Program in Sustainable Energy

The Program in Sustainable Energy is designed for Princeton undergraduate students who interested in pursuing careers or graduate education in the area of Sustainable Energy Science and Technology to achieve:

1. An understanding of current energy resources, carriers, end users, technologies, and their impact on climate and environment
2. The ability to quantitatively analyze, design, and develop innovative energy systems and technologies that support sustainable economic growth, energy security, biological diversity, and environmental harmony for life on earth.
3. An understanding of earth, global climate, and environmental change from the perspective of engineering, technology, and policy.

The future of societies, the global economy, and the global environment depend on collaborative research into renewable energy, alternative fuels, advanced energy conversion and storage systems, technology transfer to developing countries, and prudent judgment on policies to support sustainable energy technology. Innovations and inventions require multi-disciplinary approaches and entrepreneurship, as well as grounding in theory and practice, in topics that are not covered by a single department. This certificate program offers an integrated set of core and elective courses, introducing students to fundamental concepts, providing depth in specific fields of interest, gaining laboratory and site visit experiences, and setting the stage for further work in the field. Students are encouraged to expand their experience through summer internships with companies, government agencies, and university laboratories.

Admission to the Program

The program is open to sophomores, juniors and seniors at Princeton University who have a satisfactory background in engineering and science. Normally, students should have successfully completed MAT103, MAT104, PHY103, PHY104 (or their equivalents, including AP equivalents). Students who have slightly different preparation should consult with the Program Director to discuss eligibility. A student planning to earn the program certificate should complete the Student Profile as early as possible, and be no later than the mid-point of the fall term of his or her junior year. Application for admission is made to the Program Committee. Upon acceptance to the program, the Program Director will assign a program advisor to the student to assist in planning a program of study, research, and off-campus internship.

Program of Study

A concentrator in this program must satisfy both program and departmental requirements. The program for each student is worked out by the student and his or her departmental adviser. The program requirements are as follows:

1. All students must take *six* courses, including *two* core courses and *four* elective courses. The two core courses must be taken by choosing one from Introduction to Energy

Technology category (A1) and the other one from Introduction to Climate Change and Geo-environmental Science category (A2), respectively. Depending on the student's interest and background, the four elective courses should be taken with at least one from a different energy subject area listed below (B1 and B2). To qualify for the certificate, a minimum grade average of B- in the six program courses, independent work, and senior thesis is required. In some cases, an elective course that fulfills this certificate program requirement can also meet a regular departmental requirement.

A. *Core Courses* (One from each category – A1 and A2)

A1. Introduction to Energy Technology
Students who have completed Thermodynamics (MAE 221 or CHE 246) are encouraged to take MAE 328. Students who do not have a Thermodynamics background should choose MAE 228.
MAE 328 Energy for a Greenhouse-Constrained World
MAE 228 Energy Solutions for the 21st Century

A2. Introduction to Climate Change and Geo- environmental Science
ENV/GEO 339 Climate Change: Scientific Basis, Policy, and Implications
ENV/EEB 417 A,B Ecosystems and Global Change
CEE 303/ENV 303/URB 303 Introduction to Environmental Engineering
GEO 399/ENV 399 Environmental Decision Making
WWS 334/ENV 334 Global Environmental Issues

B. *Elective Courses and Subject Areas* (Four courses with least *one* from a different subject area – B1 and B2)

B1. Energy Science and Technology (Fossil energy, non-fossil and renewable energy, energy conversion and storage systems and technologies)
MAE 427 Energy Conversion and the Environment: Transportation Applications
MAE 531 Combustion Science and Technology
MAE 426 Rockets and Airbreathing Propulsion
MAE 570 Advanced Topics in Materials and Mechanical Systems II: Materials for Energy Storage and Conservation
ELE/MAE/ENV 431 Solar Energy Conversion
PHY/AST/MAE 309 Nuclear Energy in a Carbon-Constrained World: Fission and Fusion
ENV 525 Production of Renewable Fuels & Energy
CHE 342/MAE 335 Fluid Mechanics or CEE 306 Hydrology
CHE 341 Mass, Momentum and Energy Transfer or MAE 423 Heat Transfer
CHE 421 Catalytic Chemistry
CHE 441 Chemical Reaction Engineering
ELE 441/442 Solid State Physics I, II

B2. Environmental Science and Geoscience (Earth science, climate, environment, ecosystems, policy and economic assessments of carbon capture and storage technology)
MAE 425/GEO 425 Introduction to Physical Oceanography

GEO427 Introduction to Atmospheric Science Atmospheric Composition and Thermodynamics
GEO 322 Biogeochemical Cycles and Global Energies
GEO 235 The Physical Earth
GEO/ENV 399 Environmental Decision Making
CHE 333 Oil to Ozone
ENV/GEO 339 Climate Change: Scientific Basis, Policy, and Implications
ENV/EEB 417 A, B Ecosystems and Global Change
ENV 201 Fundamentals of Environmental Studies: Population, Land Use, Biodiversity, and Energy
CEE471 Introduction to Water Pollution
CEE 424/GEO 424 Introductory Technology Seismology and Oil Exploration
NES 368/POL 437 Oil Politics in the Middle East (Social Analysis Area)

2. A senior independent work project or thesis whose topic is relevant to the program and acceptable to the Program Committee must be completed and presented to the committee. A minimum grade of B- for the project or thesis is required to qualify for the certificate.
3. Close collaboration with faculty is expected. Program students are expected to demonstrate strong academic performance. Program courses may not be taken on a pass/D/fail basis unless that is the only grading alternative for the course.
4. Program students must fill out the Student Profile form at the beginning of each year in which they are members of the program. This is especially important during the senior year to assure that requirements for the certificate will be met by the end of the year.

Seminars on Energy and the Environment
Seminars on energy and environment are announced to all students registered in this program. Advanced students are encouraged to attend regularly scheduled departmental and PEI seminars to further enrich their understanding of the field.

Undergraduate Independent Research Projects
Undergraduate projects usually are undertaken for Independent Work or Senior Thesis credit, and opportunities exist for summer and work-study projects. These projects typically last for one or two academic terms, although they may extend over greater periods of time. Students work closely with faculty and staff members in academic departments and university associated laboratories such as PPPL, and they have access to sophisticated computers and experimental facilities while conducting their independent research.

Undergraduate Off-Campus Experiences and Internship
Students are encouraged to expand their experience through site visits and to summer internships with companies, government agencies, and university laboratories (e.g. PPPL). The core laboratory course will provide several off-campus site visit experiences to power generation stations, fusion laboratory, and fuel refinery stations.

Director Yiguang Ju

Executive Committee

Craig Arnold, Mechanical and Aerospace Engineering
Jay Benziger, Chemical Engineering
Andrew B. Bocarsly, Chemistry
Emily Carter, Mechanical and Aerospace Engineering
Michael Celia, Civil and Environmental Engineering
Charles Dismukes, Chemisty
Frederick Dryer, Mechanical and Aerospace Engineering
Robert Goldston, Astrophysics
Kathy Hackett, Princeton Environmental Institute
Yiguang Ju, Mechanical and Aerospace Engineering
Chung K. Law, Mechanical and Aerospace Engineering
Luigi Martinelli, Mechanical and Aerospace Engineering
Tullis Onstott, Geosciences
Michael Oppenheimer, Geosciences and International Affairs
Steven Pacala, Ecology and Evolutionary Biology
Catherine Peters, Civil and Environmental Engineering
George Philander, Geosciences
Daniel Sigman, Geosciences
Robert Socolow, Mechanical and Aerospace Engineering
Sigurd Wagner, Electrical Engineering
Bess Ward, Geosciences
David S. Wilcove, Ecology and Evolutionary Biology and Public Affairs