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## Energy and Environmental Ph.D. Program

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### OBJECTIVE

The program is designed to prepare men and women for positions in research and consulting in industry, government and service organizations, and teaching and research positions in colleges and universities. Graduates will be able to:

1. Conceive, develop, and conduct original research leading to useful applications in energy and environmental systems.
2. Incorporate into their professional work considerations relating to scientific, technical, managerial, and social aspects of energy and environmental systems.
3. Contribute to societal understanding of global energy and environmental issues including homeland security through development of interdisciplinary educational materials and participation in international exchanges.
4. Demonstrate effective written and oral communication skills related to research issues in energy and environmental systems.

### GENERAL PROGRAM ADMISSION REQUIREMENTS

Requirements for admission are:

1. A master's degree in engineering, agriculture, physical, biological and computational sciences, technology, or business and economics from a college or university recognized by a regional or general accrediting agency with a minimum GPA of 3.25/4.0.
2. GRE score of at least 1100.
3. For applicants whose native language is other than English, Test of English as a Foreign Language (TOEFL) examination score of 550 or higher on the written examination or at least 213 on the computer examination.
4. For international applicants, application for the fall semester completed by April 15 and for the spring semester by October 15.

Students admitted on an unconditional basis are expected to have completed the courses below as part of their prior undergraduate and graduate studies:

Calculus (minimum of 8 semester hours)  
Differential Equations  
Physics (minimum of 6 semester hours)  
Chemistry (minimum of 3 semester hours)  
Computer Programming (minimum of 3 semester hours)

### Co-Major

Students in the Energy & Environmental Ph.D. Program may co-major with other Ph.D. programs offered by NC A&T State University or through the inter-institutional Ph.D. program. This will require the approval of both Ph.D. programs and approval of the student's combined advisory committee. Co-majors must meet all requirements for majors in both programs. Only one degree is awarded and the co-major is noted on the transcript. Co-majors are not permitted between Doctorate-level and lower-level programs.

### PROGRAM OPTIONS AND DEGREE REQUIREMENTS

The program requires 51 credit hours beyond the M.S. degree distributed as follows:

27 credit hours for course work,  
3 credit hours for seminars,

3 credit hours for professional practice/development,  
and 18 credit hours for dissertation research.

Students progress through the program by passing a written qualifying exam over the four core courses and a preliminary exam over the student's proposed research. As an indicator of their research competency, all students will be required to submit at least two refereed journal articles that have been approved by their dissertation committee before graduation. The program requirements are summarized as follows:

Requirement Category	Credits	Courses
Core Courses	12	EES 700, EES 730, EES 810*, EES 811 + one from EES 710, EES 720, EES 750
Written Qualifying Examination	0	EES 991, Covers core courses only
Elective Track	9	Progressive series of courses at the 600-level (maximum of two courses), 700-level or 800-level, Options are presented below.
Supervised Teaching/Practicum	3	EES 990, EES 993 or EES 996
Seminar Requirement	3	<u>EES 992</u>
Technical Electives	6	Courses at the 700-level or 800-level, Subject to advisor approval **
Preliminary Examination	3	<u>EES 995</u>
Dissertation	15	<u>EES 997</u>
<b>TOTAL</b>	<b>51</b>	

\*EES 810 is a prerequisite for EES 811.

\*\*EES 710 is required as a core course only for students who have not previously had undergraduate or graduate courses in the biological or chemical aspects of energy and environmental science.

#### Elective Tracks

**Atmospheric Sciences** (CHEM 711, CHEM 721, CHEM 722, CHEM 723, CHEM 727, CHEM 731, CHEM 732, CHEM 741, CHEM 742, CHEM 743, CHEM 744, CHEM 746, CHEM 748, CHEM 749, CSE 701, CSE 702, CSE 704, CSE 713, EES 785, EES 885, INEN 675, PHYS 735, PHYS 736, PHYS 744, PHYS 745, and other courses subject to advisor approval)

**Bio-energy/Bio-materials** (BIOL 703, BIOL 704, BIOL 739, BIOL 741, BIOL 749, BIOL 750, BIOL 780, CHEM 756, CSE 701, EES 785, EES 885, HORT 700, PHYS 744, CHEN 760, EES 785, EES 885, INEN 675, MEEN 810, MEEN 820, MEEN 822, MEEN 850, MEEN 860, and other courses subject to advisor approval)

**Biotechnology** (ANSC 771, BIOL 700, BIOL 703, BIOL 704, BIOL 739, BIOL 741, BIOL 749, BIOL 750, BIOL 780, CHEM 756, CSE 701, EASC 718, EES 785, EES 885, HORT 700, INEN 675, PHYS 744, and other courses subject to advisor approval)

**Energy and Environmental Education** (CUIN 711, CUIN 721, CUIN 729, CUIN 746, ECT 785, EES 785, EES 885, INEN 675, LEST 800, LEST 802, LEST 810, LEST 811, LEST 820, LEST 850, TECH 715, TECH 762, TECH 763, TECH 764, TECH 765, TECH 766, TECH 767, and other courses subject to advisor approval)

**Energy Technologies** (CSE 701, ECT 785, EES 785, EES 885, INEN 675, MEEN 838, PHYS 738, PHYS 739, and other courses subject to advisor approval)

**Environmental Sciences** (ANSC 701, BIOL 700, CHEM 711, CHEM 721, CHEM 722, CHEM 723, CHEM 727, CHEM 731, CHEM 732, CHEM 741, CHEM 742, CHEM 743, CHEM 744, CHEM 746, CHEM 748, CHEM 749, CSE 701, CSE 702, EASC 718, EES 785, EES 885, INEN 675, PHYS 736, PHYS 735, PHYS 738, PHYS 739, PHYS 744, PHYS 745, SLSC 710, SLSC 715, SLSC 717, SLSC 727, SLSC 734, and other courses subject to advisor approval)

**Fate and Transport of Contaminants** (CHEN 710,CHEN 720, CHEN 750,CHEN 760, CIEN 702,CIEN 712,CIEN 724,CSE 701,CSE 702,CSE 703,CSE 704,CSE 713,EASC 718,EES 785,EES 885,INEN 675,MATH 712,MATH 721,MATH 723,MATH 731,MATH 733,MATH 752,MATH 765,MATH 781, MEEN 716,MEEN 752,MEEN 820,MEEN 822,MEEN 850,MEEN 860,SLSC 734, and other courses subject to advisor approval)

**Information Technology** (ANSC 771,BIOL 706,BIOL 755,COMP 710,COMP 711,COMP 712,COMP 713,COMP 732,COMP 740,COMP 755,COMP 770,COMP 785,CSE 701,CSE 702,CSE 703,CSE 704,EES 785,EES 885,ELEN 720,ELEN 821,ELEN 822,INEN 675,MATH 706,MATH 708,MATH 721,MATH 733,MATH 752,MATH 765, and other courses subject to advisor approval)

**Materials** (CHEN 760,CSE 701,EES 785,EES 885,ELEN 701,ELEN 710,ELEN 801,ELEN 802,ELEN 803,ELEN 804,ELEN 805,ELEN 810,INEN 675,MEEN 752,MEEN 810,MEEN 813,MEEN 820,MEEN 822,MEEN 850,MEEN 860, and other courses subject to advisor approval)

**Nanotechnology** (CSE 701,CSE711,CSE712,CSE713,EES 785,EES 885,INEN 675,PHYS 735, and other courses subject to advisor approval)

**Sensors and Controls** (CSE 701,EES 785,EES 885,ELEN 762,ELEN 764,ELEN 861,ELEN 862,ELEN 866,ELEN 867,ELEN 868,ELEN 869,ELEN 870,ELEN 871,INEN 675,INEN 851,INEN 852,MATH 752, and other courses subject to advisor approval)

**Separations and Reactions** (CHEM 749,CHEN 720,CHEN 750,CHEN 760,CSE 701,CSE 702,CSE 713,EES 785,EES 885, INEN 675,SLSC 734, and other courses subject to advisor approval)

**Systems Management and Economics** (ACCT 714,BUAD 712,BUAD 713,BUAD 715,BUAD 716,BUAD 718,CSE 701,CSE 702,ECT 785,EES 785,EES 885,INEN 675,INEN 721,INEN 731,INEN 734,INEN 821,INEN 822, INEN 832,INEN 833,INEN 843,INEN 844, and other courses subject to advisor approval)

**Sustainable Technologies for the Built Environment** (AREN 702,AREN 742,AREN 762,AREN 765,AREN 770,AREN 772,AREN 778,CSE 701,ECT 785,EES 785,EES 885,INEN 675,and other courses subject to advisor approval)

**Transportation and Logistics** (CSE 701,EES 785, EES 885, INEN 675,TRAN 701, TRAN 720,TRAN 725,TRAN 727,TRAN 730, and other courses subject to advisor approval)

## **Ph.D. COMMITTEE AND PLAN OF GRADUATE WORK**

Initially, the Director of the program will serve as the academic advisor for all new students entering the program. Each student in the Ph.D. program is expected to select a major advisor by the beginning of the second year with the approval of the Director. The major advisor must hold a tenure or tenure-track, full-time faculty position at the university. However, a co-advisor may have non-tenure-track/adjunct status. The Ph.D. Committee will consist of a minimum of four (4) graduate faculty members with the major advisor as its chairperson. Committee members must be from at least two different departments. Also, members must represent more than one campus School/College. The Ph.D. Committee will be recommended by the major advisor, with input from the student, to the Director of the Ph.D. program, for approval by the Dean of Graduate Studies.

## **PRELIMINARY EXAMINATION**

A student's written dissertation proposal is submitted to his/her major advisor and the Ph.D. Committee for review. Dissertation proposals are expected to review the state-of-the-art and should clearly indicate that a substantial literature search has been completed. The proposal must be orally defended by the candidate before the Ph.D. Committee, and it must be accepted by the committee. The signature of committee members on the dissertation proposal constitutes approval to proceed with research. After receiving a passing grade in the preliminary exam course, EES 995, the student may register for the Energy & Environmental Ph.D. Dissertation course, EES 997.

## **ADMISSION TO CANDIDACY**

Admission to candidacy for the Ph.D. degree in Energy & Environmental Studies will require compliance with the following:

- a) Completion of all core and elective courses approved for the student's program of study,
- b) A minimum cumulative GPA of 3.0 or better, and
- c) Successful completion of the preliminary examination.

## FINAL ORAL EXAMINATION

The final oral examination is scheduled after the dissertation is complete, except for such revisions as may be necessary as a result of the examination, but not earlier than one semester, or its equivalent, after admission to candidacy and not before at least two refereed journal articles have been approved by the Ph.D. Committee and are in review by the journals. The examination consists of the candidate's defense of methodology used and the conclusions reached in the research, as reported in the dissertation. It is conducted by the student's Ph.D. Committee. Approval by a majority vote of the Ph.D. Committee is required to pass the final oral examination. Approval may be conditioned, however, on the student's meeting specific requirements described by the Ph.D. Committee. Failure of a student to pass the examination terminates his/her work at this institution unless the Ph.D. Committee recommends a reexamination. No reexamination is given until one full semester has elapsed and only one reexamination is permitted.

## OTHER INFORMATION

See "Requirements for the Doctor of Philosophy Degree" elsewhere in this catalog for information related to residence requirements and time limit. Additional details of requirements for the program are outlined in the Energy & Environmental Ph.D. Program Student Handbook available from the Graduate School.

<b>List of Courses</b>	<b>Credits</b>
EES 700 Introduction to Research Ethics	1
EES 710 Applied Environmental Chemistry & Microbiology	3
EES 720 Theory and Practice of Alternative Energy Technologies	3
EES 730 Research Proposal Writing	3
EES 750 Atmospheric Physical and Chemical Processes	3
EES 785 Special Topics	3
EES 810 Theory and Practice of Energy & Environmental Economic Policy Analysis	3
EES 811 Applications of Energy and Environmental Economic Policy Analysis	3
EES 885 Special Topics	3
<b>Ph.D. Level Pass/Fail Courses</b>	
EES 990 Doctoral Supervised Practicum	3
EES 991 Doctoral Qualifying Examination	0
EES 992 Doctoral Seminar	1
EES 993 Doctoral Supervised Teaching	3
EES 994 Doctoral Supervised Research	3
EES 995 Doctoral Preliminary Examination	3
EES 996 Laboratory Internship	3
EES 997 Doctoral Dissertation (Variable)	3-9
EES 999 Continuation of Doctoral Degree	1

## COURSE DESCRIPTIONS

### Energy & Environmental Course Listings

#### Ph.D. Courses

EES 700	Introduction to Research Ethics
EES 710	Applied Environmental Chemistry & Microbiology
EES 720	Theory and Practice of Alternative Energy Technologies
EES 730	Research Proposal Writing
EES 750	Atmospheric Physical and Chemical Processes
EES 785	Special Topics
EES 810	Theory and Practice of Energy and Environmental Economic Policy Analysis
EES 811	Applications of Energy and Environmental Economic Policy Analysis
EES 885	Special Topics

#### Ph.D. Level Pass/Fail Courses

EES 990	Doctoral Supervised Practicum
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EES 991 Doctoral Qualifying Examination  
EES 992 Doctoral Seminar  
EES 993 Doctoral Supervised Teaching  
EES 994 Doctoral Supervised Research  
EES 995 Doctoral Preliminary Examination  
EES 996 Laboratory Internship  
EES 997 Doctoral Dissertation  
EES 999 Continuation of Doctoral Degree

### **Energy & Environmental Course Descriptions**

**EES 700. Introduction to Research Ethics** **Credit 1(1-0)**

This course will cover the policies regulating research at land grant universities and the ethical principles on which these policies are based. Topics covered include use of humans in research; use of animals in research; research misconduct; authorship and peer review; intellectual property; proper experimental design, data collection, and statistical interpretation; and discipline-specific issues. Prerequisites: Graduate standing and consent of instructor.

**EES-710. Applied Environmental Chemistry and Microbiology** **Credit 3(2-2)**

This course provides an integrated presentation of the biological and chemical aspects of applied environmental science. The laboratory component of the course involves designing experiments and methodologies to evaluate environmental samples. Prerequisites: Graduate standing and consent of instructor.

**EES-720. Theory and Practice of Alternative Energy Technologies** **Credit 3(2-2)**

The course will cover the thermodynamic, mass and energy balance, economic, and environmental considerations of alternative energy technologies. Alternative energy technologies and conventional energy technologies will be compared. Prerequisites: Graduate standing and consent of instructor.

**EES 730. Research Proposal Writing** **Credit 3(3-0)**

This course will guide the student to prepare a written research proposal that contains a thorough literature review, a clear hypothesis about an issue that has not been resolved in the literature, and appropriate methodologies for determining whether or not the hypothesis is correct. Throughout the course, emphasis will be placed on developing critical thinking and technical writing skills. Prerequisites: Graduate standing and consent of instructor.

**EES 750. Atmospheric Physical and Chemical Processes** **Credit 3(2-2)**

This course presents physical chemistry principles related to atmospheric environmental systems, processes, and measurements. Various experimental techniques will be covered including gas chromatography and mass spectrometry, laser spectroscopy, and remote sensing. Prerequisites: Graduate standing and consent of instructor.

**EES-785. Special Topics** **Credit 3(3-0)**

This course allows the introduction of new topics on a trial basis at the master's level. The topic of the course will be determined prior to registration. Prerequisites: Graduate standing and consent of instructor.

**EES-810. Theory and Practice of Energy and Environmental Economic Policy Analysis** **Credit 3(3-0)**

This course provides the economic framework necessary for analyzing energy and environmental issues. Microeconomic and macroeconomic principles and analytical techniques relevant to the analysis of energy markets and environmental protection are covered. Current energy and environmental regulatory systems at the state, national, and international levels are presented. The need for and effectiveness of various types of regulations related to key energy and environmental issues are discussed for each level. Prerequisites: Doctoral Standing and consent of instructor.

**EES-811. Application of Energy and Environmental Economic Policy Analysis** **Credit 3(2-2)**

This course provides the quantitative economic techniques necessary for analyzing energy and environmental projects and issues. The techniques covered include engineering economics techniques for energy project valuation and econometric techniques used in valuing environmental resources and in forecasting the demand for energy and environmental services. During the first part of the course, empirical case studies will be reviewed; later in the course, students will prepare their own case studies. Prerequisites: EES 810.

**EES-885. Doctoral Special Topics**

**Credit**

**3(3-0)**

This course allows the introduction of new topics on a trial basis at the doctoral level. The topic of the course will be determined prior to registration. Prerequisites: Graduate standing and consent of instructor.

**EES-990. Doctoral Supervised Practicum** **Credit**  
**3(0-6)**

This course represents the supervised internship for the doctoral student that satisfies the 3 credits of required professional development. Oral and written presentations on the experience will be provided to the faculty. Grading is pass/fail evaluation only. Prerequisites: Doctoral standing and consent of instructor.

**EES-991. Doctoral Qualifying Examination** **Credit**  
**0(0-1)**

This course will guide the student to take the qualifying examination. The qualifying examination will consist of a written examination over the Energy & Environmental program core courses. The maximum number of times a student may enroll in the course is two. Prerequisites: EES 700, EES 730, EES 810, EES 811 or Consent of Instructor. Corequisites: EES 811 and EES 820.

**EES-992. Doctoral Seminar** **Credit**  
**1(1-0)**

This course includes presentations delivered by the doctoral students, faculty, and invited speakers on topics related to energy and environmental issues and research. Grading is pass/fail evaluation only. Prerequisite: Doctoral standing.

**EES-993. Doctoral Supervised Teaching** **Credit**  
**3(1-4)**

This course represents the supervised teaching for the doctoral student that satisfies the 3 credits of required professional development. This course introduces the doctoral student to classroom or laboratory teaching under the supervision of a faculty mentor. Doctoral students who serve as teaching assistants or as instructors are required to take this course during the first semester they teach. Grading is pass/fail evaluation only. Prerequisites: Doctoral standing and consent of instructor.

**EES-994. Doctoral Supervised Research** **Credit**  
**3(3-0)**

This course is supervised research under the mentorship of a member of the graduate faculty before a student passes the preliminary exam. This research should lead to the identification of a dissertation topic and written research proposal. Grading is pass/fail evaluation only. Prerequisites: Doctoral standing and consent of instructor.

**EES-995. Doctoral Preliminary Examination** **Credit**  
**3(3-0)**

In this course dissertation advisors will guide their students towards completing the preliminary examination. The preliminary examination will consist of a written proposal and oral defense of the student's dissertation proposal. Grading is pass/fail evaluation only. Prerequisite: EES 991.

**EES 996. Laboratory Internship** **Credit**  
**3(0-6)**

This course allows a student to explore various research areas first-hand by performing multiple projects in different laboratories under the mentorship of members of the graduate faculty. It should be taken before a student passes the qualifying exam. Grading is pass/fail evaluation only. Prerequisites: Doctoral standing and consent of instructor.

**EES-997. Doctoral Dissertation** **Variable Credit**  
**3(3-9)**

This course represents the supervised research leading to the dissertation for the doctoral student who has passed the preliminary exam. Doctoral dissertation research will be conducted under the supervision of the dissertation committee chairperson and include regular meetings with the dissertation committee to evaluate progress on the dissertation. Grading is pass/fail evaluation only. Prerequisite: EES 995.

**EES-999. Continuation of Doctoral Degree** **Credit**  
**1(1-0)**

This course is a continuation of work toward the doctoral degree. Grading is pass/fail evaluation only. Prerequisites: Doctoral standing