Faculty of Engineering and Architecture (FEA)
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Historical Background

The first programs leading to a master's degree were introduced in 1962. Since then other programs have been added to help meet the growing demand for advanced engineering education. Between October 1990 and October 1994, six new master's degree programs were introduced: the Master of Engineering Management (1990); four programs leading to the degree of Master of Engineering, with majors in computer and communications engineering; electric power engineering; electronics, devices and systems; and environmental and water resources engineering (1991-93); the Master of Mechanical Engineering (1994) with majors in advanced engineering courses (600 and above) that meet the program requirements with a score of at least 80. In addition, the total number of transferable credits from BE to ME should not exceed 12 credits. This means that if a student has taken overload during his/ her undergraduate BE studies, he/she can only waive a maximum of 12 credits.

Mission

The Faculty of Engineering and Architecture (FEA) at the American University of Beirut is a leading professional school in the Middle East. The FEA offers educational programs of the highest standards, advances knowledge through research and scholarly creative work of its faculty and students, and provides services to the community at large, while addressing the needs of Lebanon and the region. The FEA undergoes continuous improvement to maintain a challenging and intellectually stimulating environment, and prepares its students to be lifelong learners, innovators, and professionals capable of being leaders in their chosen careers, committed to personal integrity, and civic responsibility.

Graduate Programs

Master's Degree Programs

The Faculty of Engineering and Architecture offers graduate programs of study leading to the degree of Master of Engineering (ME), with majors in civil engineering; environmental and water resources engineering; electrical and computer engineering; mechanical engineering; and chemical engineering*. The Faculty also offers the degrees of Master of Engineering Management (MEM); Master of Urban Design (MUD); Master of Urban Planning and Policy (MUPP); Master of Science in Environmental Technology (MS); Master of Engineering (ME), major applied energy; Master of Science in Chemical Engineering (MS); and Master of Science in Construction Engineering (MS).

In addition, a professional diploma in green technologies with majors in Energy, Building, and Water is offered in the faculty for professionals who wish to enhance their knowledge in the field.

The requirements for admission to the master's programs are those specified for the master's degree in the Admissions section in this catalogue, with the following interpretations and additions:

Graduate Programs

Master's Degree Programs

Applications for admission to graduate study should be submitted on line through the link https://graduateadmissions.aub.edu.lb/ according to deadlines set in the Admissions section pages 33–46.

• Applications are considered complete upon receipt of at least two letters of recommendation from professors or supervisors of the applicant, and an official transcript covering at least the end of the first semester of the senior year or its equivalent.

• All applications may include an application for graduate assistantships which is also submitted on line. All applications for graduate assistantships received after admission application deadlines will be considered, pending availability.

Process of Admission

• The Office of Admissions forwards applications for graduate admission to the program/ department concerned directly. The graduate faculty adviser, the departmental representative on the graduate studies committee, and the chairperson consider each case individually.

• Recommendations for admission are forwarded to the FEA Graduate Studies Committee from the Dean’s Office.*

1 At this time the department or program of the intended major may also recommend a waiving of up to nine credits of course work for students who have completed a Bachelor of Engineering Degree (BE) and are applying for admissions to a Master of Engineering Program (ME), which is subject to approval by the advisor and the chairperson. To apply, the student must have completed electives in advanced engineering courses (600 and above) that meet the program requirements with a score of at least 80. In addition, the total number of transferable credits from BE to ME should not exceed 12 credits. This means that if a student has taken overload during his/ her undergraduate BE studies, he/she can only waive a maximum of 12 credits.

1 Pending the approval of New York board of Education
The Faculty Graduate Studies Committee meets in ‘special sessions for admission’ and recommends applicants for admission.

Upon confirmation of the admission list by the Graduate Studies Committee, the chair of the graduate studies committee will forward it to the Dean who in turn will forward the list to the university Office of Admissions.

The Office of Admissions prepares and sends the admission packages.

Students who are accepted must confirm their acceptance of admissions and assistantships within one month. If a student does not respond within this time, the assistantship will be re-assigned.

Regulations for Master’s Students taking Undergraduate Courses

• Master’s-level students who are required to take undergraduate courses must obtain a grade of at least 70 in each undergraduate course taken.

• If a student fails to obtain a grade of 70 in any of these undergraduate courses, the student is allowed to repeat that course only once.

• Failure to meet the requirements stipulated above will result in the student being dropped from the graduate program.

Curricula and Courses

The curricula and courses offered in each department are presented in the appropriate sections of this catalogue.

Courses Open to Students from Other Faculties

Students from other Faculties are allowed to take any course for credit offered by the FEA, provided space is available, the prerequisites are satisfied, and the student has prior approval of both his/her Faculty and the department offering the course.

Doctor of Philosophy (PhD) Programs

The Faculty of Engineering and Architecture offers graduate programs leading to the degree of Doctor of Philosophy (PhD) with specializations in civil engineering, electrical and computer engineering, environmental and water resources engineering, and mechanical engineering.

Criteria for Regular Admission to PhD Programs

Candidates for a doctoral degree program must hold a master’s degree or its equivalent and must demonstrate outstanding academic ability (minimum average of 85 or its equivalent) at the master’s level, as well as the potential to conduct scholarly research. Additional specific requirements for each program can be found in the departmental sections of this catalogue. Application to the doctoral program will follow the deadlines set by the Admissions Office. All applicants are required to take the General Exam part of the Graduate Record Examination (GRE) and submit their scores. Students other than AUB graduates and graduates of recognized colleges or universities in North America, Great Britain, Australia, and New Zealand must meet the English language proficiency requirements described for Master’s students.

Admission to a PhD program requires the recommendations of a department, the FEA Graduate Studies Committee, and the approval of the AUB Board of Graduate Studies.

Criteria for Admission to the Accelerated PhD Programs

To apply to the accelerated program, students must have an average in their undergraduate work of 85 or above. This applies to the average in the major as well as the cumulative average.

In addition to meeting the requirements described in the General University Academic Information Section of the AUB catalogue there may be specific requirements described in the departmental sections of the catalogue.

Financial Support Available to Graduate Students

The FEA offers three types of financial assistance to the most qualified applicants to its graduate programs: fellowships, graduate research assistantships (GRA), and graduate teaching assistantships (GA).

The students who receive financial support are expected to maintain a high level of academic performance, satisfactory progress toward a degree, and a satisfactory performance of the work assignments associated with the aid.

Fellowships, GRAs, and GAs, covering tuition and stipends are available for students at the graduate level in return for assisting faculty members in teaching and/or research for a specified number of hours per week in an academic department. Recipients are selected on the basis of their academic record and departmental need.

Applicants opting for non-thesis option in the following programs will not be offered graduate assistantships:

• Masters of Engineering: Major Civil Engineering
• Masters of Engineering: Major Environmental and Water Resources Engineering
• Masters of Engineering: Major Electrical Computer Engineering
• Masters of Engineering Management
Professional Diploma Program in Green Technologies (ProGreen)

General Description of the Pro-Green Diploma Program

The Pro-Green diploma program aims at producing a unique and focused diploma program that caters for professionals aspiring to enhance or complement their technical and decision-making skills in green technologies or progress in green businesses in the areas of energy utilization, building design, construction, and management systems, and sustainable and safe water production, water management and waste water treatment. The diploma degree programs that will be offered are:

- Professional Diploma Program in Green Technologies; Major: Energy
- Professional Diploma Program in Green Technologies; Major: Building
- Professional Diploma Program in Green Technologies; Major: Water

The programs are offered in five universities in Lebanon and Egypt. The Universities offering the diplomas in Lebanon are: American University of Beirut (AUB) and Lebanese American University (LAU). The Universities offering the diplomas in Egypt are: American University of Cairo (AUC); Helwan University (HU); and Suez Canal University (SCU).

Objectives of the Green Technologies Diploma Programs

The Green Technologies Diploma Program is designed to address the trend towards healthier and socially responsible communities by training professionals on effective ways to develop and advance sustainable energy and water efficiency in production, utilization, storage, and re-use.

The program objectives are:

- To promote a problem-based approach among professionals pursuing careers in green industries and green careers preparing students to meet the diverse and critical skills needed to advance in these areas.
- To develop effective lifelong learning skills among students from different disciplines to develop expertise in green technologies related to applications in energy, water, and building.

On successful completion of this Green Technology Diploma Program in any area of specialization, students/trainees will:

- Acquire an in-depth understanding of green technologies relevant to jobs in planning, design and implementation methods for sustainable energy, building, and water technologies and industries.
- Build analysis and hands-on skills needed for development and implementation of green products and processes in the area of specialization (energy, building, or water).
- Develop life long learning skills in the green technologies field. The Pro-Green program emphasizes lifelong learning through problem/project-based learning, including case studies related to real life applications from the participants' own fields of practice.
- Understanding how economic analysis, policy and regulatory frameworks can help in expanding green technologies' market.

Eligibility

Professionals and individuals interested in and/or involved in the development and implementation of green technologies in their practice including architects, engineers, facility managers and contractors. The courses are offered at postgraduate level. The applicants should have a recognized and related bachelor degree in natural science, mathematics, engineering, or architecture. Consideration will be given to students who have BA degrees provided that they have completed prerequisites of the courses offered in the selected specialization.

Admissions Requirements

Native English speakers and graduates of universities in which the language of instruction is English may be exempt from TOEFL. Students should have a GPA of at least 70 out of 100 or equivalent from recognized universities and good recommendations to be enrolled in the diploma program. Professional experience might be considered on a case by case basis where the student can register as a student not working for the diploma and performance is assessed in these courses.

Language Requirements

The diploma program is offered in English. The student will follow University policy regarding the English Language Proficiency Requirement (ELPR) for graduate students. Since the students are not graduate degree seekers, the English requirements are determined by requirements of similar diploma programs at the consortium institutions.

For students applying to the diploma program, a minimum score of 500 in EEE (TOEFL: CBT 240 or IBT 92) is required for admission. Applicants who are graduates of an English speaking university are exempted from the English language test. An applicant might also be required to report for an interview with the program coordinator.

ProGreen Program Structure and Degree Requirements

The diploma program permits part-time enrollments. To obtain a diploma degree in green technologies in any of the offered specializations, the student must complete a minimum of 18 credits of course work depending on the specialization including a project in an area related to the selected specialization. The diploma program credit requirement is distributed as follows:

- 6 credits of core courses
- 6 credits of courses in the area of specialization including project in the area of specialization
- 4 credits for elective course as approved by project advisor/s from the list of elective courses or other courses in the specialization
- Project (equivalent to 2 credit hours)
- 0-credit Seminar/Webinar (to be registered twice).

The core, specialization, and elective courses are summarized in the following sections.
Course Requirements

Core Courses

Students are required to complete the following 6 credits of core courses that are common to the three specializations in Energy, Building, and Water:

- PRGR 601 Green Economy, Policies and Law (3 cr.)
- PRGR 602 Green Technologies System Approach to Sustainability and Management (3 cr.)
- PRGR 698B Seminar/Webinar (0. cr.)

Specialization Courses

Students are required to complete a minimum of 6 credits from their selected specialization. The courses in the various specializations are as listed below.

Energy Specialization

- PRGR 611 Solar Radiation and Solar Electricity using PV Technology 2 cr.
- PRGR 612 Wind Energy: Wind Turbines and Wind Farms and Siting 1 cr.
- PRGR 613 Energy Storage Technologies 1 cr.
- PRGR 614 Solar Thermal Energy Conversion 1 cr.
- PRGR 615 Biofuels 2 cr.
- PRGR 616 Waves, Tidal, and Hydro Renewable Energy 2 cr.
- PRGR 617 Energy Efficiency in Buildings Evaluation and Design 1 cr.
- PRGR 618 Energy Efficiency in Agriculture Evaluation and Design 1 cr.
- PRGR 619 Hybrid Renewable Energy Lab 1 cr.
- PRGR 620 Energy Systems and Sustainable Environments 2 cr.
- PRGR 621 Waste to Energy Processes and Technologies 2 cr.
- PRGR 622 Renewable Energy Projects Evaluation and Market Analysis 1 cr.
- PRGR 623 Energy Audit Lab 1 cr.
- PRGR 699 E Project 2 cr.

Buildings Specialization

General Green Building Modules

- PRGR 631 Low Energy Architecture and Passive Building Design 1 cr.
- PRGR 632 Sustainable Building Materials 2 cr.
- PRGR 634 Moisture and Control of Humidity in Buildings 2 cr.
- PRGR 635 Construction and Demolition Management 1 cr.
- PRGR 636 Modular Building Construction 1 cr.
- PRGR 637 Green Building Basics and Building Rating Practices 2 cr.
- PRGR 638 Sustainable Restoration of Existing Building 1 cr.
- PRGR 640 Building Physics lab 1 cr.

Elective Courses

The elective courses can be selected from specialization courses outside the area of the specialization of the student. In addition a number of elective course modules can be selected from the following:

- PRGR 670 Life Cycle Assessment 2 cr.
- PRGR 671 Energy Conversion and Storage 2 cr.
- PRGR 672 Energy Systems Integration 2 cr.
- PRGR 673 Research Skills Development - General 2 cr.
- PRGR 674 Innovation and Knowledge Transfer I: Entrepreneurs 1 cr.
- PRGR 675 Innovation and Knowledge Transfer I: Concept to Commercialization 1 cr.
- PRGR 676 Global Sustainable Business Management 2 cr.
- PRGR 677 Cost-Benefit Analysis 2 cr.
- PRGR 679 Project Management, Risk Management and Planning 2 cr.
Course Loads, Credit Transfer, and Sample Program

Course Loads

Normally, the maximum number of credits that can be taken in a regular semester is 9 credits. A student who wishes to enroll in more than the maximum number of credits must petition the Faculty Graduate Studies Committee to obtain permission.

Credit Transfer

A maximum of 6 credits can be transferred from other institutions out of the 18 credits for the student to earn the Diploma from the home institution in which the student was originally admitted to. This means that 2/3 of the 18-credit requirements for the diploma should be registered at the institution that will grant the degree. Normally the core courses of the program are duplicated and are offered at each of the partner institutions.

Requirements for Double Specialization

Students may enroll and earn diploma in one or two specializations.

To fulfill the basic requirement for the double specialization, a student must complete a minimum of 12 credit hours of graduate course work over and above the requirements for the first specialization. The remaining credits include the core courses that are credited for the double specialization. The minimum total credit hours for a double specialization of green technology diploma would be 30 credit hours.

Requirements for Joint Degree in Two Specializations

This option allows students to study green technologies in two institutions and receive joint diplomas from both institutions. A student registered in one specialization in one institution can apply for a second specialization in another institution and should complete 12 credits over and above the 18 credits required by the first specialization. The 6-credit core courses are considered common for the joint degree in two specializations.

Course Descriptions

Core Courses

PRGR 601 Green Economy, Policies and Law 3 cr.
The course covers environmental and resource economics and policy; environmental issues and regulations; global sustainability and future trends; international environmental law; carbon management for green environment; the science of urban ecology; corporate environmental responsibility; green laws compliance; cost benefit analysis; environmental economics and sustainable development; green tech and finance. International climate change mitigation financing mechanisms. Best practices and case studies for successful implementation of climate change mitigation strategies locally and internationally. Introductory statistical and data modeling tools are used as basis of effective decision-making or analysis.

PRGR 602 Green Technologies System Approach to Sustainability and Management 3 cr.
The course covers green technologies applications including renewable energy sources versus conventional; solar systems: solar thermal, photovoltaic, solar concentrators, wind; biofuels and biotechnologies; water production and quality; wind; hydrogen cells; low energy architecture and energy efficient buildings; and recycling and reuse of materials, elements and components. The course also covers system approach to sustainability and management including environmental management systems and auditing; environmental impact assessment; sustainability management; sustainable operations; and project and portfolio management.

Energy Specialization Courses

PRGR 611 Solar Radiation and Solar Electricity using PV Technology 2 cr.
Solar Radiation: Components, Geometry of Earth and Sun, Geometry of collector and sun beam, Effect of Earth’s atmosphere, Measurements of solar radiation. Semi-conductor basics, Photo-Voltaic (PV) module characteristics, Efficiency analysis; PV module types: mono-crystalline, Polycrystalline, Amorphous, Multilayer cells, Current research; PV module manufacture; Grid connection and grid-codes, Remote (off-grid) connections; Economical and sustainability aspects.

PRGR 612 Wind Energy: Wind Turbines and Wind Farms and Siting 1 cr.
The module covers the fundamentals of wind energy and the process and limitations of converting wind kinetic energy to electrical energy. It discusses the efficiency law and the governing equation of the conversion process. The module also covers the various types of wind turbines available in the commercial market along with their characteristics, and implementations’ advantages and disadvantages.

PRGR 613 Energy Storage Technologies 1 cr.
In this course various energy technologies will be presented and discussed in terms of their principle of operation, system components, energy density, maintenance, and cost. The different technologies that will be addressed are: batteries, compressed air, fly-wheel storage, pumped hydro-power, super-capacitors, and superconducting magnetic energy storage.

PRGR 614 Solar Thermal Energy Conversion 2 cr.
This course provides a comprehensive analysis of solar thermal energy collection and utilization with an emphasis on the design, sizing and selection of solar thermal technologies such as: solar thermal power plants, solar water heaters, solar concentrators, solar ponds, and solar updraft towers.

PRGR 615 Biofuels 2 cr.
Course content includes studies of types, sources and processing of biodiesel, biomass, bio-methane and bioethanol, and assessing advantages, problems and principles in biofuel production. Biogas and digester design.

PRGR 616 Waves, Tidal, and Hydro Renewable Energy 2 cr.
This course gives an overview of the use of ocean thermal, wave, tidal, and hydro renewable energy. It provides a comprehensive analysis of hydro renewable energy collection and utilization for electric power production and other applications with an emphasis on design, sizing, performance analysis and selection of hydro renewable energy technologies. Mini-hydro systems are also covered. It also discusses variety of designs for devices for extracting energy from waves, the technologies and methods for generating electricity from different ocean temperatures between the warm surface water of the ocean and the cold deep water.
The course will address energy use and conservation in agriculture and food production systems. The course will explore energy conservation improvements through reduced fossil fuel dependency and use of renewable resources. No prerequisite courses are required.

**PRGR 618  Energy Efficiency in Agriculture Evaluation and Design** 1 cr.
The module discusses various schemes of conserving energy in buildings and energy types including, space heating and cooling, water heating and energy for lighting and powering electrical and electronics equipment. It also covers passive and active energy conservation techniques including energy efficient HVAC equipment. Addresses integration of solar energy into boilers and condensing units of building systems and introduces optimized control strategies.

**PRGR 619  Hybrid Renewable Energy Lab** 1 cr.
Photovoltaic Cells: Operating principles of PV cells, Characteristics of PV modules, Effect of Temperature and Irradiance, series parallel combinations, Alignment geometry, Maximum power point tracking, and Partial shading. Wind Power: Wind turbines types, Design and operation, Physical fundamentals, Doubly-fed induction generator, Effect of wind speed on voltage and frequency, and Optimal operating point.

**PRGR 620  Energy Systems and Sustainable Environments** 2 cr.
This course covers a wide range of topics: (i) Worldwide importance of energy systems including their historical and current energy perspectives, concepts and applications of energy systems. (ii) Sustainable Energy systems; approaches to energy systems analyses and sustainability metrics. Biological Carbon Capture Storage, including the following processes: soil carbon, CO2 to energy, Forests and forest ecology, Digestate from Anaerobic Digestion (AD) process, Biochar Grassland management, Biomass to oil; and (iii) Comprehensive overview of the principal types of renewable energy-including solar, thermal photovoltaics, bioenergy, hydro, tidal, wind, and wave.

**PRGR 621  Waste to Energy Processes and Technologies** 2 cr.
The course covers the fundamental principles of waste management, with particular emphasis on organic wastes. Waste generation and characterization, and techniques for waste collection, storage, transport, utilization (including recycling and recovery). Focus is on the application of engineering science to develop integrated waste management systems. Waste-to-energy technology: mass burning and modular combustion, refuse derived fuel systems, anaerobic digestion, composting. Comparison and benchmarking of the technologies with respect to energy efficiency, environmental impacts, costs etc. Hazardous waste generation, producer responsibility and legislation. Waste-to-energy projects implementation concepts: risk assessment; implementation process including; feasibility, siting, procurement/ownership, financing, plant construction and operations.

**PRGR 622  Renewable Energy Projects Evaluation and Market Analysis** 2 cr.
Renewable energy integration strategies including market development issues and challenges to large-scale deployment. Supporting policy frameworks to include national and international targets. Impacts of key factors supporting the development of renewable energy projects (e.g., economics/finance, risks, laws and regulations). Market trends/status and utilization of market information to develop strategic opportunities. Market entry and penetration strategies and contention with or removal of barriers. Current and potential future regulations/directives, protocols and research needs. Renewable energy project evaluation, market analysis and policy case studies (biomass, small hydro, solar thermal and photovoltaic, wind and so on).

**PRGR 623  Energy Audit Lab** 2 cr.
The students will carry out measurements to investigate ventilation, air conditioning equipment, lighting and other office and lab equipment. The students will then be introduced to Visual DOE or E-Quest to perform energy simulation of buildings. Such tools will then be used carry a full building simulation taking into consideration occupancy data, equipment, lights, and building envelope. A base case of energy usage will thus be established and energy conservation measures are then applied to deduce possible savings and their economic value.

**Building Specialization Courses**

**General Green Building Modules**

**PRGR 631  Low Energy Architecture and Passive Building Design** 1 cr.
This course centers on issues surrounding the integration of sustainable and passive design principles, into conceptual and practical building design. Topics will include: solar geometry, climate/regional limitations, natural lighting, passive design and sustainability initiatives, insulating and energy storing material. Bioclimatic design and concepts. Case studies will be used extensively as a vehicle to discuss the success/failure of ideas and their physical applications.

**PRGR 632  Sustainable Building Materials** 1 cr.
Green and recyclable building material, embodied energy, sustainable construction.

The module serves as the main process for a establishing a net zero energy building/architecture by means of enabling a building to generate the electrical energy it needs from its own resources. The module thus delves into the two main building's self-energy sources; wind and solar PV. It covers the implementations of micro or mid-scale wind turbines and solar PV systems for the generation of electrical energy. The module also covers storage and grid connection mechanisms as well. Lighting efficiency and electrical installation issues.

**PRGR 634  Moisture and Control of Humidity in Buildings** 2 cr.
Sources of moisture and factors affecting its entry and buildup inside the buildings such as construction practices, and choice of building materials and furniture. Impact of moisture on thermal comfort and energy performance of the air-conditioning system. Solid/liquid desiccant dehumidification and hybrid air-conditioning systems. Modeling of moisture transport. Industrial need to control indoor humidity. Moisture-caused health issues including mold formation and growth.

**PRGR 635  Construction and Demolition Management** 1 cr.
Building disposal techniques including deconstruction as well as selective and partial selective demolition. Design and construction for deconstruction and reuse. Sustainable waste management including recycling and reuse of waste materials and components.

**PRGR 636  Modular Building Construction** 1 cr.
Pre-fabrication and preassembly of building elements. Benefits of modular construction in terms of cost and time savings, and waste minimization.

**PRGR 637  Green Building Basics and Building Rating Practices** 2 cr.
Assessment of building design and construction operations: Project rating systems (LEED, BREEAM, QSAS, etc.). Embodied energy, carbon content, and emission of CO2, SO2 and NOx of building materials, elements, and construction process. Water conservation, water management systems, water efficient landscaping, green roofing, rainwater harvesting, sanitary fixtures and plumbing systems, wastewater treatment and reuse, and process water strategies.
The Building Management Systems course provides the necessary tools to control, monitor, and optimize the building's facilities, mechanical and electrical equipment for comfort, safety, and efficiency. It covers the principles of the building automation systems (BAS) applied to commercial HVAC equipment, lighting systems, fire and security systems; with keen emphasize on the control routine for energy efficiency.

PRGR 642  Building Management Systems (BMS)  
1 cr.

The Building Management Systems course provides the necessary tools to control, monitor, and optimize the building’s facilities, mechanical and electrical equipment for comfort, safety, and efficiency. It covers the principles of the building automation systems (BAS) applied to commercial HVAC equipment, lighting systems, fire and security systems; with keen emphasize on the control routine for energy efficiency.

PRGR 643  Heat Pumps and Innovative Methods to Improve Performance with Direct Applications  
2 cr.

Heat pumps in low energy and passive buildings. Ground source Heat Pump fundamentals, loop systems, open systems, soil/rock classification and conductivity, grouting procedures, performance of ground source heat pumps in housing units. Water loop heat pumps, inside the building, bore holes, design and optimization of heat pump plants, including heat sources for such plants are considered in detail. Cost effective design options.

PRGR 644  HVAC Lab  
2 cr.

This course is designed to give the students “hands-on” experience with building energy systems and expose them to basic and advanced methods of measurements and data analysis to design, test, and evaluate indoor climate conditions and HVAC systems’ performance under appropriate control strategies for comfort and indoor air quality. The students will be exposed to electrical HVAC instrumentation and hardware, IAQ testing equipment, tracer gas techniques for ventilation rates measurements, flow characterization measurements and air leakages and fenestration ratings. Experiments and lab projects will span a series of advanced modules on sustainable, energy-efficient HVAC and refrigeration systems as laboratory topics.

PRGR 645  Building Energy System Modeling  
2 cr.

Indoor space thermal models. Analysis and modeling of building energy systems involving applications of thermodynamics, economics, heat transfer, fluid flow and optimization. The use of modern computational tools to model thermal performance characteristics of components of HVAC systems including chillers, recovery systems, flow control devices, heat exchanges, solar panels, dehumidification systems, boilers, condensers, cooling towers, fans, duct systems, piping systems and pumps.

Water Specialization Courses

PRGR 650  Instrumentation  
1 cr.

This course offers an introduction to the instrumentation trade as it applies to the day-to-day operation of water/wastewater treatment plants. Topics discussed include types of instruments and control equipment, process measurement and control principles, terminology, design and control systems documentation, operators training and troubleshooting techniques. It is important to note that this course is not aimed to create tradespersons, but is designed from the viewpoint of plant operators, so they can develop more awareness of the plant staff and allow them to effectively monitor and control the plant and major equipment, the treatment process, water production and plant wastes.

PRGR 651  Water Essentials  
1 cr.

This course includes: a short history of water, patterns of water use, the urban water crisis and management, and water use in home and commercial buildings. The course covers basic information about the water and sewer utility operating environment and water sources, as well as the key issues in water demand planning. Students will learn about the history of drinking water regulations and current regulations including the Safe Drinking Water Act and the Clean Water Act. Topics include: today’s water crisis, management and best practices, an introduction to regulatory affairs and restrictions, water sources in the region and globally, commercial and domestic water use, the colors of water, our water footprint, responding to the water crisis, and new trends.

PRGR 652  Smart Irrigation  
1 cr.

New technologies in irrigation aiming at water savings at the operation and management level. Soil Moisture sensors and types of irrigation controllers, determining water requirements of different plants in different environments, irrigation scheduling, operation and management technologies

PRGR 653  Water Treatment  
2 cr.

Physical, chemical and biological water quality parameters determinations and standards; water treatment techniques: screens; sedimentation, thickening, coagulation/flocculation processes, filtration, and disinfection. Case studies are presented.

PRGR 654  Wastewater Treatment  
2 cr.

Mass balances and hydraulic flow regimes; attached and suspended growth biological wastewater treatment systems including: activated sludge and its variations, aerated lagoons, SBR, trickling filters, RBC; basic nitrification-denitrification processes; oxygen requirements; introduction to sludge treatment and disposal; professional and ethical responsibility issues. Case studies are presented.

PRGR 655  Wastewater Treatment Plant Design  
1 cr.

Analysis and design of wastewater treatment plants using commercially available software: sizing of tanks; and effluent concentration. Results visualizations and assessment. Corequisite: PRGR 654 Wastewater Treatment.

PRGR 656  Water Networks Design  
1 cr.

Analysis and design using commercially available software: municipal water distribution systems including pipes, reservoirs, pumps and losses. Results visualizations and assessment: pressure, velocity, head losses.
PRGR 657 Wastewater Networks Design 1 cr.
Analysis and design using commercially available software: wastewater collection systems including pipes, manholes, drop manholes, wet wells, and other appurtenances. Results visualizations and assessment.

PRGR 658 Sludge Treatment 1 cr.
Sludge stabilization; Composting; Conditioning; Anaerobic digestion; Thickening; Dewatering and drying; reuse; disposal; Waste to Energy.

PRGR 659 Basic Operations of Wastewater Treatment Plant 1 cr.
Maintenance and Safety; Sampling, Sampling Methods and Parameters; Analysis and Data Handling; Management and Supervision.

PRGR 660 Water Resources Planning and Management 2 cr.
Linear programming and dynamic programming applications to water resources planning; practical water problems including allocation, quality management, reservoir operations, flood control, resources management, basin modeling and flood and drought forecasting.

PRGR 661 Desalination 2 cr.
This course will survey the commonly used thermal and membrane based desalination technologies. Fundamental thermodynamic and transport processes which govern desalination will be developed. Environmental, sustainability and economic factors which may influence the performance, affordability and more wide-spread use of desalination systems for fresh water production and reuse will be highlighted. Renewable energy technologies coupled with desalination processes will be reviewed. A team based student project will be assigned to design a reverse osmosis membrane desalination plant (brackish water, seawater, or treated sewage effluent) using conventional or alternative energy sources.

PRGR 662 Sustainable Water Management 1 cr.
Strategies for water management at the project and field scale including water shortage management, irrigation strategies, water harvesting, non-conventional water sources for agriculture, groundwater recharge, and catastrophe protection, and flood management; techniques, methods, and strategies for agricultural, domestic, industrial, and municipal water conservation and sustainable use in dry lands.

PRGR 663 Liquid Waste Management 1cr.
This course focuses on management techniques of liquid waste disposal from domestic, commercial and industrial effluents. Methods for managing waste collection, recycling, and transportation of nonhazardous and hazardous materials will be studied. The effect of this waste on the environment will be assessed according to the legislation. Design strategies and calculations will also be discussed for the different types of waste. Cost analysis of the different processes will also be highlighted.

Elective Courses

PRGR 670 Life Cycle Assessment 2 cr.
This module introduces the principles and methods of life cycle thinking and life-cycle assessment (LCA) with specific reference to agricultural and energy systems using attributional LCA. The module will be based around the ISO 14040 methodology and will involve developing a LCA model common software packages such as MS-Excel. It will focus on the four common stages of LCA: (i) definition of the Goal and Scope; (ii) Life Cycle Inventory Analysis; (iii) Life Cycle Impact Assessment and (iv) Interpretation with a specific focus on carbon footprint, water footprint and energy audit. Case studies will consider LCA studies of agricultural systems, energy systems and selected industrial processes and products.

PRGR 671 Energy Conversion and Storage 2 cr.
Fundamentals of renewable energy processes: heat engines (thermo-mechanical, thermo-chemical, electrochemical, and photoelectric processes and technologies); on-shore and off-shore energy conversion; innovative energy storage devices; energy carriers, synthesized fuels. Emphasis is on advanced energy technologies, energy efficiency, systems performance and minimization of environmental impacts. Introduction to principles of multiple sources of renewable energies. Deployment of energy storage technologies: technical and economic advantages of energy storage; electricity storage systems; characteristics of energy storage techniques, and; comparison of the different storage techniques Renewable energy deployment in transport. Supply chains of liquid and gaseous transportation fuels; alternative transportation technologies and infrastructure for advanced future transportation systems (land, water and air); environmental and social impact assessments. Models/tools for estimating the energy consumption and emissions in different transportation systems; evaluation of external impact factors and means of reducing pollution and optimizing energy consumption.

PRGR 672 Energy Systems Integration 2 cr.
Develop choice awareness of energy resources and methods for energy demand and supply characterization (including forecasting). Laws and regulations (for local energy production). Micro-generation, cogeneration, tri-generation, and poly-generation systems; energy flows, low-carbon/renewable energy systems, energy systems integration, and bases for sustainable energy systems. Methods and tools for hybrid energy systems integration to provide specified service loads (viz., electricity, heating, and cooling). Energy infrastructure; centralized vs. decentralized systems; on-shore and offshore systems. Energy demand and supply modeling; simulation, econometric and other forms of parameter estimation, input/output modeling, and integrated systems modeling and optimization.

PRGR 673 Research Skills Development - General 1 cr.
Objective of this module is to enable learners to develop critical research skills, including requisite skills for clear and concise communication of research plans, research progress and findings to experts in their respective area thought more efficient use of software and commonly used resources. Focus is on structured inquiry from experiments and/or data collection and analysis, rather than hypothesis or theory to be tested. The module processes will integrate knowledge gained from all other modules in the program, to develop the rationale for research, set out research objectives and methods, analyze and interrogate data, and draw validated conclusions.
PRGR 674  Innovation and Knowledge Transfer I: Entrepreneurs  1 cr.
The Innovation and Knowledge Transfer modules will provide an introduction to the area of Innovation and Entrepreneurship in the context of the Knowledge Economy. Initial focus will be on the entrepreneurial process in the journey from identification of the innovative idea through to the launch of a successful business. It will identify the key factors influencing success along the way. Concepts will be explored by way of case studies and question and answer sessions with successful entrepreneurs, telling their real-life success stories. The emphasis of the module will be to create an awareness of how innovative ideas can lead to commercial opportunities and identify the entrepreneurial qualities required to convert these ideas into viable business propositions.

PRGR 675  Innovation and Knowledge Transfer I: Concept to Commercialization  1 cr.
This will cover the management process required to transform an innovative idea into a commercial opportunity or business proposition. It will detail the stages and processes involved in the management and commercialization of intellectual property (IP). Students from all disciplines will be involved in the creation of knowledge in the form of intellectual property. Students will be provided with a fundamental understanding of how to manage the development of IP and transfer this asset to the Knowledge Economy. The module will begin by examining some success stories and then addresses the requirements to manage and protect intellectual property rights (IPR) in areas such as ICT, Life Sciences, Engineering, Food and Energy. The potential routes to commercialization and the key business feasibility questions will be considered.

PRGR 676  Global Sustainable Business Management  1 cr.
The deliverables of this module will require team projects and participants will graded via continuous assessment. The aim of this module is to help students understand theory and practice for investing in and managing green ventures while exercising corporate social responsibility. Sustainability within the organization and in the external environment.

PRGR 677  Cost-Benefit Analysis  2 cr.

PRGR 679  Project Management, Risk Management and Planning  2 cr.
The abilities to propose, plan, execute and close a project are essential qualities of every manager. This proposal aims to help the student to develop the skill required from every project manager. It will also address common risk management and contingency planning. This should be delivered in accordance with internationally recognized global project management standard bodies, such as PMI, to aid the students who wish to become certified project managers.