze design and simulation issues for secure power networks as resilient smart grid infrastructure.

Course Topics

Week 1: Introduction: The future of the electric power system

Week 2: Advanced metering infrastructure (AMI) and general operational and communication issues.

Week 3: Reliability Principles and Improvement of service reliability and optimization of energy delivery (Part 1): The Changing Nature of Reliability; Growing Vulnerabilities for the Electric Grid.

Week 4: Reliability Principles and Improvement of service reliability and optimization of energy delivery (Part 2): Markets and Their Impact on Reliability and Resilience; Grid Operations Planning and Resilience.

Week 5: Optimal sizing and placement of Smart-Grid-Enabling technologies for maximizing renewable integration (Part 1): Objectives, mathematical formulation of the problem and constraints.

Week 6: Optimal sizing and placement of smart-Grid-Enabling technologies for maximizing renewable integration (Part 2): Uncertainty and variability management and case study.

Week 7: Safety design of resilient micro energy grids (MEG) (Part 1): MEG infra structure and MEG performance modeling.

Week 8: Safety design of resilient micro energy grids (Part 2): Safety design and protection layers for MEGs and control types of MEG.

Week 9: Design and simulation issues for secure power networks as resilient smart grid infrastructure (Part 1): Smart Grid Design Challenges and Smart Grid Control Infrastructure.

Week 10: Design and simulation issues for secure power networks as resilient smart grid infrastructure (Part 2): Modern Distribution Architectures in Smart Grid

Week 11: High-performance large Microgrid.

Week 12: Scheduling interconnected micro energy grids with multiple fuel option.

Week 13: Energy storage integration with interconnected micro energy grid.

Week 14: SCADA and smart energy grid control automation (Part 1): Smart Grid SCADA integration and applications.

Week 15: SCADA and smart energy grid control automation (Part 2): SCADA in PV plants, wind farms; Fuel cells control and monitoring.

References

[1] *H. Gabbar,*"Smart Energy Grid Engineering", 1st Edition, Academic Press 2016.
[2] S. T Mak , "New Technologies for Smart Grid Operation", IOP Publishing Ltd 2015.
[3] J.H. de Wilde, J. A. Beaulieu and J.M.A. Scherpen, "Introduction—Smart Grids: Design, Analysis and Implementation of a New Socio-technical System", Springer International Publishing Switzerland 2016.
[4] J. Momoh, “Smart Grid Fundamentals of Design and Analysis,” IEEE Press, Wiley, 2012.

Course Code : **SGT 719**

Course Title : **Power Control in Smart Grid**

Credit Hours : **3**

Course Description

This course provides the basic fundamentals to understand the main aspects of active and reactive power control in the modern electric power systems/smart grids. At the end of the course students are able to understand the main technical problems related to converter control techniques, active and reactive power control of Grid-Connected PV and wind energy conversion systems, and harmonic filters.

Course Objectives

The student will be able to:

- Apply the control theories of active and reactive power control in microgrids.
- Develop the appropriate design of current and voltage control for renewable energy systems.
- Examine the performance and the stability of the control system.

Course Topics

Week 1: Principles of Electrical Power Control and Quality Problems in Smart Networks
Week 2: Integration of Distributed Generation with Electrical Power System (Control hierarchy of micro-grids)
Week 3: Control of DC Micro-grids (Droop control, Voltage control, Active power sharing, Economical Sharing,)
Week 4: Control of AC Micro-grids (Droop Control, Frequency control, Active power sharing, Economical Sharing)
Week 5: Control of Hybrid Micro-grids (Power management control)
Week 6: Reactive power control in smart grid
Week 7: Control of Power Converters for Grid-Interactive Distributed Power Generation Systems (Inner and outer loop control)
Week 8: Selective Non-linear control techniques (Sliding mode control, Predictive control, etc.)
Week 9: Dynamic Static Synchronous Compensator (D-STATCOM)
Week 10: Dynamic Voltage Restorer (DVR) and voltage regulators
Week 11: Harmonics mitigation and filtering
Week 12: Controls and grid requirements for modern renewable energy system (islanding detection, LVRT)
Week 13: MPP control for PV Systems.
Week 14: MPP control for Wind systems.
Week 15: Case Study

References

- H. Abu-Rub, M. Malinowski, and K. Al-Haddad. *Power Electronics for Renewable Energy Systems, Transportation and Industrial Applications*. John Wiley & Sons, 2014.
- R. M. Strzelecki, Ed., *Power Electronics in Smart Electrical Energy Networks*. London: Springer-Verlag, 2008.
- N. Femia, et al. *Power Electronics and Control Techniques for Maximum Energy Harvesting in Photovoltaic Systems*. CRC Press, 2012.
- R. Teodorescu, L. Marco, and P. Rodriguez. *Grid Converters for Photovoltaic and Wind Power Systems*. John Wiley & Sons, 2011.

Course Code : **SGT 720**

Course Title : **Energy Storage Systems**

Credit Hours : **3**

Course Description

To gain an understanding of how current and future energy storage systems operate and how these can be used to deal with the variable nature of the demand and supply on the grid in particular due to the intermittent nature of renewable electrical energy sources

Course Objectives

The student will be able to:

- Understand the different energy storage systems in terms of their generation and an appreciation of their limitations in terms of storage capacity and time frame.
- Apply fundamental concepts to solve problems based on calculation of storage capacity and conversion efficiencies.

Course Topics

Week No. 1: Energy Storage: Supply and Demand.
Week No. 2: Energy Storage Usability in Smart Grid.
Week No. 3: Energy Storage Technologies and Systems: Electrical ES.
Week No. 4: Energy Storage Technologies and Systems: Mechanical ES.
Week No. 5: Energy Storage Technologies and Systems: Thermoelectric ES.
Week No. 6: Battery ESS.
Week No. 7: Impedance Measuring Methods of Battery ESS.
Week No. 8: Factors Influencing the Storage Capacity in Transmission and Distribution Systems.
Week No. 9: Model Development of ESS in Electric Power Systems.
Week No. 10: Energy Management of Distributed ESS.
Week No. 11: Reliability in Smart Grids with ESS.
Week No. 12: Economics of Electric ESS.
Week No. 13: Energy storage; Status and Potential.
Week No. 14: Case Study: Battery Sizing for Renewable Energy Resources Based on IEEE Standards.
Week No. 15: Case Study: ES System Layout for Maximum Renewable Energy Use and Storage Efficiency.

References

- P. Du, and N. Lu, *Energy Storage for Smart Grids: Planning and Operation for Renewable and Variable Energy Resources (VERs)*. Elsevier Science, 2014.
- R.A. Huggins, *Energy Storage: Fundamentals, Materials and Applications.* Springer International Publishing, 2015.
- P. Komarnicki, P. Lombardi, and Z. Styczynski, *Electric Energy Storage Systems: Flexibility Options for Smart Grids.* Springer Berlin Heidelberg, 2017.
- P.T. Moseley, and J. Garche, *Electrochemical Energy Storage for Renewable Sources and Grid Balancing*. Elsevier Science, 2014.

Course Code : **SGT 721**

Course Title : **Advanced Power Electronics**

Credit Hours : **3**

Course Description

This course provides the fundamentals for understanding the main aspects of power electronics devices, topologies and their modulation techniques for renewable energy and smart grid. At the end of the course students are able to understand the main technical problems relevant to the selection of power converter topologies for renewable energy and smart grid applications, selection of electronic devices and their impact on the operation and performance of the designed converter, thermal and packaging technologies for these converters.

Course Objectives

The student will be able to:

- Study advanced converters and switching techniques implemented in recent SG technology.
- Derive a mathematical model to analyze, explain and design power electronic converters and the associated driving modulation techniques.
- Analyze different converters and control with their applications.

Course Topics

Week 1:	Introduction to Power Electronics: Power Electronics Today and Tomorrow
Week 2:	Silicon Power Electronic Semiconductors
Week 3:	Advanced Power Devices (SIC, GAN …etc.).
Week 4:	Practical issues about power semiconductor devices (losses calculations, heat sink design, …)
Week 5:	Gate driver circuits for different power devices.
Week 6:	Power Electronics Converter Topologies (Fundamental Converters, Single stage/Two stage converters)
Week 7:	Topology (Part I: Multi-level Converters).
Week 8:	Topology (Part III: Z-source Converters).
Week 9:	Topology (Part IV: Resonant Converters).
Week 10:	Topology (Part II: Matrix Converters & Bi-directional Converter)
Week 11:	Advanced Power Electronics for smart grid
Week 12:	Modulation Techniques for Power Converters
Week 13:	Advanced Modulation Techniques for Power Converters.
Week 14:	Thermal Management and Power Electronics Packaging
Week 15:	Case Study application

References

- L. M., Tolbert, et al., "Power Electronics for Distributed Energy Systems and Transmission and Distribution Applications," U.S. Department of Energy, Oak Ridge National Laboratory, UT-Battelle, LLC, ORNL/TM-2005/230, 2005.
- N. Femia, et al. *Power Electronics and Control Techniques for Maximum Energy Harvesting in Photovoltaic Systems*. CRC press, 2012.
- Y. Liu, et al., *Impedance Source Power Electronic Converters*. Wiley-IEEE Press, 2016.
- G. M. Masters, *Renewable and Efficient Electric Power Systems*. Wiley-IEEE Press, 2013.

Course Code : **SGT 722**

Course Title : **Electric Vehicles Integration into Smart Grid**

Credit Hours : **3**

Course Description

This course aims to cover the recent advancements in charging strategies and charging coordination for Plug-in Electric Vehicles (PEVs) in smart grids and addresses different V2G optimization techniques and approaches and the associated advantages and challenges of PEV

Course Objectives

The student will be able to:

- Understand the vehicle to grid (V2G) concept, framework and ancillary services such as: active power support, reactive power compensation, emergency backup power, support for renewable energy resources, etc.
- Solve V2G optimization problem considering grid constraints/limitations.
- Design the power flow control and energy management in smart distribution systems with V2G integrated microgrids.

Course Topics

Week No. 1:	Vehicle to grid concept and framework.
Week No. 2:	V2G advantages, challenges, and policy options.
Week No. 3:	Charging Infrastructure for Plug-in Electric Vehicle (PEVs).
Week No. 4:	Battery choice for new-generation electric vehicles.
Week No. 5:	PEV charging strategies.
Week No. 6:	Battery charger with grid-to-vehicle (G2V), vehicle-to-grid (V2G) and vehicle-to-home technologies.
Week No. 7:	Renewable energy based charging station for V2G application in smart grids.
Week No. 8:	Wireless charging systems for EVs.
Week No. 9:	Dynamic modeling of EVs.
Week No. 10:	Power flow control and energy management in smart distribution systems with V2G Integrated Microgrids.
Week No. 11:	V2G ancillary services: active power support, reactive power compensation, emergency backup power, support for renewable energy resources, etc.
Week No. 12:	V2G Optimization approaches and objectives (Part 1).
Week No. 13:	V2G Optimization approaches and objectives (Part 2).
Week No. 14:	Decentralized optimal demand-side management for PEV charging in a smart grid.
Week No. 15:	Charging coordination paradigms of PEVs.

References

- S. Rajakaruna, F. Shahnia, and A. Ghosh, *Plug In Electric Vehicles in Smart Grids: Charging Strategies*. Springer Singapore, 2014.
- J. Lu and J. Hossain, *Vehicle-to-Grid: Linking Electric Vehicles to the Smart Grid*. Institution of Engineering and Technology, 2015.
- W. Tang and Y. J. Zhang, *Optimal Charging Control of Electric Vehicles in Smart Grids*. Springer International Publishing, 2016.
- K. M. Tan, V. K. Ramachandaramurthy, and J. Y. Yong, "Integration of electric vehicles in smart grid: A review on vehicle to grid technologies and optimization techniques," *Renewable and Sustainable Energy Reviews,* Vol. 53, pp. 720-732, 2016.

Course Code : **SGT 723**

Course Title : **Simulation and Hardware Tools**

Credit Hours : **3**

Course Description

The course introduces the operation fundamentals of the different hardware tools used in control of smart grid systems and the main technical issues relevant to the selection between these tools. It also introduces the most common simulation tools used to evaluate the performance of the smart grid systems. By the end of this course, the student should recognize the practical software and hardware requirements for the accurate simulation and implementation of smart grid systems.

Course Objectives

The student will be able to:

- Understand the characteristics of an operational amplifier and describe how they can be used as the basis for design different types of circuits.
- Apply different simulation tools to model and solve large scale smart grid system.
- Develop and implement control systems of smart grid systems using the most common digital controllers and using real time digital simulator along with hardware in the loop simulation.

Course Topics

Week 1: Introduction to micro-processor components based control.
Week 2: An Overview of Simulation Tools.
Week 3: Overview of MATLAB
Week 4: Smart grid simulation using MATLAB.
Week 5: Smart grid simulation using PSIM.
Week 6: Control Systems Development and Implementation with Micro-controllers.
Week 7: Control Systems Development and Implementation with FPGA (Part 1).
Week 8: Control Systems Development and Implementation with FPGA (Part 2).
Week 9: Control Systems Development and Implementation with Digital Signal Processors (DSPs).
Week 10: Control Systems Development and Implementation with Digital Signal Processor for Applied and Control Engineering (dSPACE).
Week 11: Real-Time Simulation for Smart Grid applications (Part 1).
Week 12: Real-Time Simulation for Smart Grid applications (Part 2).
Week 13: Hardware in the Loop simulation.
Week 14: Case study project.

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References

- C. T. Kilian, *Modern Control Technology: Components and Systems*. Novato, CA: Delmar Thomson Learning, 2000.
- F. Vasca, and L. Iannelli, *Dynamics and Control of Switched Electronic Systems. Advanced Perspectives for Modeling, Simulation and Control of Power Converters.* London: Springer London, 2012.
- H. Abu-Rub, M. Malinowski, and K. Al-Haddad. *Power Electronics for Renewable Energy Systems, Transportation, and Industrial Applications*. Chichester, West Sussex, United Kingdom ; Hoboken, New Jersey: Wiley/IEEE, 2014.

Course Code : **SGT 724**

Course Title : **Smart building and Internet of Things (IoT)**

Credit Hours : **3**

Course Description

The Internet of things technologies are helping the properties owners and managers to enable systems that deliver more accurate and useful information for improving operations and provide the best experience for tenants. This course focuses on the interaction between technology, energy, people and nature in the context of smart buildings. Moreover, it describes the novel technologies and procedures available for this environment.

Course Objectives

The student will be able to:

- Understand the functionalities of the main smart building technologies.
- Learn appropriate approaches and methods
- Identify and characterize problems within the intelligent building system.
- Evaluate the outcomes, and communicate developed solutions.

Course Topics

Week No. 1: Introduction to Smart Buildings and the Internet of Things
Week No. 2: Building Requirements and Performance Indicators
Week No. 3: Essential attributes of a smart building
Week No. 4: Information technologies in building systems
Week No. 5: Building energy modeling
Week No. 6: Management of building system data
Week No. 7: Real time location systems
Week No. 8: IoT communication technologies and protocols
Week No. 9: Hardware Infrastructure, sensors, actuators, edge devices
Week No. 10: Distributed Computing Systems
Week No. 11: Programming for the Internet of Things
Week No. 12: Cybersecurity, Privacy and Access Control
Week No. 13: Applications: HVAC, Light, Occupancy.
Week No. 14: Applications: Safety, Security, Energy and Smart Home.
Week No. 15: Applications: Utilization, Fault Detection

References

- J. Sinopoli, *Advanced Technology for Smart Buildings*. Artech House, 2016.
- N. Y. Jadhav, *Green and Smart Buildings: Advanced Technology Options*. Singapore: Springer, 2016.

Course Code : **SGT 725**

Course Title : **Advanced Metering Infrastructure**

Credit Hours : **3**

Course Description

This course is designed to provide the students with direct experience in the design, implementation, and operation of the advanced metering infrastructure (AMI). The course will elucidate the basic architecture and technology of the AMI as an integral part of the smart grid system. Topics include fundamental concept and components of the AMI, technologies and topologies of AMI, AMI communication infrastructure, information transport methods, and cyber security related aspects to AMI systems.

Course Objectives

The student will be able to:

- Explain the use and function of Advanced Metering Infrastructure systems.
- Examine the capabilities, limitations, and vulnerabilities of metering infrastructure systems
- Design and configure FAN and WAN communication networks for AMI systems.

Course Topics

Week No. 1: Introduction to AMI systems.
Week No. 2: Conventional energy meters and smart meters : architecture and operation.
Week No. 3: Smart meter measurements.
Week No. 4: Smart meter protocols and standards.
Week No. 5: Metering connectivity to a power system.
Week No. 6: AMI communication infrastructure and technologies.
Week No. 7: Wireline technologies for Field Area Networks (FAN).
Week No. 8: Wireless technologies for Field Area Networks (FAN).
Week No. 9: Wide area network (WAN) Technologies for the AMI.
Week No. 10: Home (Local) area Networks (HANs).
Week No. 11: Performance evaluation for AMI communication systems.
Week No. 12: AMI Meter Data Management System (MDMS).
Week No. 13: AMI security architecture and protocols.
Week No. 14: Applications of AMI systems.
Week No. 15: Practical case studies for worldwide implemented AMI systems.

References

- K. C. Budka, J. G. Deshpande, and M. Thottan, *Communication Networks for Smart Grids - Making Smart Grid Real*. London: Springer, 2014.
- D. Mah, P. Hills, V. O. K. Li, R. Balme, Eds.,*Smart Grid Applications and Developments*. London: Springer, 2014.
- H. Sun, N. Hatziargyriou, H. V. Poor, L. Carpanini, *Smarter Energy - From Smart Metering to the Smart Grid*. IET, 2016.

Course Code : **SGT 726**

Course Title : **Cyber Security and Data Privacy**

Credit Hours : **3**

Course Description

This course aims to cover the recent advancements in smart grid security and data privacy. Discuss common security tools(firewall, techniques to protect smart grid networks.

Course Objectives

The student will be able to:

- Understand the concepts of confidentiality, integrity, authentication, availability, risk management.
- Understand how to provide security for smart grid nework.

Course Topics

Week 1: What is smart grid (Network architecture review).

Week 2: Cybersecurity from system engineering perspectives: information assurance: Confidentiality, integrity, authentication, availability, risk management, threats and vulnerabilities, balancing cost, functionality, and security..

Week 3: Common security tools: firewalls, access control list, virtual private network. (Part 1)

Week 4: Common security tools: intrusion detection system, security information and event management, and anti-virus. (Part 2)

Week 5: Fundamentals of applied cryptography: symmetric and asymmetric cryptography.

Week 6: Block ciphers and the Data Encryption Standard.

Week 7: Public-key Encryption and key distribution.

Week 8: Smart grid security threats and reported vulnerabilities.

Week 9: Privacy concerns in smart grids (Personal data, Privacy risks associated with the Smart Grid, Privacy impact assessment.

Week 10: Security Models for SCADA, ICS, and Smart Grid. (A simplified Smart Grid reference model)

Week 11: Security the smart Grid (Implementing security control within Smart Grid endpoints, Establishing strong boundaries and zone separation, Protecting data and applications within the Smart Grid, Situational awareness, Use case: defending against Shamoon).

Week 12: Smart grid cybersecurity: (demand response security issues in smart grid, home area network, gateway, and neighborhood area network security).

Week 13: Smart grid system performance evaluation:smart grid risks versus benefits, smart grid laws, and industry guidance.

Week 14: Advanced metering infrastructure security.

Week 15: Look to the future of smart grid security.

References

- E. Knapp and R. Samani, *Applied Cyber Security and the SmartGrid: Implementing Security Controls into the Modern Power Infrastructure*. Elsevier, 2013.
- G. N. Sorebo, and M. C. Echols, *Smart Grid Security: An End-to-End View of Security in the New Electrical Grid*. CRC Press, 2011.
- R. Anderson, *Security Engineering: A Guide to Building Dependable Distributed Systems*. Wiley, 2008.

Course Code : **SGT 727**

Course Title : **ICT Infrastructure in Smart Grid**

Credit Hours : **3**

Course Description

This course aims to cover survey and study various approaches, protocols, standards and novel techniques for data communications and networking infrastructures in smart grids and the employing of machine intelligence concepts and algorithms in smart grids communications for enhanced networking operations and sustained QoS levels.

Course Objectives

The student will be able to:

- Identify the main components of any smart grid system including the energy infrastructure, communication infrastructure, computing and information management platform and running applications, and the challenges that affect the design and operation of ICT infrastructure at smart grids.
- Design a wireless sensor network as ICT network infrastructure for smart grids.
- Perform a set of simulation scenarios using appropriate simulation environments that can emulate ICT infrastructure at smart grids.

Course Topics

Week 1: Introduction to the ICT infrastructure and the primary needs for designing ICT infrastructure for smart grids.
Week 2: wireless communication technologies
Week 3: Wired and optical fibers communication technology
Week 4: Cloud computing-based ICT network infrastructure for smart grids
Week 5: ICT network infrastructure for various smart grids scale from power grids to microgrids to nanogrids
Week 6: ICT network infrastructure for advanced metering of utilities at heterogeneous customers (residential, commercial and industrial)
Week 7: Data routing architectures at ICT network infrastructure of smart girds
Week 8: QoS preservation in ICT network infrastructure for smart grids
Week 9: Cyber security at ICT infrastructure of smart grids
Week 10: ICT applications at smart grids for more sustainable energy production, management and consumption.
Week 11: Employing machine intelligence at ICT infrastructure (Fundamentals)
Week 12: Employing machine intelligence at ICT infrastructure of smart grids (Application in data classification and forwarding)
Week 13: Modeling and simulation of ICT network infrastructure (Introduction to a set of ICT network models and simulation environments in literature)
Week 14: Simulation of ICT network infrastructure for smart grids using models of cyber physical systems
Week 15: Discussing and evaluating smart ICT network infrastructure for semantics-driven management of solar energy systemsase study

References

- Y. Xiao, *Communication and Networking in Smart Grids*: CRC Press, 2012.
- J. Ekanayake, et al., *Smart Grid: Technology and Applications*. Wiley, 2012.
- F. Bouhafs, et al., *Communication Challenges and Solutions in the Smart Grid*. Springer, 2014.
- S. F. Bush, *Smart Grid: Communication-enabled Intelligence for the Electric Power Grid*. Wiley-IEEE Press, 2014.

Course Code : **SGT 728**

Course Title : **Cloud Computing and Big Data Analysis**

Credit Hours : **3**

Course Description

This course provides a working knowledge of fundamentals, design, analysis, and development of Cloud Computing using Big Data Concepts.

In addition, an appreciation of the challenges of managing vast quantities of structured and unstructured big data, and how organizations are trying to leverage big data stores via analytics for strategic decision-making are gained, with practical experience to solve problems across a range of smart grid application..

Course Objectives

The student will be able to:

- Understand Cloud Computing Models including public cloud, private cloud and hybrid clouds, physical compute system & storage system architectures, principles of Virtualization platforms, and big data phenomenon and characteristics.
- Analyze and select application development guidelines and technologies to best leverage cloud computing offerings
- Perform predictive analytics to a variety of use cases including asset management, grid planning and investment, grid operation and maintenance

Course Topics

Week No. 1: Cloud Computing at a Glance.
Week No. 2: Cloud Computing Models including public cloud, private cloud and hybrid clouds.
Week No. 3: Infrastructure/Platform/Software – as-a-service.
Week No. 4: Cloud Computing Architecture.
Week No. 5: Principles of Virtualization platforms.
Week No. 6: Cloud Platforms in Industry such as Google App Engine, Amazon Web Service, and Microsoft Windows Azure.
Week No. 7: Cloud service quality such as availability, performance, and security.
Week No. 8: Overview of Big Data.
Week No. 9: Hadoop ecosystem.
Week No. 10: Using Hive to query Hadoop files.
Week No. 11: Big Data and machine learning (Spark).
Week No. 12: Big Data security and privacy challenges in the cloud.
Week No. 13: Smart grid and big data analysis (Application in asset management).
Week No. 14: Smart grid and big data analysis (Application in grid planning and investment) - Part 1.
Week No. 15: Smart grid and big data analysis (Application in grid operation and maintenance) – Part 2.

References

- M. Trovati, R. Hill, A. Anjum, S. Y. Zhu, L. Liu, Eds., *Big-Data Analytics and Cloud Computing Theory, Algorithms and Applications*. Springer, 2015.
- R. Buyya, C. Vecchiola, S. T. Selvi, *Mastering Cloud Computing.* Elsevier, 2013.
- D. Rountree, and I. Castrillo, *The Basics of Cloud Computing:Understanding the Fundamentals of Cloud Computing in Theory and Practice*. Syngress, 2014.
- Many recent papers in leading conferences/journals will be discussed.

Course Code : **SGT 729**

Course Title : **Carbon Capture, Utilization and Storage (CCUS)**

Credit Hours : **3**

Course Description

The course provides an understanding of carbon capture, utilization and storage through the entire supply chain, a large-scale decarburization technology of the energy and industrial sector, from a multidisciplinary approach.

Course Objectives

The student will be able to:

- Describe the main sources of greenhouse gas emissions and their impact on climate change.
- Identify, describe and explain principles and applications of CO_2 capture and separation technologies, and technologies used for CO_2 conditioning and CO_2 transport.
- Design methods to decrease the carbon footprint of electricity generation.
- Integrate technology, economics, sustainability, environmental impact, regulatory framework and public acceptance in a full-chain project.

Course Topics

Week No. 1: Energy/Electricity production and its effect on greenhouse gases and climate change.
Week No. 2: Climate change mitigation strategies,CO_2 sources, and Carbon cycle.
Week No. 3: Carbon Capture. Introduction to capture technologies.
Week No. 4: Applications of CCS for the coal-powered electricity industry.
Week No. 5: Monitoring, verification, and accounting of carbon dioxide in different settings.
Week No. 6: Carbon Capture. Separation technologies (Part 1).
Week No. 7: Carbon Capture. Separation technologies (Part 2).
Week No. 8: Carbon Capture. Research gaps. CO_2 conditioning.
Week No. 9: Carbon transport. Pipelines and shipping systems.
Week No. 10: Carbon storage. Geological storage trapping mechanisms.
Week No. 11: Carbon storage. Geological storage formations Modeling of carbon dioxide storage.
Week No. 12: Carbon storage. Injection strategies.
Week No. 13: Power generation with CCS. Impact on the grid. Cost and regulatory framework.
Week No. 14: Impact of Smart Grid Technology on CO2 Production.
Week No. 15: Applications of CCS in smart grids. Measurement, monitoring and verification

References

- B. Smit, J. A. Reimer, C. M. Oldenburg, and I. C. Bourg, *Introduction to Carbon Capture and Sequestration*, World Scientific, 2014.
- M. Goel, M. Sudhakar, and R. V. Shahi, Eds., *Carbon Capture, Storage and, Utilization: A Possible Climate Change Solution for Energy Industry*. New Delhi: TERI Press, 2015.
- R. Guerrero-Lemus, and J.M. Martínez-Duart, *Renewable Energies and CO_2: Cost Analysis, Environmental Impacts and Technological Trends- 2012 Edition*. London: Springer, 2013.
- W. Kuckshinrichs, and J.F. Hake, Eds., *Carbon Capture, Storage and Use: Technical, Economic, Environmental and Societal Perspectives*. Springer International Publishing, 2015.
- S.A., Rackley, Carbon Capture and Storage. Elsevier Science, 2009.

Course Code : **SGT 701**

Course Title : **Research Methodology**

Credit Hours : **3**

Course Description

This course aims to give you an introduction to the research methods most often used in fundamental and applied research. Students will gain a knowledge and understanding of the concepts and terminology of empirical methods used in the field. Research design, data collection, analysis, validity, and report writing will all be covered.

The Thesis writing is also covered. Quantitative research methods are included in this course as they are appropriate for certain research investigations. Selection of a particular research method will be determined based on the problem under investigation and its underlying assumptions.

Course Objectives

The student will be able to:

- Acquire skills to locate problem areas in organizational settings, and plan, organize, design, and conduct research to help solve the identified problems.
- Gather and analyze data, using both qualitative and quantitative methods.
- Write and present research reports.
- Develop skills and knowledge to discriminate "good" from "bad" research reported in academic, business, and trade journals.

Course Topics

Week No. 1: Introduction to Research.
Week No. 2: The Research Process.
Week No. 3: Choosing a Research Problem : Reviewing Literature.
Week No. 4: Why do we need research?
Week No. 5: Formulating the Research Problem.
Week No. 6: Identifying Variables.
Week No. 7: Selecting the Sample.
Week No. 8: Data Collection.
Week No. 9: Data Processing (Statistical Analysis).
Week No. 10: Displaying Data.
Week No. 11: Technical Writing: Complies 3 Parts.
Week No. 12: Part a: Writing a Research Proposal.
Week No. 13: Part b: Writing a Report.
Week No. 14: Part c: Writing a Thesis.
Week No. 15: Part c: Writing a Thesis.

References

- D. V. Thiel, *Research Methods for Engineers*. Cambridge University Press, 2014.
- J. Blackwell and J. Martin, *A Scientific Approach to Scientific Writing*. Springer, 2011.
- R. A. Day and B. Gastel, *How to Write and Publish a Scientific Paper*. Greenwood, 2011.
- مناهج وأساليب البحث العلمي – النظرية والتطبيق– الدكتور يحي مصطفي عليان والدكتورعثمان محمد غنيم – دار صفاء للنشر والتوزيع، عمان الطبعة الأولى، 2000.
- مناهج البحث العلمي – دليل الطالب في كتابة الأبحاث والرسائل العلمية – الدكتورعبد اللة محمد الشريف ، مكتبة الإشعاع، 1996.
- الكتابة العلمية – الدكتور شريف قنديل– دار حورس للنشر، الأسكندرية، 2004.