

# SUSTAINABLE DEVELOPMENT

## Programs

- Chemical Engineering, Bachelor of Science (<https://catalog.hbku.edu.qa/academic-degrees/cse/sd/chem-bs/>)
- Sustainable Energy, Master of Science (<https://catalog.hbku.edu.qa/academic-degrees/cse/sd/sustainable-energy-ms/>)
- Sustainable Energy, PhD (<https://catalog.hbku.edu.qa/academic-degrees/cse/sd/sustainable-energy-phd/>)
- Sustainable Environment, Master of Science (<https://catalog.hbku.edu.qa/academic-degrees/cse/sd/sustainable-environment-ms/>)
- Sustainable Environment, PhD (<https://catalog.hbku.edu.qa/academic-degrees/cse/sd/sustainable-environment-phd/>)

## Division Courses

### Core Science & Engineering

**CSE 602 Statistics for Science and Engineering** **3 Credits**  
Grade Mode: Standard Letter, Audit/Non Audit

This course covers probability and statistical methods for data analysis and experimental design. The course emphasizes on fundamental principles of statistics and their applications in science and engineering. Topics include: probability distributions and probability models; hypothesis testing based on single and multiple samples; single and multi-factor ANOVA; linear, logistic, and nonlinear regression; design, analysis, validation of experiments; nonparametric techniques; advanced statistical methods in scientific research.

**CSE 603 Advanced Mathematics** **3 Credits**  
Grade Mode: Standard Letter, Audit/Non Audit

This course introduces advanced math topics such as differential equations and their applications in energy and other engineering domains

**CSE 605 Computational Data Analytics** **3 Credits**  
Grade Mode: Standard Letter, Audit/Non Audit

It gains common computational tools for rapid analysis of several energy, environment and sustainability data sets.

**CSE 606 Numerical Methods for Scientists and Engineers** **3 Credits**  
Grade Mode: Standard Letter, Audit/Non Audit

Numerical Methods for Scientists and Engineers

**CSE 607 Advanced Systems Optimization** **3 Credits**  
Grade Mode: Standard Letter, Audit/Non Audit

This course focuses on introducing selected optimization tools for energy, environment and sustainability applications.

**CSE 730 Hardware Security** **3 Credits**  
Grade Mode: Standard Letter

This course explores vulnerabilities and defenses at the intersection of hardware and system security. Students will study microarchitectural side channels, memory attacks, firmware/boot chain threats, trusted execution environments, and emerging hardware threats in cloud and IoT. Emphasis is placed on understanding the underlying computer engineering principles and evaluating real-world exploits and defenses.

**CSE 770 Nano-Bio-Technology** **3 Credits**  
Grade Mode: Standard Letter, Audit/Non Audit

Introduction to nanoscale bio-systems and the application of nano-bio-technology. Topics covered include nanomaterials synthesis and characterization, surface and interfaces properties, biohazard risk assessment, toxicity, drug deliver, diagnostics, lab-on-chip systems, hyperthermia, antimicrobials.

**CSE 785 Innovation Entrepreneurship and Leadership I** **3 Credits**  
Grade Mode: Standard Letter, Audit/Non Audit

This course first provides introductory discussions on theories of design innovation, entrepreneurship and leadership. Then, it focuses on experiential learning for design and development of products, processes, systems and business models. Topics include design thinking, system thinking, design process; understanding and developing user/stakeholder needs/input for a sustainable solution; generating technical and marketing specifications; and prototyping methods to reduce development time.

**CSE 786 Innovation Entrepreneurship Leadership II** **3 Credits**  
Grade Mode: Standard Letter, Audit/Non Audit

This course first provides introductory discussions on theories of design innovation, entrepreneurship and leadership. Then, it focuses on experiential learning for design and development of products, processes, systems and business models. Topics include design thinking, system thinking, design process; understanding and developing user/stakeholder needs/input for a sustainable solution; generating technical and marketing specifications; and prototyping methods to reduce development time.

### Sustainability Studies

**SENS 601 Research Methods and Ethics** **3 Credits**  
Grade Mode: Standard Letter, Audit/Non Audit

The course prepares students for performing graduate level research. It introduces students to quantitative and qualitative methods for critical exploration of research, locating and summarizing and critiquing relevant literature, developing a research problem, framing a problem with an appropriate research method, constructing a coherent research designs. Introduction to ethics and ethical misconduct, intellectual property and environmental health and safety. Through the course students will be developing a research proposal.

**SENS 611 Sustainability Fundamentals and Tools** **3 Credits**  
Grade Mode: Standard Letter, Audit/Non Audit

This course gives a general introduction to sustainability and how this concept evolved from the environmental movement of the post-World Water 2 era to the present. It outlines the major global issues that sustainability confronts, the major stakeholders involved and the barriers that prevent the wide scale application of sustainability principles. Students will be introduced to the main methods of quantifying sustainability, assessing the strengths and limitations of each method.

**SENS 681 Integrated Sustainable Design for the Built Environment** **3 Credits**  
Grade Mode: Standard Letter, Audit/Non Audit

Students gain principles of sustainable design, and implement, demonstrate and debate them for specific built-environment projects in teams.

**SENS 695 Master's Thesis Hours** **1-6 Credits**  
Grade Mode: Pass/Non Pass

The student formulates and undertakes an independent scientific research project under the supervision of their research adviser. A successful thesis defence leads to a Pass grade.

**SENS 698 Industrial/Applied Project** **6 Credits**  
Grade Mode: Standard Letter, Pass/Non Pass

The student formulates and undertakes an independent scientific research project under the supervision of their research adviser. A successful thesis defence leads to a Pass grade.

**SENS 701 Research Seminars** **0 Credits**  
Grade Mode: Audit/Non Audit, Pass/Non Pass

Research seminars are a regular slot for invited speakers and students to present scientific research and be listen to Sustainability related topics outside their main research focus.

**SENS 706 Independent Studies** **3 Credits**  
Grade Mode: Standard Letter

Independent studies offer an opportunity for students to perform independent research work in any area related to Sustainable Development under the supervision of a faculty member

**SENS 712 Environmental Quality and Health** **3 Credits**  
Grade Mode: Standard Letter, Audit/Non Audit

The course will provide an overview on the relationship between Environmental Quality and health and the link to economic growth and sustainable development. Case studies will demonstrate the importance of growth, expansion of urban population and their impact on land, and water resources quantity and quality. In addition the course will cover the risks, transport and toxicity mechanisms associated with Chemicals of Emerging Concern in daily life, industry, and drinking water.

**SENS 714 Sustainability: Energy, Environment and Economics** **3 Credits**  
Grade Mode: Standard Letter, Audit/Non Audit

This course provides an introduction to the interactions between energy, environment, economics and society, and how these impact sustainable development. The course will explore the influence of society through population growth, changing consumption rates and a desire to grow GDP on the extraction and utilization of energy sources and related environmental impacts. In particular the course will focus on the economic and social impacts of renewable energy development and environmental resource management.

**SENS 715 Life Cycle Assessment - LCA** **3 Credits**  
Grade Mode: Standard Letter, Audit/Non Audit

The need for sustainable engineering is fueling the development of novel tools and techniques for studying the behavior of industrial systems and their relationship with the biosphere and society. Life Cycle Assessment (LCA) is an environmental modeling method that has become increasingly popular within business and academia for evaluating the environmental impacts of products or systems. LCA considers impacts along the entire life cycle, from production to consumption to disposal, and generally provides quantitative information for a range of different environmental issues to inform decisions. This course enables students to develop a practical understanding of the intellectual foundation and standards of LCA, common databases and software packages used, and their application to products and systems. Process-based analysis models, input-output and hybrid approaches are presented for LCA. This is a research based course and is suitable for students interested in researching in depth a particular topic.

**SENS 716 Efficiency: Resource Use and Behavioural Analysis** **3 Credits**  
Grade Mode: Standard Letter, Audit/Non Audit

This course explores the various uses of energy and other resources in a variety of human activities, the relative magnitudes of resource consumption and waste and the technological, social and economic factors that impact energy and resource efficiency and conservation.

**SENS 718 Sustainable Cities and Urban Mobility** **3 Credits**  
Grade Mode: Standard Letter, Audit/Non Audit

This course offers a multidisciplinary exploration of sustainable urban development by integrating advanced energy systems and smart city frameworks with traditional urban planning and transportation studies. Students will analyze the interplay between urban design, mobility, and public health alongside topics such as energy and sustainability. Building on established smart city frameworks, the course incorporates a smart city matrix that assesses urban progress through seven sub-indexes—Smart Environment, Smart Economy, Smart Society, Smart Governance, Smart Energy, Smart Infrastructure, and Smart Transportation—allowing students to quantify a city's transition toward sustainability.

**SENS 719 Energy Water Food (EWF) Nexus** **3 Credits**  
Grade Mode: Standard Letter, Audit/Non Audit

This course investigates the nexus of energy, water and food (EWF) resources and the complex interaction with human behavior and natural systems, in addition to the inter-dependencies that exist between the EWF resources themselves. The social, technical and economic nature of these interdependencies is explored throughout the life cycle of various systems to determine optimal solutions for a sustainable future.

**SENS 720 Additive Manufacturing for Sustainability** **3 Credits**  
Grade Mode: Standard Letter, Audit/Non Audit

This course focuses on Additive Manufacturing and the relevant issues of materials, design, process, applications, modelling and simulation. It will introduce the fundamental concepts, its relevance, use and importance under the field of sustainability in terms of materials, time, space and resource efficiency; part, process and application flexibility; distributive, on-time and on-demand nature of production capability; and possible intertwining with other disciplines of materials science, design, industry, production, arts and architecture. Then, it will gain knowledge on various emerging types, approaches, applications of Additive Manufacturing in addition to materials, design, modelling and economics for it.

**SENS 721 Advanced Materials Synthesis and Characterization** **3 Credits**  
Grade Mode: Standard Letter, Audit/Non Audit

This course provides an overview and hands on experience on processing and characterization techniques of advanced materials used in energy, water, and electronics applications. Both chemical and physical processes to synthesize and deposit materials in various scales including nanostructures, thin films and bulk are tackled. The course also provides basic training in advanced characterization technics such as AFM, SEM, XPS, TOF-SIMS, XRD, Raman and FTIR. In addition, advanced tools related to PV characterization (e.g. TRPL, PL mapping and micro PCD) will be as well introduced in-depth

**SENS 722 Sustainable Chemical Industry - A Green Approach** **3 Credits**  
Grade Mode: Standard Letter, Audit/Non Audit

This course will introduce principles and practices of sustainable chemical process design to reduce industry's impact on the environment. Specific examples will cover the possibilities of running industrial chemical processes in a sustainable manner and provide an up-to-date insight into the main concerns for sustainable process optimization.

**SENS 728 Electrochemistry and Environmental Corrosion** **3 Credits**  
Grade Mode: Standard Letter, Audit/Non Audit

This course is designed for graduate students who are interested in learning by doing in the area of applied electrochemistry and environmental corrosion. The course specifically focuses on how to make electrode and cells (e.g., battery). Also, the course extends to study corrosion behavior of metallic substrates under a given condition that develop in our living environment. Furthermore, the course teaches advanced techniques used to understand electrode reactions in particular corrosion processes and estimate important parameters, such as corrosion potential and corrosion rates.

**SENS 729 Electrochemistry and Electrochemical Processing** **3 Credits**  
Grade Mode: Standard Letter, Audit/Non Audit

This course is about introducing fundamentals and applications of electrochemistry in energy storage

**SENS 762 Advanced Transport Phenomena** **3 Credits**  
Grade Mode: Standard Letter, Audit/Non Audit

This course will acquaint the student with important topics in advanced transport phenomena (momentum, heat and mass transport). Topics include laminar and turbulent flow, thermal conductivity and the energy equation, molecular mass transport and diffusion with heterogeneous and homogeneous chemical reactions. Focus will be to develop physical understanding of principles discussed and with emphasis on different field of engineering applications. In addition to the text, the student will be exposed to classic and current literature in the field. Two exams, homework assignments and a student project are required

**SENS 780 Green Building: Design, Construction and Operation** **3 Credits**  
Grade Mode: Standard Letter, Audit/Non Audit

The built environment is a major source of environmental impact. This course teaches all major aspects of green building design, construction and operation with life cycle thinking in order to reduce these impacts. All green building categories are covered: location & transportation, sustainable sites, energy and atmosphere, water efficiency, materials & resources, and indoor environmental quality. The United States Green Building Council's LEED rating system is used to demonstrate one possible green rating system.

**SENS 785 Innovation Entrepreneurship Leadership I** **3 Credits**  
Grade Mode: Standard Letter, Audit/Non Audit

This course first provides introductory discussions on theories of design innovation, entrepreneurship and leadership. Then, it focuses on experiential learning for design and development of products, processes, systems and business models. Topics include design thinking, system thinking, design process; understanding and developing user/stakeholder needs/input for a sustainable solution; generating technical and marketing specifications; and prototyping methods to reduce development time.

**SENS 786 Innovation Entrepreneurship Leadership II** **3 Credits**  
Grade Mode: Standard Letter, Audit/Non Audit

This course first provides introductory discussions on theories of design innovation, entrepreneurship and leadership. Then, it focuses on experiential learning for design and development of products, processes, systems and business models. Topics include design thinking, system thinking, design process; understanding and developing user/stakeholder needs/input for a sustainable solution; generating technical and marketing specifications; and prototyping methods to reduce development time.

**SENS 791 Geospatial Information Systems** **3 Credits**  
Grade Mode: Standard Letter, Audit/Non Audit

This course is about introducing information system fundamentals for geospatial applications

**SENS 890 Dissertation Hours**  
Grade Mode: Pass/Non Pass

**1-9 Credits**

Original and independent doctoral thesis research. A successful defense of the thesis leads to the grade Pass

## Sustainable Energy

**SENR 615 Oil and Gas Geopolitics**

**3 Credits**

Grade Mode: Standard Letter, Audit/Non Audit

This course focuses on geopolitical aspects of the oil and gas industry starting with an introduction of history of oil and gas and the geopolitics. It provides a global understanding of sources of crude oil and natural gas; current statistics of oil and gas reserve and production; economic analysis and environmental impacts of the oil and gas industry; finance and current market share; the future of this fossil fuel industry versus sustainable energy resources.

**SENR 724 Solid State Physics**

**3 Credits**

Grade Mode: Standard Letter, Audit/Non Audit

The course covers the physics concepts that describe the electrical, optical and thermal properties of materials and their energy related applications as well as some of the advanced techniques that are used to study these properties. Course topics include: (i) Perfect crystals and defects, (ii) electronic properties, (iii) Optical properties, (iv) thermal properties, (vi) Properties of Nanomaterials.

**SENR 727 Science and Engineering of Thin Films and Interfaces**

**3 Credits**

Grade Mode: Standard Letter, Audit/Non Audit

It introduces fundamentals of thin films and their applications in solar PV

**SENR 740 Energy Resources, Generation, Science and Technology**

**3 Credits**

Grade Mode: Standard Letter, Audit/Non Audit

It introduces comparatively basic technology and economic aspects of various energy resource technologies

**SENR 741 Oil and Gas Technology and Economics**

**3 Credits**

Grade Mode: Standard Letter, Audit/Non Audit

This course focuses on various aspects of the oil and gas industry; the history of oil and gas and the geopolitics of the industry; sources of crude oil and natural gas; current statistics of oil and gas reserve and production; the process from extraction to consumer delivery (Well to Wheel); natural gas in Qatar; natural gas processing, transport, and storage; economic analysis and environmental impacts of the oil and gas industry; petroleum finance and current market share; the future of this fossil fuel industry versus sustainable energy resources.

**SENR 742 The Life Cycle of Oil and Gas Fields**

**3 Credits**

Grade Mode: Standard Letter, Audit/Non Audit

This course focuses on the life cycle of an oil and gas fields; specifically, the upstream component. It discusses the technical, theoretical and operational aspects for this component. Drilling technologies and operations, formation evaluations, well testing, and production strategies will be studied. Moreover, it focuses on the recovery mechanisms, enhanced oil recovery, reservoir simulation and management, the life cycle of a well and the abandonment process. Finally, it discusses the environmental effects for this component of the oil and gas industry and how it has decreased over the past decades.

**SENR 743 Photovoltaic Solar Technology**

**3 Credits**

Grade Mode: Standard Letter, Audit/Non Audit

This course focuses on various aspects of the oil and gas industry; the history of oil and gas and the geopolitics of the industry; sources of crude oil and natural gas; current statistics of oil and gas reserve and production; the process from extraction to consumer delivery (Well to Wheel); natural gas in Qatar; natural gas processing, transport, and storage; economic analysis and environmental impacts of the oil and gas industry; petroleum finance and current market share; the future of this fossil fuel industry versus sustainable energy resources.

**SENR 744 Renewable Energy Systems**

**3 Credits**

Grade Mode: Standard Letter, Audit/Non Audit

This course is about comparative discussions of renewable energy systems

**SENR 750 Energy Storage Devices and Systems**

**3 Credits**

Grade Mode: Standard Letter, Audit/Non Audit

This course provides fundamental information about energy storage technologies, applications, and their integration with renewables. This course applies thermodynamic fundamentals to energy storage systems. Furthermore, environmental impacts of energy storage technologies are comparatively presented. The course covers most of the established energy storage technologies and their fundamentals. Energy storage methods considered include; mechanical, thermal, thermochemical, chemical, electrochemical, electromagnetic, biologic and emerging methods.

**SENR 754 Smart Power Grids**

**3 Credits**

Grade Mode: Standard Letter, Audit/Non Audit

Smart Power Grids course will provide fundamental insights into century long energy studies that aims to match the demand with the supply, as well as a decade long re- search and development efforts in Smart Energy Grids to improve the energy efficiency, reliability, and environmental aspects of the power grids. More specifically, the course will provide a rich introduction to the new multi-disciplinary field of smart grids and it will cover variety of special topics including demand response, advanced metering networks, communication and sensing technologies, distributed energy generation and storage, electric vehicles, wide-area power system monitoring, energy markets, and cyber-security.

**SENR 755 Micro-grids: Operation, Management and Planning**

**3 Credits**

Grade Mode: Standard Letter, Audit/Non Audit

It is about applications of smart grid technologies for small scale applications

## Sustainable Environment

**SENV 713 Environmental Impact and Management Systems**

**3 Credits**

Grade Mode: Standard Letter, Audit/Non Audit

This course will review the main sources of pollution and present the methods for assessing their environmental impacts. Impact and management systems will be explored in the context of both local and international environmental legislation; the phases of an EIA; how emission and discharge limits are set; dispersion modelling; risk prioritization; and life cycle analysis. Actual case studies from the process industries will be discussed.

**SENV 745 Energy NanoTechnology** **3 Credits**  
 Grade Mode: Standard Letter, Audit/Non Audit

This course introduces an overview of nanomaterials used for energy production, storage and conservation. The course provides an overview of the synthesis and characterization techniques for nanomaterial used in energy applications such as fuel cells, energy harvesters and energy storage devices.

**SENV 760 Air Quality and Climate Change** **3 Credits**  
 Grade Mode: Standard Letter, Audit/Non Audit

This course introduces important aspects of air quality issues and its relevance to climate change

**SENV 761 Atmospheric Chemistry and Climate Change** **3 Credits**  
 Grade Mode: Standard Letter, Audit/Non Audit

This course provides an exploration of the chemical and physical processes occurring in the near-ground, troposphere and stratosphere including atmospheric composition, structure, transportation and the photochemically driven reactions. In turn students will gain an insight into the role of industrial emissions on smog, ozone depletion and climate change.

**SENV 770 Desalination Technologies** **3 Credits**  
 Grade Mode: Standard Letter, Audit/Non Audit

This course provides an overview of water production in the Gulf Cooperation Council Countries (GCC) through Desalination Processes. The course will explore various technologies including thermal and membrane systems as well as power-cogeneration

**SENV 772 Water and Wastewater Treatment** **3 Credits**  
 Grade Mode: Standard Letter, Audit/Non Audit

This course introduces students to important physiochemical and biological processes in wastewater treatment and the sustainable developments that are occurring in this field. Topics include priority contaminants, water discharge standards and design of suitable treatment processes with a focus on biological treatment of municipal wastewater.

**SENV 773 Water Resources Management** **3 Credits**  
 Grade Mode: Standard Letter, Audit/Non Audit

This course explores the water cycle with a particular focus on hydrology, water conservation, system efficiency, and issues of public health. A range of engineering and social science topics related to water use and management are covered.

**SENV 774 Water Treatment and Reuse** **3 Credits**  
 Grade Mode: Standard Letter, Audit/Non Audit

The course develops graduate level concepts for the examination of drinking water quality and discussion of state of the art technologies for treating drinking water. Case studies will be introduced highlighting the inadequacy or susceptibility to failure of existing drinking water infrastructure to provide students with understanding of what challenges may come across in their professional practice, and how to avoid similar situations in future.

**SENV 776 Solid and Hazardous Waste Management** **3 Credits**  
 Grade Mode: Standard Letter, Audit/Non Audit

This course introduces students to the characterisation, separation, handling and disposal of various wastes from a variety of municipal, construction and industrial sources and explores management and societal issues, treatment/control technologies and resource recovery methods. Methods to eliminate, recover, recycle and re-use wastes are a major focus for this course

**SENV 778 Principles of Hydrogeology** **3 Credits**  
 Grade Mode: Standard Letter, Audit/Non Audit

This course introduces students to the fundamentals of hydrogeology and groundwater science. It covers the physical properties of the aquifers, groundwater flow, well hydraulics and groundwater developments, with emphasis on Qatar as a case study. The course also covers basics of groundwater modelling, protection and management.