Master's Degree in Electrical Engineering

1. Areas of Specialization:

- Energy and Power Systems (Thesis track or Non-thesis track).
- Communication and Network Systems (Thesis track or Non-thesis track).
- Renewable Energy Systems (Thesis track or Non-thesis track).

2. Program Structure

- Four-semester/Thesis track:
  - A total of 39 credit hours distributed as follows.
    - 27 credit hours coursework.
    - 12 credit hours research thesis work.

- Four-semester/Non-thesis track:
  - A total of 42 credit hours distributed as follows.
    - 39 credit hours coursework.
    - 3 credit hours engineering design project work.

- **Proposed study sequence for the first academic year: All specializations/tracks**

Semester 1			Semester 2		
Course ID	**Course Title**	**Cr.**	**Course ID**	**Course Title**	**Cr.**
ELEE 500	Probability and Stochastic Processes	3	ELEE XXX	Specialization Elective	3
ELEE 501	Linear System Analysis	3	ELEE XXX	Specialization Elective	3
ELEE 503	Advanced Control Systems	3	ELEE XXX	General Elective	3
			ELEE 599	Research Methodology	3
Total		**9**	**Total**		**12**

- **Proposed study sequence for the second academic year: All specializations (Thesis track)**

Semester 1			Semester 2		
Course ID	**Course Title**	**Cr.**	**Course ID**	**Course Title**	**Cr.**
ELEE XXX	Specialization Elective	3	ELEE XXX	General Elective	3
ELEE 610A	Research Thesis	3	ELEE 610C	Research Thesis	3
ELEE 610B	Research Thesis	3	ELEE 610D	Research Thesis	3
Total		**9**	**Total**		**9**

- **Proposed study sequence for the second academic year: All specializations (Non-thesis track)**

Semester 1			Semester 2		
Course ID	**Course Title**	**Cr.**	**Course ID**	**Course Title**	**Cr.**
ELEE XXX	Specialization Elective	3	ELEE XXX	General Elective	3
ELEE XXX	Specialization Elective	3	ELEE XXX	General/Specialization Elective	3
ELEE XXX	General/Specialization Elective	3	ELEE 611	Engineering Design Project	3
ELEE XXX	General/Specialization Elective	3			
Total		**12**	**Total**		**9**

3. Program Requirements and Guidelines

- A Thesis/Non-thesis track student must complete
  - 24/15 credit hours from the Core Courses list.
  - at least 6 credit hours from the General Elective Courses list.
  - at least 9/12 from the Specialization Elective Courses list
- The number of completed courses, from the General Elective Courses and Specialization Elective Courses lists, determines the student's area of specialization.
- A non-thesis track student majoring in "Energy and Power Systems", "Communication and Network Systems", or "Renewable Energy Systems" can at most register 9 credit hours from other areas of specialization to be counted in his/her study plan.
- A student may transfer from one specialization to another and/or from one track to another, through filing and submitting a transfer request to the head of the department, after one semester he/she joins the program.
- For the Thesis track option, a student must submit a "Thesis Supervisor Assignment Form" along with a "Thesis Proposal Form" no later than the end of one-third of the second semester of his/her regular graduate studies. A student may not proceed in the Thesis track option, unless his research proposal was approved.

Courses Description

4. Core Courses

ELEE 500 Probability and Stochastic Processes 3(3, 0, 0)
This course is intended as a first semester graduate course on probability and stochastic processes with application to signal processing, communications, estimation and control. The objective is to present a comprehensive coverage of the basic tools needed by an electrical engineering graduate student specializing in the above areas.

Prerequisite: STAT 230 and ELEE 350.

ELEE 501 Linear System Analysis 3(3, 0, 0)
Fundamental concepts in linear system theory: matrix algebra, linear vector space, linear operator; linearity, causality, relaxedness, and time invariance. Input-output and state space models. Solutions of linear dynamic equations and impulse responses. Characteristics of linear systems: controllability, observability and stability.

Prerequisite: ELEE 380 and MATH 215.

ELEE 503 Advanced Control Systems 3(3, 0, 0)
This is a first graduate level course on control systems with an emphasis on controller design. The course will deal mainly with linear systems (or linearized systems), some nonlinear control concepts will be introduced. In class and homework examples will be taken from various application domains and research projects, and MATLAB will be used for analysis, design and simulations of these systems.

Prerequisite: ELEE 380 and ELEE 399L.

ELEE 599 Research Methodology 3(3, 0, 0)
Graduate students working towards the M.S. degree are required to attend the seminars given by faculty, visiting scholars, and fellow graduate students. Additionally, each student must present at least one seminar on a timely research topic. Among other things, this course is designed to give the student an overview of research in the department, and a familiarity with the research methodology, journals and professional societies in his discipline.

Prerequisite: Graduate Standing.

ELEE 610 Research Thesis 3(3, 0, 0)
The student has to undertake and complete a research topic under the supervision of a faculty member in order to analyze and solve a specific problem in the research area related to his/her specialization.

Prerequisite: ELEE 599.

ELEE 611 Engineering Design Project 3(3, 0, 0)
Application of knowledge and skills acquired during the study of the graduate program in the solution of open-ended, advanced level design problems from a technical, environmental and socio-economic viewpoint. Students can work with senior engineers from industry on a specific design project.

Prerequisite: Advisor Consent.

5. General Elective Courses

ELEE 502 Optimization Techniques for Electrical Engineering 3(3, 0, 0)
Optimization theory and algorithms and their application to electrical engineering. Sparse optimization methods, Eigen-decomposition techniques, the expectation maximization algorithms, stochastic optimization techniques, and special techniques relevant to large-scale optimization.
Prerequisite: MATH 215.

ELEE 507 Digital Communications 3(3, 0, 0)
Elements of communication theory and information theory applied to digital communications systems. Characterization of noise and channel models. Characterization of communication signals and systems, representation of digitally modulated signals and spectral characteristics. Optimum receivers for AWGN channels: evaluation of error rate performance and channel bandwidth requirements. Broadcast and Multiple access channels. FDMA, TDMA, and CDMA.
Prerequisite: ELEE 470.

ELEE 514 Environmental Impacts of Energy Systems 3(3, 0, 0)
World energy resources and classifications. Sources and effects of air pollution. Air quality modeling, Gaussian dispersion models. Motor vehicles emissions and noise pollution, mitigation strategies. Environmental impacts of electricity generation, pollution control systems, electromagnetic radiations. Sustainability and environmental impact of different energy technologies, including conventional energy sources as well as renewable and/or clean energy sources. The technological challenges, potential for future development, and environmental impacts (community, regional, and global). The role of renewable energy in the global combat of climate change. Environmental impact assessment.
Prerequisite: Advisor Consent.

ELEE 519 Smart Grids 3(3, 0, 0)
The concept of Smart-grid, with network, components, technologies and trends. Significance to participants throughout the value chain, opportunities, threats, business models and regulatory issues. Integration of distributed variable generation, planning, management, operation, voltage stability and protection Advanced metering systems and intelligent buildings with demand side management and energy efficiency. ***Prerequisite: ELEE 461.***

ELEE 525 Digital Control Systems 3(3, 0, 0)
The course covers the design of practical control systems intended for implementation using digital controllers and embedded systems. In particular, the course covers: digital control systems, discrete systems, stability analysis, digital controller synthesis, digital PID controllers, design of digital controllers, state-space models, observability and controllability, pole placement design, optimal design methods, nonlinear discrete-time systems, digital control of power systems, case studies. ***Prerequisite: ELEE 501 and ELEE 503.***

ELEE 550 Wireless Power Transfer 3(3, 0, 0)
This course provides a comprehensive overview of the emerging field of wireless power transfer (WPT). It presents a multidisciplinary treatment of WPT theory, technology, and applications. Case studies in cutting-edge fields are explored to illuminate the basic concepts and inspire thoughts in future applications.
Prerequisite: Advisor Consent.

ELEE 551 Electromagnetic Compatibility 3(3, 0, 0)
Introduction to Electromagnetic Compatibility (EMC), EMC requirements of electronic systems, signal spectra, non-ideal behavior of components, conducted emissions and susceptibility, radiated emissions and susceptibility, crosstalk, shielding, and system design for EMC.
Prerequisite: ELEE 390.

6. Specialization Elective Courses

a. Energy and Power Systems Elective Courses

ELEE 504 Advanced Power System Analysis 3(3, 0, 0)
A course on optimal dispatch of generation, symmetrical components and unbalanced faults, transient stability, control of generation, state estimation in power systems, and power system simulation.
Prerequisite: ELEE 461.

ELEE 506 Advanced Analysis of Electric Machines 3(3, 0, 0)
Generalized theory of electrical machines, transient analysis in transformers: short circuit forces, inrush currents, transients and dynamics of DC and AC machines (synchronous and induction), special machines: brushless AC motors, switched reluctance motors, linear motors, stepper motors, computer implementation and analysis of electrical machines.
Prerequisite: ELEE 360 and ELEE 463.

ELEE 512 Power System Planning 3(3, 0, 0)
Mathematical methods and modern approaches to power system planning. Demand forecasting. Generation system planning: deterministic and probabilistic methods. Transmission system planning: heuristic and stochastic methods. Optimization methods for transmission planning. Route selection: environmental and other considerations. Distribution system planning: system layout, and choice of components. Power system expansion planning and management. Micro-grids scheduling. Progress of renewable energy in terms of application, construction and operation. Grid-connected and stand-alone renewable energy sources planning, recent-integration requirements, and compatibility with grid codes.
Prerequisite: Advisor Consent.

ELEE 513 Renewable Energy Systems 3(3, 0, 0)
This course seeks to impart in students a sound understanding of renewable energy systems. The course includes: wind energy, solar energy, biomass energy, hydro power and geothermal energy systems.
Prerequisite: Advisor Consent.

ELEE 515 Energy Policy 3(3, 0, 0)
A course that focuses on features of modern energy policy. Topics covered include the interaction among the technological, economic, environmental, and sociopolitical aspects of energy supply and use; electricity, oil, and gas industries, and their market structures. Demand-side energy policy**.** Energy policy selection and analysis, including regulation, taxation, tariffs, feed-in traffic, targets, incentives and market-based. Energy transition. Technical and policy challenges of incorporating renewables. Integration of renewable energy into electricity markets: Standards and requirements. Impact of renewables policy on climate change.
Prerequisite: Advisor Consent.

ELEE 516 Power Electronics Systems and Applications 3(3, 0, 0)
A course that reviews converter topologies for AC/DC, DC/AC, and DC/DC; power supply applications; converter applications to motor drives; utility interface of distributed energy systems; static VAR systems; flexible AC transmission; high voltage DC; power quality control; active and passive harmonics compensation. In addition, this course covers the design and applications of power electronic devices for off-grid and grid connected renewable energy systems.
Prerequisite: ELEE 461 and ELEE 462.

ELEE 517 Electric Power Systems Control and Stability 3(3, 0, 0)
A course on short-term load forecasting, generation unit commitment, economic load dispatch, loss formula coefficients, nonlinear programming, optimal power flow, security assessment, security dispatch, spinning reserve evaluation, automatic generation control, reactive power and voltage control, and state estimation.

Prerequisite: Advisor Consent.

ELEE 518 Energy Efficiency 3(3, 0, 0)
Topics covered in the course include: utility companies and energy supply; energy sustainability; energy use and associated GHG emissions; cogeneration systems: CHP and CCGT; reciprocating engines; distributed generation; demand side management; energy audit: types and data analysis, monitoring and targeting of energy, energy- efficient rotating machines, design and performance optimization. Methods to reduce energy consumption, such as energy labelling scheme, energy management and audit. Building management systems. The impacts of renewable energies on the power system efficiency. Case studies.

Prerequisite: Advisor Consent.

ELEE 520 Protection of Power Systems 3(3, 0, 0)
A course on the elements of protection in power systems mainly targeting design and implementation of protective relays: operating characteristics; power and current directional relays; differential relays; distance and wire pilot relays; protection of generators, busbar, capacitors and reactors; reclosers; under frequency relays; heating and harmonic effects; and Computer-based protective device coordination; instrument transformer (effect of dc component, estimation of CT performance), coupling capacitor voltage transformer.

Prerequisite: ELEE 469.

ELEE 521 Electric Safety and Grounding System Design 3(3, 0, 0)
This course discusses grounding of power systems and equipment; the impact of grounding on system performance, system equipment integrity, safety of personnel as well as safety of the public at large. The course addresses the problem of grounding mainly in distribution systems: the effects on reliability of supply to customers, survivability of end-use equipment, and safety of individuals.

Prerequisite: ELEE 469.

ELEE 522 Special Topics in Energy and Power Systems 3(3, 0, 0)
Advanced topics selected from the broad area of energy and power systems to provide the student with knowledge of recent advances and contemporary development in this area.

Prerequisite: Graduate Standing and/or Advisor Consent.

ELEE 544 Power Systems Operations 3(3, 0, 0)
An advanced course that mainly introduces the basic concepts related to power system operation. It depends strongly on power system analysis. This course will introduce the Electric power generation, transmission and distribution. Unit commitment and economic operation principles; optimal economic dispatch; generation scheduling formulation and solution techniques; optimal power flow solution techniques and applications; state estimation, substation design, load and energy forecasting. Operation of electric grid under high penetration of intermittent renewable resources.

Prerequisite: ELEE 461.

ELEE 545 Advanced Power Distribution Systems 3(3, 0, 0)
Electric power distribution system planning, design and operations; load characteristics and distribution transformers; design of subtranmission lines and distribution substations; primary and secondary feeder design considerations; distribution system voltage regulation, protection and reliability; distributed generation and smart grid application.

Prerequisite: ELEE 461.

ELEE 546 Power System Reliability 3(3, 0, 0)
An advanced course that mainly introduces the basic techniques used in power systems reliability calculations. It depends strongly on Statistics and Probability theory. This course will introduce the Quantitative Reliability, Probability Theory, Stochastic Processes, Frequency Balance, Power System Reliability, Generation System Reliability, Multi-area Power System Reliability, Composite power system.

Prerequisite: STAT 230 and ELEE 461.

b. Communication and Network Systems Elective Courses

ELEE 508 Advanced Digital Communications 3(3, 0, 0)
Digital signaling over channels with intersymbol interference and AWGN. Wireless multipath channel models: time and frequency dispersive channels, level crossing and average fade duration. Diversity concepts: modeling and error probability performance evaluation. Spread spectrum in digital transmission over multipath fading channels, performance analysis and fading mitigation techniques.

Prerequisite: ELEE 507.

ELEE 511 Modeling and Simulation of Communication Systems 3(3, 0, 0)
The course covers the principles and methods for simulation of computer networks and data communication systems. Topics include: Simulation and modeling basics (traffic modeling, link-, system-, packet level simulation, SW/HW in the loop), probability theory fundamentals, random number generation, mobility models, channel models, topology models, graph theory and algorithms, queuing models, queuing networks, network calculus, discrete event-based simulation, Monte-Carlo simulation, rate-based simulation, analysis of simulation results, statistical analysis, visualization of results, simulation languages and tools, simulation packages.

Prerequisite: ELEE 470 and ELEE 500.

ELEE 531 Information Theory 3(3, 0, 0)
This course introduces the field of information theory and its applications to communications theory, computer science, statistics, and probability theory. Covering all the essential topics in information theory, we introduce the basic quantities of entropy, relative entropy, and mutual information, and show how they arise as natural answers to questions of data compression, channel capacity, rate distortion, and hypothesis testing.

Prerequisite: Advisor Consent.

ELEE 532 Queuing Theory 3(3, 0, 0)
A course that covers Poisson counting and renewal processes; Markov chains and decision theory, branching processes, birth death processes, and semi-Markov processes; simple Markovian queues, networks of queues, general single and multiple server queues, bounds and approximations.

Prerequisite: ELEE 500.

ELEE 533 Stochastic Processes, Detection, and Estimation 3(3, 0, 0)
This is a graduate-level introduction to the fundamentals of detection and estimation theory involving signal and system models in which there is some inherent randomness. The concepts that we'll develop are extraordinarily rich, interesting, and powerful, and form the basis for an enormous range of algorithms used in diverse applications. The material in this course constitutes a common foundation for work in the statistical signal processing, communication, and control areas.

Prerequisite: ELEE 500.

ELEE 534 Multimedia and Advanced Signal Processing 3(3, 0, 0)
The course provides an overview of the current multimedia standards and technologies and a brief description of future technologies. It also addresses the fundamental principles and techniques in multimedia signal processing: text, graphics, speech, audio, image, video; standards for multimedia

coding, processing and compression.

Prerequisite: ELEE 451.

ELEE 535 Computer Network Architectures and Protocols 3(3, 0, 0)

This course introduces the concepts and techniques used to model and implement communications between processes residing on independent hosts. The course examines the conceptual framework for specifying a computer network - the network architecture, and investigates the set of relevant protocols. The OSIRM is presented, and the service definitions and protocol specifications for implementing each of the seven layers of the Reference Model are analyzed in detail.

Prerequisite: ELEE 431.

ELEE 536 Wireless Networks 3(3, 0, 0)

The objective of this course is to give an introduction to the fundamentals of the wireless communications systems, the wireless network architectures, protocols, and applications. Topics of study include an overview of wireless communications and mobile computing systems, signal propagation characteristics of wireless channels, wireless channel modeling, frequency reuse/cellular/microcellular concepts, spread spectrum modulation for wireless systems, multiple access techniques, and wireless networking standards (e.g., 2.5G, 3G, IEEE 802.11, IEEE 802.15, IEEE 802.16/WiMAX, LTE).

Prerequisite: ELEE 508.

ELEE 537 Mobile Communications Networks 3(3, 0, 0)

Cellular networks, ad hoc networks; access protocols; radio and network resource management; quality of service; mobility and location management; routing; mobile-IP; current wireless technologies for personal, local and satellite networks.

Prerequisite: ELEE 536.

ELEE 538 Optical Fiber Communication 3(3, 0, 0)

Dielectric slab waveguides. Classification of mode types. Parabolic two-dimensional media. Circular waveguides. Step-index and graded-index optical fibers. Effect of loss. Dispersion effects. Fabrication methods in integrated optics and optical fibers. Light sources. Light Detectors. WDM concepts and 19 components. Optical Amplifiers. Point-to-point link system considerations. Photonic devices. Applications in communication systems.

Prerequisite: Advisor Consent.

ELEE 540 Introduction to Optical Electronics 3(3, 0, 0)

Principles, devices and materials used to generate, modulate, and detect optical radiation. Review of important properties of light and semiconductors. Light-emitting diodes and lasers. Electro-optic modulation. Thermal and quantum detection. Emphasis on semiconductor-based devices and application to fiber-optical communications.

Prerequisite: Advisor Consent.

ELEE 541 Special Topics in Communication and Network Systems 3(3, 0, 0)

Advanced topics selected from the broad area of communication and network systems to provide the student with knowledge of recent advances and contemporary development in this area.

Prerequisite: Graduate Standing and/or Advisor Consent.

ELEE 553 Antennas for Wireless Communications 3(3, 0, 0)

The principles of analysis and design of antenna arrays are discussed. Special attention is paid to antennas popular in mobile (cellular, satellite) telecommunications: Fundamental parameters; radiation integrals; wireless systems; wire, loop, and microstrip antennas; antenna arrays; smart antennas; ground effects; multipath.

Prerequisite: ELEE 390.

ELEE 555 RF System Engineering for Wireless Communications 3(3, 0, 0)
This course introduces students to system blocks, system parameters, and architectures of RF systems for wireless communications. It focuses on the design of a radio system for transmission and reception of voice and data information: receivers and transmitters system topologies, key system blocks in a wireless system, determination of system block parameters from radio requirements and system analysis, tradeoffs between various blocks in a radio system, and frequency planning. It discusses how modulation and demodulation schemes and multiple-access techniques used in present wireless applications influence RF systems requirements. The last part of the course focuses the link budget analysis of RF radio links.

Prerequisite: ELEE 470.

c. Renewable Energy Systems Elective Courses

ELEE 512 Power System Planning 3(3, 0, 0)
Mathematical methods and modern approaches to power system planning. Demand forecasting. Generation system planning: deterministic and probabilistic methods. Transmission system planning: heuristic and stochastic methods. Optimization methods for transmission planning. Route selection: environmental and other considerations. Distribution system planning: system layout, and choice of components. Power system expansion planning and management. Micro-grids scheduling. Progress of renewable energy in terms of application, construction and operation. Grid-connected and stand-alone renewable energy sources planning, recent-integration requirements, and compatibility with grid codes.

Prerequisite: Advisor Consent.

ELEE 513 Renewable Energy Systems 3(3, 0, 0)
This course seeks to impart in students a sound understanding of renewable energy systems. The course includes: wind energy, solar energy, biomass energy, hydro power and geothermal energy systems.

Prerequisite: Advisor Consent.

ELEE 515 Energy Policy 3(3, 0, 0)
A course that focuses on features of modern energy policy. Topics covered include the interaction among the technological, economic, environmental, and sociopolitical aspects of energy supply and use; electricity, oil, and gas industries, and their market structures. Demand-side energy policy**.** Energy policy selection and analysis, including regulation, taxation, tariffs, feed-in traffic, targets, incentives and market-based. Energy transition. Technical and policy challenges of incorporating renewables. Integration of renewable energy into electricity markets: Standards and requirements. Impact of renewables policy on climate change.

Prerequisite: Advisor Consent.

ELEE 518 Energy Efficiency 3(3, 0, 0)
Topics covered in the course include: utility companies and energy supply; energy sustainability; energy use and associated GHG emissions; cogeneration systems: CHP and CCGT; reciprocating engines; distributed generation; demand side management; energy audit: types and data analysis, monitoring and targeting of energy, energy- efficient rotating machines, design and performance optimization. Methods to reduce energy consumption, such as energy labelling scheme, energy management and audit. Building management systems. The impacts of renewable energies on the power system efficiency. Case studies.

Prerequisite: Advisor Consent.

ELEE 544 Power Systems Operations 3(3, 0, 0)
An advanced course that mainly introduces the basic concepts related to power system operation. It depends strongly on power system analysis. This course will introduce the Electric power generation,

transmission and distribution. Unit commitment and economic operation principles; optimal economic dispatch; generation scheduling formulation and solution techniques; optimal power flow solution techniques and applications; state estimation, substation design, load and energy forecasting. Operation of electric grid under high penetration of intermittent renewable resources.

Prerequisite: ELEE 461.

ELEE 546 Power System Reliability 3(3, 0, 0)

An advanced course that mainly introduces the basic techniques used in power systems reliability calculations. It depends strongly on Statistics and Probability theory. This course will introduce the Quantitative Reliability, Probability Theory, Stochastic Processes, Frequency Balance, Power System Reliability, Generation System Reliability, Multi-area Power System Reliability, Composite power system.

Prerequisite: STAT 230 and ELEE 461.

ELEE 572 Solar Photovoltaic Systems 3(3, 0, 0)

This course explores the solar cell types, solar photovoltaic (PV) technologies, design, and installation of solar PV systems and their applications both off-grid and on-grid. Both centralized solar power plants and distributed topologies will be considered. Techno-economics of power generation through solar PV technology. It also covers the economic analysis of a PV project and its environmental benefits. Case studies.

Prerequisite: ELEE 468 and/or Advisor Consent.

ELEE 573 Wind Energy Systems 3(3, 0, 0)

An overview of energy sustainability and wind energy history. Wind resources characteristics. Fundamentals of physical wind, basic meteorology of wind, extraction of energy from wind. Basic introduction to wind energy and energy conversion systems. Various types of wind energy, conservation systems and aerodynamics; blade and tower structural loads, kinematics of blades and meteorology. Wind plant development, and environmental and ecological impact of wind energy plants. On and off-grid wind energy systems.

Prerequisite: ELEE 468 and/or Advisor Consent.

ELEE 574 Energy Conversion and Storage 3(3, 0, 0)

An introduction to the principles, theories, and processes of devices and systems that convert thermal, chemical, nuclear, and electromagnetic energy into electrical or mechanical forms. Analysis of energy conversion and storage in thermal, mechanical, nuclear, chemical, and electrochemical processes in power systems, with emphasis on efficiency, performance, and environmental impact. Energy conversion and storage performance characteristics in a variety of applications that include conventional fossil energy combustion-based systems, nuclear, solar, wind, and biomass systems. Energy storage types (i.e., batteries, electrolysers, compressed air, fuel cells, and flywheels).

Prerequisite: Advisor Consent.

ELEE 575 Green Buildings 3(3, 0, 0)

This course will cover the principles of green building design and construction, including incorporating green principles in renovating and remodeling, and preservation of historic structures as well as new buildings. Energy efficiency, indoor environmental quality, and sustainable building materials. Greenhouse gas production, climate-appropriate building design, implementing energy efficiency measures. Prediction of building thermal, lighting, and solar access. PV modules in greenhouse building envelope. Technical aspect of the use of PV in buildings and the urban environment, such as heat transfer processes, partial shading, and mismatch and system siting, sizing and configuration will be investigated. System performance assessment and prediction.

Prerequisite: Advisor Consent.

ELEE 576 Hydrogen Energy Systems 3(3, 0, 0)

This course will cover hydrogen production, storage, distribution, and use. Specific energy scenarios such as renewable hydrogen cycles will be explored focusing on transportation applications. Introduction to fuel cell technologies; Fuel cell components and systems; field flow plates, electrolytes, electrode materials, electrode catalysts, on-board reformers. Portable devices, utility-scale power production, transportation systems. The concept of hydrogen economy will be discussed in the context of global energy crisis.

Prerequisite: Advisor Consent.

ELEE 577 Special Topics in Renewable Energy Systems 3(3, 0, 0)

Advanced topics selected from the broad area of renewable and sustainable energy systems to provide the student with knowledge of recent advances and contemporary development in this area.

Prerequisite: Graduate Standing and/or Advisor Consent.