THE UNIVERSITY OF TRINIDAD AND TOBAGO

Centre for Energy Studies

Empowering Communities
Protecting the Environment
Shaping Policies

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1.0 EXECUTIVE SUMMARY

The Energy Research Group will conduct innovative, marketable and value added research covering emerging Renewable / Alternative Energy and Green Technologies. The group has identified six core areas:

1. Renewable Energy and Green Technology
2. Power Systems and Electro-Technology
3. Demand-Side Management
4. Environmental protection
5. Thermal System Optimisation
6. Petroleum Studies

These core areas cover the range of technologies of interest in the following areas:

a) Energy Conservation Technologies

b) Energy Management

c) Energy Efficiency Enhancement

d) Energy Demand-side Management

e) Clean Fuel Combustion Technology

f) Bio-Fuels (especially algae and local plants)

g) Bio-gas and Hydrogen Technology

h) Hybrid Co-Generation for Electricity and Water Desalination

i) Wireless SCADA and Automation Systems

j) Electric Vehicles and Hybrid Drive Systems

k) Power Quality and Voltage Stability

This comprehensive Research initiative will investigate the following specific energy areas:

a) Thin-film efficient photovoltaic system utilization

b) Wave/Tidal/Small Hydro Energy utilization

c) Wind Energy utilization

d) Waste to Energy – Plasma Technology

e) Sewage to Energy – Bio-reactors

f) On-line Electric Energy Management Systems

g) Proton Exchange Membrane (PEM) - Fuel Cell, Hydrogen Utilization Technology

h) Demand Side Management (DSM) Technologies

i) On-line Energy Monitoring and Anomaly Detection

j) Hybrid – Dual Fuel Systems (Diesel – NG), (Diesel, Electric) for Motor Drives, Transportation and Loco-Motives

k) Efficient Fuel Combustion / Burning Technologies

l) Bio-Fuels from Algae

m) Biodiesel from recycled oils and indigenous plants.

n) Energy Efficient Utilization in Smart Buildings

o) AI – Soft Computing, Anomaly, Failure, Fault Detection and Monitoring Systems for Electric Equipment and Electro Mechanical Systems

p) Electric Utility Planning and Security Reliability Studies

Some of the current research activities:

CORE AREA	Project Title	Project Description	Researchers
Renewable Energy and Green Technology	Waste to Energy utilising Plasma Technology	This project seeks to fulfil part of the Government's keen plan to find solutions for the increasing waste and use of landfills and at the same time provide an alternative source of "green" energy. Plasma gasification Technology is being employed to convert the waste to energy.	Kamel Singh, Solange Kelly, Adel Sharaf, Mohammed El Sayed
Power Systems and Electro-Technology	Decision coordination for asset management of industrial equipment	To develop maintenance and operations tools aimed at aiding Asset Managers gain maximum economic benefit out of critical plant equipment	Arvind Singh K. D. Srivastava
Thermal System Optimisation	Application of Exergoeconomics to the Optimisation of a Chemical process plant.	Optimisation of the PCS Nitrogen plant based on the principles of exergy and exergoeconomics	Solange Kelly Kamel Singh Nick Ramnarine (Beng Student)
Power Systems and Electro-Technology	Online Power Quality System	This project is being done in fulfilment of a PhD thesis. It seeks to incorporate AI based techniques including particle swarm optimization to monitor power quality, to detect anomalies and to predict failures/faults in the power grid.	Sohan Heerah, Adel Sharaf

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CORE AREA	Project Title	Project Description	Researchers
Thermal System Optimisation	Feasibility Study of a Hybrid Fuel Cell Power Generating System	This project entails an energy and exergy analysis of a solid oxide fuel cell / gas turbine power plant. The primary goal is to compare the first and second law performances of the power plant with and without the fuel cell.	Denver Cheddie, Adesh Pragg (B.Eng student).
Demand-side management (DSM)	Facility energy management and conservation	DSM measures to delay installing new electricity generating capacity and optimize use of natural-gas resource through: • Energy-efficient air conditioning strategies, and • Smart-building technologies for energy efficiency	Sharaaz Hosein Adel Sharaf Mohammed El Sayed
Environmental Protection	Implementing a national carbon exchange market and developing the small scale carbon reduction/ renewable technology sector	Focus on the policy, regulatory and economic factors required to implement a national carbon exchange market. Modelling and simulation approach to support introduction of a pilot programme for industrial sector. Techno-economic studies to support entrepreneurship and investment in small scale carbon reduction/ sequestration and renewable technologies.	Kalim Shah Adel Sharaf

2.0 Centre for Energy: Overview

The Centre for Energy Studies was established to conduct research into renewable/green energy technologies, more efficient use of existing energy sources, and environmental issues. The Ministry of Energy has recognized the need to reduce the levels of greenhouse emissions, hence the requirement for more environmentally friendly means of power generation. There is also the need to preserve the natural resources of Trinidad and Tobago (namely oil and natural gas) by employing technologies that use them more efficiently. Considering the limited nature of these resources, it is imperative that the nation's long term energy supply be protected by conducting meaningful research into renewable energy sources and technologies.

To facilitate these national energy-related imperatives, the Centre for Energy has identified six (6) core research areas:

1. Renewable Energy and Green Technology
2. Power Systems and Electro-Technology
3. Demand-Side Management
4. Environmental Protection
5. Thermal Systems Optimisation
6. Petroleum Studies

While these areas are limited to discrete entities, there will be significant collaboration and synergy between and among them. This is the single most important operating principle for the Centre for Energy.

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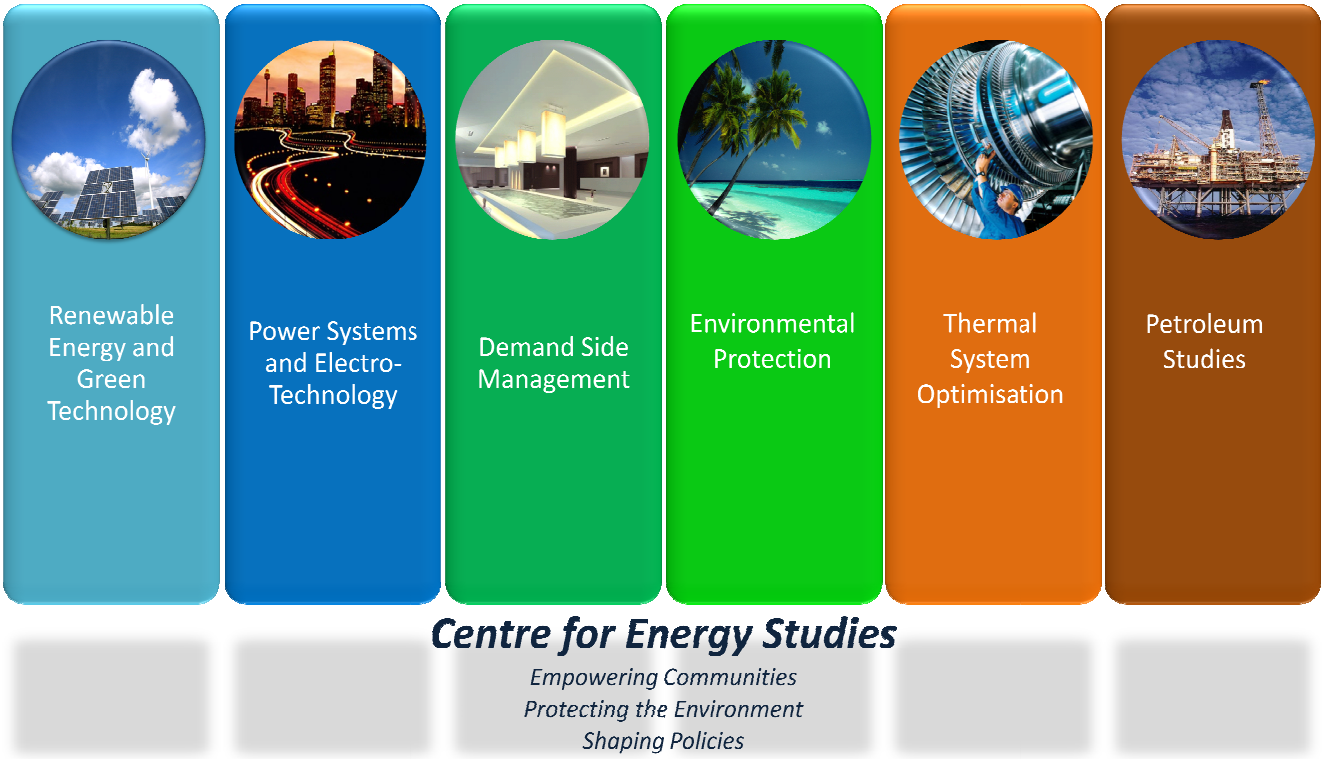
2.1 Core Areas



Renewable Energy

Renewable energy is energy generated from natural resources such as sunlight, wind and ocean tides. Utilizing such sources of energy for island Caribbean States will result in an increased opportunity for a more sustainable energy supply and thereby contributing to the region's social and economic development.

Research topics in this area include:

- ❑ Waste (Municipal Solid waste and Sewage) to Energy
- ❑ Developing a Hydrogen Economy
- ❑ Solar, Wind and Ocean Energy
- ❑ Renewable Energy Technologies for Electricity and Desalination
- ❑ Bio Fuels Energy

Power Systems and Electro-Technology

Electro-technology which involves working with all aspects of electrical, electronic and communications technology offer reduced operating cost and improve energy utilization when applied to power systems.

Research topics in this area include:

- ❑ Wireless/SCADA and Automation Technologies for Energy Control and Efficient Utilization
- ❑ Micro Grid Hybrid Schemes for Cottage Electricity.
- ❑ Electro-Chemical and Electromagnetic/Electrostatic Germicidal

Demand Side Management

Demand Side Management (DSM) is the implementation of policies and measures which influence (by reducing) the quantity of use of energy consumed by end users.

Research topics in this area include:

- ❑ Smart Building and Energy Smart Technologies
- ❑ Energy Conservation Technologies
- ❑ Energy Efficiency Measures

Environmental Protection

Protecting the Environment is of utmost concern in this century. With high levels of air, land and sea pollution, it has become imperatives that both technology and policy work together to reduce the rate at which our planet is being destroyed.

Research topics in this area include:

- ❑ Small Scale Pollution Abatement and Scrapper Technologies

- Control and Disinfection Technologies

Thermal System Optimisation

The design of both efficient and cost effective energy conversion systems is an on-going challenge facing energy engineers. With the increasing need to reduce the impact of waste from these systems on the environment and an ever increasing global demand for energy, especially in developing countries, it is becoming extremely important to develop even more accurate and systematic approaches for improving the design of energy systems.
Research topics in this area include:

- Co-generation Systems
- Exergy/Exergoeconomic Analysis of Thermal Systems.

Petroleum Studies

Petroleum studies include the bringing together of geologists, geophysicists, petroleum engineers and other technologists to advance the state of the art in exploration and reservoir management without negatively impacting the environment while at the same time increasing the resource base production levels of such resources.
Research topics in this area include:

- Thermal Recovery of Heavy Oil
- PVT Properties for CO_2 Enhanced Recovery
- Reaction Kinetics in Biodiesel manufacture
- Revitalization of Abandoned Oilfields
- Dynamics of Wind Generation
- Use of Brown's gas fuel in Alternate Fuels
- Direct Methanol injection in Fuel Cells
- Risk & Uncertainty in Natural Gas Value Chain
- Heavy Oil Recovery by In-Situ Combustion
- Exploitation of Tar Sands

2.2 Personnel

Table 1: List of Researchers in the Centre for Energy

Researcher	Major research interest	Minor research interest
Prof. Adel Sharaf	Power Systems & Electro-technology	Green & Renewable Energy
Prof. Mohammed El Sayed	Power Systems: Operation, Planning, Reliability	Power System Analysis, Artificial Intelligence Applications on Power systems, Renewable Energy
Dr. Adel El-gammel	Electric Power and Machines, Electric Drives, Computer-Based Controllers, Computer Simulation	Artificial Intelligence Applications on Power Systems, Energy Technology/Green Renewable Energy
Dr. Denver Cheddie	Modeling and simulation of fuel cells, Hybrid fuel cell systems for power generation, Implementation of a hydrogen economy in the Caribbean	Renewable energy technologies
Dr. Sharaaz Hosein	Demand Side Management	Methanol to power Facility energy management
Mr. Rodney Jagai	Petroleum Engineering Studies	Heavy Oil Recovery, Alternate Energy

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Researcher	Major research interest	Minor research interest
Mr. Kamel Singh	Design of Machines	Green and Renewable Energy
Dr. Solange Kelly	Thermal System Optimization, Exergoeconomics, Exergy Destruction	Green and Renewable Energy (waste to energy)
Dr. Arvind Singh	Power Systems, Infrastructure interdependency modeling	AI Applications in Monitoring and Fault Detection, Energy conservation
Dr. Tennyson Jagai	Petroleum Engineering	PVT analyses, Improved Oil Recovery, Miscible CO_2 flooding
Dr. Adel Mnaouer	Routing and MAC layer design in Wireless Network (Ad hoc, Mesh and sensor Networks). Cluster, Grid and Cloud computing.	Online fault prediction/prevention using Wireless sensor Networks and Multi-agent technologies. Soft Computing techniques applied to Green Renewable Energy.
Dr. Puran Bridgemohan	Agronomic potential of crude fat content, Efficient extraction, purification and filtration techniques, energy conversion - electricity and diesel	Harnessing solar and wind energy for agricultural operations: irrigation, electricity, dryers
Dr. Kalim Shah	Environmental management and policy	Environmental performance indicators, environmental policy modeling and analysis

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Researcher	Major research interest	Minor research interest
Mr. Sohan Heerah	Neural Networks- Application to Power Systems	Analog Electronic devices. Green and Renewable Energy
Mr. Anthony Alexander	Gas turbines, Combined Cycle technology, Automotive engineering	Wind Power Technology

3.0 Centre for Energy Activities

3.1 Planned Activities

1) Renewable and Clean Energy prototyping and Demonstration Projects
2) Applications of Green Energy (Electricity Supply and Water Desalination)
3) Educational and Promotional public awareness Seminars, Conferences, Lectures and Programmes regarding energy; energy conservation; energy efficiency.
4) Agri-business and sustainable farming including bio-fuel; bio-reactors; methane and hydrogen production for electricity generation, water pumping, farm mechanisation, drying processing; heating and refrigeration.
5) Green Plug Filters, FACTS Compensators
6) Power Quality Enhancement and STATCOM Devices
7) FACTS Based Active Power Filters
8) Educational degree programmes and short courses

The Research Activities will be supported by specialized Faculty Members and up to (20) Graduate Students in addition to four (4) dedicated laboratories, viz.

1) Sustainable Electrical Energy Laboratory (SEEL) **(Approved)**
2) Clean Energy Electro Technical Lab (CEEL) **(Approved)**
3) Intelligent Soft Computing Control Laboratory (ISCC) **(Approved)**
4) Computerized AI-Based Anomaly (CAD-M) Detection and Monitoring **(Proposed)**

3.2 Short-term Consulting and Training Services

The Energy Group will provide short-term consulting services and Training courses/Workshops in the different specialization areas to businesses, Industry and the Commercial Sector, in collaboration with the Professional Education Unit (PEU) and the newly proposed Office of Research and Consulting Services (ORCS). Table 2 lists the short courses being offered.

3.3 New Educational Programmes

The Research Group will be involved in developing a new Diploma (NETD) Programme on Renewable Energy and Green Technology (REGT), in addition to the existing BASc./M.Eng. Utilities Programme. A Focused and dedicated productive Post-graduate Master of Science, Master of Philosophy and Doctor of Philosophy slate of programmes are planned in the above mentioned areas. Table 3 and 4 highlights the energy and petroleum courses being offered in the graduate programme.

3.4 External Research and Development Funding

The Value Added Research and Development R&D activities will be funded by the University of Trinidad and Tobago, National and International Funding Agencies i.e. World Bank, CIDA, Green Energy Fund and European Union (EU). Joint International Research links and alliances are planned with leading Universities and Research Centres in USA, Canada and European Union.

4.0 Deliverables

The Energy Research Group will include deliverables from its Faculty members as outlined. Deliverables are categorised into the following areas:

- Education
- Research
- Collaborative Initiative
- Publications
- Funding
- Outreach Initiatives
- Facility Development

Table 5 specifies the deliverables for each category mentioned.

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Short Courses Offered

Table 2: Short Courses being offered by the Centre for energy

Course	Instructor
Java & Internet programming	Adel Mnaouer
C++ programming	Adel Mnaouer
Wireless mesh and Sensor Networks: new trends, design issues, future directions and economic impact	Adel Mnaouer
Introduction to Exergy Analysis	Solange Kelly
Introduction to Artificial Intelligence	Mohammed El-Sayed
Power System Quality	Adel El gammel
Power System Stability	Adel El gammel
Power System Optimisation	Adel El gammel
Introduction to Petroleum Engineering Overview of Petroleum Industry Basic Petroleum Technology	Indar Narace, Rodney Jagai
Basic Well Logging Introduction to Petrophysics	Neal Alleyne, Indar Narace, Burt Sinanan
Basic Reservoir Engineering	Tennyson Jagai, Rodney Jagai, Randell Jackman
Basic Drilling Applied Drilling Practices Advanced Well Drilling Drilling & Completions	Doodnath Ramsundar, Francis Jaipaulsingh
Production Operations Introduction to Production Engineering Surface Production Engineering	Indar Narace, Francis Jaipaulsingh
Enhanced Oil Recovery Improved Oil Recovery Thermal & Heavy Oil Engineering	Tennyson Jagai, James Speight
Intro to Natural Gas Engineering	Indar Narace, Rodney Jagai
Well Logging, Reservoir Engineering, Industry Overview, LNG	Marsha Maraj, Rodney Jagai

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Graduate Course Programme

Table 3 shows the courses being proposed for the MPhil and PhD programmes.

Table 4 shows the courses being proposed for the MSc programme in Petroleum studies.

Table 3: MPhil. and PhD. Proposed Courses

Course Name	Description
Thermoeconomics	This course covers the fundamentals of exergy analysis and costing and the use of such costing to improve thermal systems and assign costs to the products they deliver. This course will cover areas such as costing of process streams, costing of irreversibilities, understanding ways of performing both design and performance evaluation of thermal systems.
Economic Modeling and Analysis	This course introduces students to capital investments, estimation of capital investments, cost estimates of Purchased Equipment. The course also covers principles of economic evaluation, time value of money, inflation and its effects on fuel operating and maintenance costs. Taxes, Insurance and calculation of revenue requirements are also addressed.
Transient analysis and control of Electrical Machines	Steady-state and dynamic analysis of electrical machines: DC machines, synchronous machines, poly phase induction machines and fractional horsepower machines, direct and quadrature axis transformation. Linear and nonlinear state space representation. Regulation and control devices. Simulation of electromechanical subsystems.
Neural Networks Theory and Applications	Introduction, background and biological inspiration. Survey of fundamentals methods of artificial neural networks: single and multi-layer networks; Perceptions and back propagation. Associative memory and statistical networks. Supervised and unsupervised learning. Merits and limitations of neural networks. Applications.

Applications of Optimization Methods in power systems	Applications of some Optimization Techniques like Genetic Algorithm GA and Particle swarm Optimization PSO in Power Quality/Filter Optimization Design, Motor Drives Control, Wind Farm Power Forecasting, Capacitor Placement and Energy Management,
Power Converters and drives	The course provides the analysis DC-DC converters, AC-AC cycle converters, Buck and Boost converters, DC-AC inverters, Multi-level converters, Multi-level voltage source modulation, Filtering the output voltage, Load resonant and resonance switch inverters, Resonant DC-link inverters, Series and parallel resonant inverters. DC drive basic, DC motor speed control, Transistor and IJBT PWM DC drives, SCR DC drives, Induction motor dynamic models, field oriented control, scalar control of induction motor, Vector control of induction motor, Construction of permanent magnet synchronous machine PMSM drive systems, Simulation and modelling of PMSM, Controlling of PMSM drives
Renewable Green Energy Systems	This course provides an overview of green energy sources of renewable energy systems. The course's topics are: Solar energy conversion: cells, PV modules, solar thermal generation; principles of wind energy conversion, fuel cells, Biomass and Biogas, Tidal and wave energy, Geothermal energy, Energy storage systems, Renewable energy interface systems, Energy conservation, Power quality problems. This course gives the students additional information about alternative supply of electricity for isolated and grid connected areas as well as implementation of power electronics in renewable energy generation. Other topics include sizing of renewable energy systems and economics of renewable energy systems in both standalone and grid interface supply systems.
Power System Stability and Control	The course provides the characteristics of modern power systems including renewable generation, Operation and stability criterion, Rotor angle stability, Voltage stability and voltage collapse, Transformation of Synchronous machine in d-q-0, Inertia constant and swing equation, Dynamic parameters of synchronous machines, frequency response characteristics, Base case load flow calculation, Excitation system modelling, Static and dynamic load modelling, Turbine and governing system modelling, State space representation, Simulation of power system dynamic response, Power system stabilizer, Sub-synchronous oscillations, Voltage stability analysis, Prevention of voltage collapse, Active power and frequency control, Automatic generation control, Under frequency load shedding, Reactive power and voltage control, Modelling of reactive compensating devices, Impact of renewable generation on system performance.

Power System Analysis	This course covers Transformers , Synchronous machines, Transmission line models (L, C components), V – I relationships and load classifications, Network calculations and models, Power flow problem and solutions, Fault calculation / short circuit studies and Economic operation of power systems. Other topics of power systems / load models, Power system stability, HVDC, renewable energy systems, dispersed generation and optimal operation are studied.
Power System Protection and Relaying	The course introduces protection fundamentals and basic design principles, characteristics of measuring devices, Selection of metering CTs and PTs and associated measurement errors and limitations. Different protective schemes over-current as well as differential protection, transformer protection and effect of inrush current, Generation protection and effect of neutral earthing, bus bar and motor protection, distance protection of transmission lines, types of distance relaying (impedance, reactance, mho and quadrant), protective relay coordination, power system fault simulation using electromagnetic transients, principle of digital relaying, effect of sampling rates, Effect of fault impedance, techniques of digital relaying, artificial intelligence application (Expert System, Neural network, Fuzzy sets) on power system protection.
Power System Operation	The Course presents the key studies involved in Electric Utilities Operation and Planning with emphasis on Generation AC Controls, Speed, Frequency, Voltage and Excitation Control Systems, Voltage Regulation and Stabilization Techniques using emerging FACTS-Flexible AC Transmission Systems, Issues dealing with resonance, ferroresonance and Control/System Interactions. Load Flow and Voltage Stability Indices, Fault Studies and Short Circuit Calculations, Stability Issues including synchronous, Harmonic and Voltage Stability Issues and Problems, Power quality Problems and Mitigative Solutions using Fixed, Switched and Active Power Filters.
Network Analysis and Simulation	The course provides the background to understand the principles, capabilities, and limitations of circuit simulation software like the EMTP for power systems. Areas covered include: discretization of differential equations, modelling of power system components, solution bandwidth, numerical oscillations, wave propagation in transmission lines, frequency dependence and diakoptics.
Condition Based Monitoring and Asset Management	This course covers the general principles of CBM and AM including analysis of failure modes, sensors and physical monitoring techniques, problems in data interpretation, asset inter-dependencies and integration schemes for

	asset management as well as common CBM schemes found in industry. An innovative project based in the CAD-M Lab is also required.
AI Applications in Power Systems	Introduction to artificial intelligence, Expert systems, Artificial Neural Networks Fuzzy sets and fuzzy logic Genetic algorithms and particle swarm optimization. AI applications in: Load forecasting, Unit commitment, Power system control, FACTS devices layout, Power tracking of renewable generation, Digital protection of power system, Power system restoration
Power System Quality	The purpose of the course is to contribute to the students' attainment of knowledge and comprehension for harmonics in power systems, how the harmonics are generated, distributed and how they can be reduced by different techniques.
Power System Stability	The course purpose is to contribute to the students' attainment of knowledge about power system stability, including frequency stability, power angle stability, voltage stability, voltage collapse phenomena and sub-synchronous oscillations and how to set up simulations models for analyzing these behaviours.
Power System Optimization	Optimization is the systemized search for the best action, the procedure used to make a system as effective or functional as possible. In the last two decades, optimization techniques have extended in the electric industry. This course includes some of the most significant present and foreseen optimization applications in electric power systems, such as: state estimation, transmission expansion planning, electricity markets, voltage control, wind power, security stability, optimal placement of equipments, distributed generation and others. All the chapters include algorithms, methods, know-how and examples of applications in real and test systems. This course will help students to understand implemented optimization tools, to know practical solutions applied in other places and, possibly, to evaluate their available operational tools

List of Graduate courses for Petroleum Studies

Table 4: MSc. Proposed Courses

Course Name	Description
Industry Overview	This course provides students with an understanding of the basic concepts of the Energy Industry. Basic petroleum technology is covered including nomenclature and terms used in the industry. The course also gives an overview of Value Chain in the Oil and Gas business and describes how the industry works to make a profit.
Introduction to Research	This course provides a basic knowledge of methods that would prepare the student for students for informed and critical reading of empirical petroleum engineering literature, and provides the basics of applying methods in research projects
Production Operations 1	This course provides students with an understanding of the application of petroleum engineering techniques to the optimization of the hydrocarbon production system as well as the fundamentals of well design, operation and treatments.
Drilling, Completions and Workovers	This course provides students with an overview of the drilling process, completion practices, and remedial workover techniques.
Fundamentals of Petroleum Geoscience	This course provides students with an understanding of geological vocabulary, an explanation of geological principles and processes and describes how certain petroleum reservoirs and source rocks are formed.
Introduction to Natural Gas Engineering	This course is intended to introduce the topics such as the chemical, physical and thermodynamic properties of oil and natural gas. The course is designed to introduce the concepts of production and transportation of natural gas; production including gas well and reservoir performance, transportation and storage of gas; metering and gauging; performance of wells; estimation of gas reserves, prevention of waste and utilization of natural gas.
Basic Reservoir Engineering	This course is intended to provide students with an understanding of the characteristics of oil and gas reservoirs, including fluid and rock characteristics, reservoir definition, delineation, classification, development

	plan, and production. Basic reservoir engineering equations are introduced with emphasis on parameter significance.
Basic Well Logging	This course is intended to provide students with a basic understanding of the fundamentals of well log and core analysis interpretation. This course introduces students to the application of well logging within the petroleum industry. It will expose students to the different types of logging equipment used and students would be given a hands-on experience of the basic logging techniques and interpretation.
Drilling Practices	This is an introduction to Drilling Engineering. The objectives are to introduce the concepts and equipment used in drilling; to examine the design requirements and techniques and to examine the optimization of the drilling activity.
Shaly Sand Petrophysics	The course is intended to provide the students with an understanding of the principles, applications, and integration of petrophysical information for reservoir description. The students will learn how to integrate petrophysical information with other data sources to assess technical risk when examining hydrocarbon reservoirs.
Natural Gas Engineering	This course is intended to provide students with an advanced understanding of the methods applied to specification and description of the properties of natural gas mixtures. The students will also learn calculations for the flow behaviour of natural gases in compressors, valves, wells, pipeline and reservoirs.
Advanced Well Logging	This course is intended to provide an advanced knowledge on well-logging analysis methods. The course is designed to give a clear understanding of quantitative evaluation of hydrocarbon formations and other engineering geological studies such as lithologic correlation, structural mapping, sedimentation, fluid migration and determination of mechanical properties of rocks.
Applied Reservoir Simulation	The course is designed to give the students an introduction to the fundamental and practical aspects of modern reservoir simulation. Particular

	emphasis is placed upon the available data and its integration into a data set that reflects a coherent model of the reservoir.
Gas Reservoir Management	This course will help students understand the engineering drivers on gas reservoir management and how a gas reservoir's value can be maximized through sound engineering practices. A full spectrum of gas reservoir engineering techniques is addressed and their application to a large variety of gas resource management options is discussed.
Thermal Heavy Oil Recovery	This course provides students with a better understanding of the heavy oil reservoir fundamentals and the important variables that influence the recovery process. The course is intended to give the students an introduction and background to oil properties and enhanced recovery methods.
Applied Pressure Transient Analysis	This course would provide students with an understanding of Diffusivity equation and solutions for slightly compressible liquids; dimensionless variables; type curves; applications of solutions to build-up, drawdown, multi-rate, and deliverability tests; extensions to multiphase flow; analysis of hydraulically fractured wells. This course stresses practical application of well test theory to design and interpretation of pressure transient tests.
Reservoir Characterization	This course provides students with an understanding of the integration of disciplines, technology and data to accurately describe productive zones within the reservoir. The reservoir characterization process integrates the technical disciplines of geology, geophysics, reservoir engineering, production engineering, petrophysics, economics, and data management. Key objectives of reservoir characterization focus on modelling each reservoir unit, predicting well behaviour, understanding past reservoir performance, and forecasting future reservoir performance. The course would require the students to confirm the assignment, review the data, reconfirm/refine the assignment, build a static model, confirm the static model through multi-disciplinary data, build the dynamic model and present solutions.
Petroleum Risk and Decision Analysis	This course provides students with a practical and systematic process for analyzing decisions under conditions of risk and uncertainty. The students will learn how to design and solve decision models. Decision tree and influence diagrams provide clear communications and the basis for valuing

	each alternative. The complementary Monte Carlo simulation technique is also presented and experienced in detail in a hand-calculation exercise.
Advanced Decision Analysis	This course provides students with an advanced understanding of the concepts developed in RISK110M. Students will gain an appreciation for the methods and practice of building good evaluation models through the construction of project evaluation and other forecasting and assessment models.

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Table 5: Deliverables for the Centre for Energy Studies Group

Education	Research	Collaboration Initiatives	Publication	Funding	Outreach	Facility Development
Professional Development Education Programme Six to nine short courses per Academic Year	Renewable and Green Technology, Prototyping and Demonstration Projects	International Research Links and Liaison with key Research Centres and Universities	Average of 35 Journal & Conference Papers per Year	National and International R & D Funding	4 Professional Development/training Workshops per year	Fully Functional and Ready for research/teaching Multi resources Laboratories
A total of 30-35 Completed Master//M.Phil and Ph.D. Supervision over a Period of 3 Years	Value added Research, Technology Transfer and Marketing of Novel Green Energy Technologies to Industry and Business Sector.			Sustainable Research, Technology Transfer and Marketing of Novel Green Energy Technologies to Industry and Business Sector.		
New Diploma and Bachelor of Science programmes in Sustainable and Renewable Energy Green Technology (REGT) Programmes, fully implemented by the year 2012	Excellent Research productivity and active Post-graduate students			Short term Engineering Consulting Services.		