DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

Postgraduate Diploma in Engineering (Smart Grid Technology): 2021

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: To qualify for admission to our PG Dip (Eng.) program in Smart Grid Technology, the applicant must hold at least a B Tech or a BSc degree.

Duration and Teaching Load:
One, or two years; Full-time basis or part-time basis. Successful completion of 8 week-long modules (15 credits each) at NQF8 level is required.

Course Module Descriptions

Common Modules (3):

The Faculty of Engineering has identified some modules that cover aspects considered to be common to all branches of Engineering. Students following PG Dip (Eng.) programmes have to include the following **three** modules in their curricula. The modules are listed below and content descriptions are provided in Appendix A.

Module Title	Code	Host Department	Credits
Data Science 774	14190	Industry Engineering	15
Project Management 713	51993	Industry Engineering	15
Project Economics and Finance 712	58157	Civil Engineering	15

Compulsory E&E Modules (4):

The course modules presented by Department of Electrical and Electronic Engineering that are the core modules of the PGDip (Eng.) in Smart Grid Technology are listed below. Students are required to complete all these **four** modules.

Module Title	Code	Host Department	Credits
Smart Grid Technology Overview 774	13808	E&E Engineering	15
Integrated Supply Side Technology 774	13806	E&E Engineering	15
Smart Grid Communications 774	13807	E&E Engineering	15
Integrated Demand Side Technology 774	13805	E&E Engineering	15

Elective Modules (1):

In addition, students are also required to select **one** additional elective module from the list below:

Module Title	Code	Host Department	Credits
Advanced PV Systems 744	13364	E&E Engineering	15
Energy Storage Systems 774	13810	E&E Engineering	15
Wind Energy 744	13185	M&M Engineering	15

APPENDIX A: COURSE MODULE DESCRIPTIONS:

INTEGRATED DEMAND SIDE TECHNOLOGIES (13805-774)

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 micro-grids (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.

INTEGRATED SUPPLY SIDE TECHNOLOGIES (13806-774)

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, and 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.

SMART GRID TECHNOLOGY OVERVIEW (13808-774)

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, e.g. batteries
- Micro-grids and power flow
- Network dynamics and stability
- Economics of SG installations
- Communications technology and selection

SMART GRID COMMUNICATIONS (13807-774)

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, i.e. Cu cable, radio, optical
- Waves, Spectrum and Units
- Information Transfer
- Modulation and demodulation fundamentals
- Noise and SNR
- Antennas, quick and simple
- Digital Transmission, i.e. 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

ADVANCED PV SYSTEMS (13364-744)

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.

ENERGY STORAGE SYSTEMS (13810-774)

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

WIND ENERGY (13185-744)

Host: Department of Mechanical and Mechatronics Engineering

This module deals with the harvesting of energy from wind and water. It addresses the availability of the resources, the types of systems and machines, their capabilities and limitations, the processes of setting up such systems, and their associated costs and environmental impacts. The main elements of the course are listed below.

- Wind Power: Brief history, current state of industry and industry drivers. Predominant technologies, theory of operation, electromechanical and aerodynamic principles. Fundamentals of power quality and grid integration. Wind energy facility development process and methodologies, including wind resource assessment. Feasibility factors such as energy capture calculation, environmental impact assessment, grid studies and essential economics

PROJECT MANAGEMENT (51993-773)

Host: Department of Industrial Engineering

The module focuses on advanced topics in project management, and it is expected that participants have either attended a project management course or have experience in managing projects. The module builds on the traditional project scheduling by addressing critical chain management and looks at managing project risks through the identification and assessment of risk potentials and mitigating strategies, including resource / cost management and contingency planning. The selection of appropriate teams and structures to facilitate contract management are discussed, along with executing project leadership through proper communication channels. The importance of procurement, from tender procedures through to supplier selection will be highlighted. The different nuances between commercial and research projects will be explained.

DATA SCIENCE (14190-774)

Host: Department of Industrial Engineering

Data science is the application of computational, statistical, and machine learning techniques to gain insight into real world problems. The main focus of this module is on the data science project life cycle, specifically to gain a clear understanding of the five steps in the data science process, namely obtain, scrub/wrangling, explore, model, and interpret. Each of these steps will be studied with the main purpose to gain an understanding of the requirements, complexities, and tools to apply to each of these life cycle steps. Students will understand the process of constructing a data pipeline, from raw data to knowledge. Case studies from the engineering domain will be used to explore each of these steps.

PROJECT ECONOMICS & FINANCE (58157-712)

Host: Department of Civil Engineering

The module focuses on how to finance a business opportunity (project) that can be isolated from the rest of a company's business activities. Financing through a combination of debt and equity are discussed, based on the future profitability of the project where project cash flow is the main source of capital recovery and the project assets are the only collateral. The concepts of construction loans and public-private partnerships are discussed. A number of case studies

will be covered in the module, including projects to construct a bridge, a satellite and a wind turbine farm. Current module content:

- Infrastructure and development finance: Sources of business finance and private sector project financing models.
- Review of: time value of money / discounted cash flow / interest calculations.
- Basic accounting statements (balance sheet, income and cash flow statements.
- Costing and management accounting – theory / techniques and costing system concepts.
- Ratio analysis, from basic ratios to the DuPont approach.
- Economic analysis of investment decisions.
- Market valuation (EVA and MVA).
- Value drivers in the company, sustainability and the Balanced Scorecard.
- The national accounts and economic growth.
- Feasibility studies and techno economic analysis:
- System identification, parameter identification, environment and system boundary
- Definition, environmental scanning, system modelling and simulation concepts, modelling
- Risk and uncertainty in infrastructure finance and project development.
- Materials, labour and equipment: Impact of required service and quality levels. Cost estimation and cost controls of construction projects.
- Revenue stream estimating and modelling. Financing models.