Dept of Electrical & Electronic Eng
Structured M.Eng in Smart Grid Technology: 2018

Administrative / Academic Requirements

General:

This is a new course offering by the Dept of E & E Eng, in response to worldwide evolutional processes in the electrical energy domain. These are seen to be technologically very exciting, but will also have considerable impact on conventional networks, in the near to medium future.

Admission:

Prerequisite: Any four year engineering B-degree, any BTech degree in engineering, or a BSc degree with a major in Physics

Duration and Teaching Load:

One, or two years; Full time basis or part-time basis. One week block per module with 45 hours of contact and additional work via distance education. Successful completion of all modules is followed by a thesis project, as set out elsewhere. Each block carries 15 credits and the project 60 credits. Modules are presented on both NQF levels 8 and 9, but at least four modules must be taken at NQF level 9.

Course Module Descriptions

1. Renewable Energy Systems

This course forms the foundation of the various modules in Renewable and Sustainable Energy Studies. It will provide course participants with an overview of the most significant renewable energy resources, concepts, technologies and challenges to overcome climate change and other sustainable development goals and an insight into the possible solutions to sustainable energy usage. Course participants will be able to recognise, understand and evaluate the different renewable energy resources available today and in the future. The main themes will include:

- Basic Energy Concepts;
- Conversion of Energy;
- Renewable Energy Resources:
- Hydro-Energy
- Geothermal Energy
- Tidal, Wave and Ocean Energy
- Wind Energy
- Solar Thermal Energy
- Photovoltaic Systems
- Renewable Energy Scenarios;
- Case studies of renewable energy systems.

2. Advanced PV Systems

The aim of the course is to provide attendees with the understanding and tools to design grid-tied (including hybrid configurations with backup power) PV systems within the South African solar resource, technical and legislative contexts. The underlying design criteria will be to optimise the energy yield versus lifecycle costs of the PV system within the given resource, technical and legislative constraints, i.e. the optimising the financial viability of the system.

Specifically, the following topics will be covered:

- Solar resource & irradiation data sources
- Different solar PV technologies
- Photo-voltaic panel: electrical characteristics, maximum power point, influence of shading & diffuse irradiation, etc.
- Photo-voltaic array: impact of positioning & tracking, string design and DC cable sizing, etc.
- Connection to the distribution grid: power electronics basics, earthing and circuit-breaker design, system sizing, AC cable sizing, South African regulations & standards, etc.
- Financial viability: understanding tariffs, payback, etc.

3. Renewable Energy Finance

(Presented by: School for Public Leadership - SPL)

The global drivers of decoupling economic growth and addressing climate change have seen much emphasis placed on the development of renewable energy projects. This module enables participants to understand the parameters that influence the financial aspects and project design of renewable energy initiatives in Africa. The participant will get to be familiar with a range of instruments, the financial structuring tools needed to attract investors, and how to use alternative financial sources, like carbon finance, outside of the commercial financial institutions to ensure the financial viability of renewable energy projects. The module therefore aims to empower professionals to incorporate appropriate financing into their decision-making pertaining to renewable energy projects. The module is mainly aimed at sensitising participants to qualitative issues in renewable energy projects, but also enables participants to deal with quantitative measures.

This includes:

- The basic financial metrics such as IRR, NPV and DSCR,
- Understanding the economic justification and impact of renewable energy projects,
- Understanding of what sustainability drivers have an effect on the renewable energy business,
- Understanding what barriers exist to renewable energy project implementation from a financial perspective
- Understanding what opportunities exist to facilitate renewable energy implementation.

4. Energy Storage Systems

The objective of the module is to enable participants to understand the concepts and technologies used for electric Energy Storage (ES). The course highlights Lithium Ion (Li-ion) batteries as the dominant technology in new projects and addresses the complex safety, performance and life issues of this technology. The technical and financial parameters that drive the project designs of grid-connected and off-grid ES will be discussed. The participant will become familiar with the major factors that determine ES selection and sizing, and be provided with various case studies to use as benchmark. The module therefore aims to provide professionals with sufficient understanding to establish the key requirements and financial benefits of ES in various grid-connected and off-grid applications.

Contents:

- Introduction: The need for Energy Storage
  - Proliferation of Renewable Energy => intermittent generation
  - Load variability
  - The utility's challenge: balancing IN and OUT in real-time
  - How storage can help
- Large Scale Energy Storage services and benefits
  - Key parameters of Energy Storage
  - 15 individual benefits
  - Stacked benefits
- Global storage project examples and statistics
  - Energy Storage Technology cost, performance and maturity
  - Macro overview and comparison of available technologies
  - Anatomy of a battery
  - Top 5 storage types in more detail
  - Examples of specific products available
- Energy Storage sizing and selection
  - Use of an open source tool
  - Understanding storage Life-Cycle Cost
  - The selection and sizing of Energy Storage for certain applications
  - Large off-grid hybrid PV/storage worked example
  - Small-scale Energy Storage applications
  - The economic impact of adding Energy Storage to certain applications
  - The regulations and safety issues related to Energy Storage systems

5. Integrated Demand Side Technologies

The perspective of this course is a view from the energy demand, or user, side of a network. The field-specific knowledge considered and applied in this module is:

- Quality of supply
- Load models and modelling strategies
- Short-term load forecasting
- Load growth modelling for network planning
- Demand side management (load shifting, energy efficiency, demand response)
- Concepts within measurement & verification
- Advanced metering infrastructure and data management
- Tariff design (pricing signals, real-time pricing, reseller scenarios)
- Mini- and microgrids (topologies, control, optimisation)

The problems considered in this module mostly require analysis and/or synthesis, and have the predominant nature of (a) routine application of the available technology and (b) a critical, engineering sciences-based evaluation of the suitability of alternative solutions and technologies. The students' problem-solving ability is further developed in homework and tutorial assignments, through discussing pertinent experience from application practice, evaluating the application of empirical data and presentation of illustrative examples.

6. Integrated Supply Side Technologies

This course presents the problems and options from the viewpoint of the energy supply side. A prime component of the course is energy load flow modelling, simulation and analysis. The field-specific knowledge considered and applied in this module is:

- Basic electrical / mechanical power system concepts
- Long-term load forecasting as input to IRPs.
- Power delivery characteristics (ramp rates, minimum on/off requirements, efficiencies under different loading conditions) of conventional power stations, such as coal-fired, nuclear, gas and solar thermal, presented within the context of the various thermodynamic cycles used in these power stations.
- The power delivery characteristics of intermittent renewable power stations such as wind farms and large, grid-connected PV systems, presented within the context of temporal and geographic solar and wind resource availability, and plant technical constraints.
- The power delivery characteristics of utility-scale energy storage.
- Economic dispatch
- Utility-scale energy storage scheduling optimisation
- Load-frequency control and inter-area power flow
- Dynamic system stability and the concept of inertia
- Overview of applicable network codes and regulations.
- Introduction to fault calculation and protection strategies.
- Business models for the future utility
- Power system modelling and simulation software
- Grid code compliance

Students will be further required to solve problems via tutorial assignments and discussions of applications and illustrative examples.

7. Smart Grid Technology Overview

This module will provide a broad overview of all components and technologies associated with, and connected to, the new Smart Grid. The field specific knowledge to be covered would be:

- Renewable Energy Systems and characteristics
- Grid code compliance
- PV components and sizing
- Storage components, eg. batteries
- Microgrids and power flow
- Network dynamics and stability
- Economics of SG installations
- Communications technology and selection

8. Smart Grid Communications

This course will cover the fundamentals of communications, before proceeding to the various techniques of transferring data from A to B. Concepts such as bandwidth, network capacity, performance metrics, data integrity, and communications media will be covered. Subsequently the different communications technologies, both wireless and cable based, will be introduced, followed by their characteristics and application areas. Smart Grid networks and their specific requirements, will be a focus area. The course will cover:

- Overview of course
- What is information
- Data transmission media intro, ie. Cu cable, radio, optical
- Waves, Spectrum and Units
- Information Transfer
- Modulation and demodulation fundamentals
- Noise and SNR
- Antennas, quick and simple
- Digital Transmission, ie ASK, FSK, PSK, Spread Spectrum
- Data Transfer – Radio: Technology overview: *VHF, UHF, Microwave, Microwave links, GSM / GPRS, 3G / LTE, WiFi: 802.11 a/b/g/n/ac, Internet of Things (IoT)*
- Data Networking Basics, *Switches & Routers, Network topologies, Protocols overview*
- Smart Grid Specific Technology
  Industrial interfaces & protocols
  Switchgear / electrical control interfaces
  Network performance
  Performance criteria for distributed SG comms
  Data transfer integrity
  Wide area network types and principles
  Telemetry for SG
  Rural network options

9. Project 884

Prerequisite:

Admission to the MEng (Structured) in Electrical & Electronic Engineering and completion of all the other required modules in the program.
Total credits of module: 60

Content:

A project that entails formulating objectives, planning the project, surveying the relevant literature and applying what was learned in the modules, as well as from the literature review and own research, to an electrical engineering research project. Critical evaluation of the research results will also be required.
The project is individually supervised.