Energy Science and Technology

Designated Emphasis

Reliable and economical energy is essential for society to endure. Reliance on fossil sources has now created a dependence that through progressive depletion in the not too distant future, may threaten the stability of economic systems and lead to serious, if not irreparable, environmental damage. To avoid future catastrophic global conflicts and damaging climatic changes, present energy technologies are required to operate at their highest possible efficiencies with the lowest possible environmental impact, and new technologies need to be devised and deployed that are economic, renewable, and of low or zero climate impact. This compelling scenario is propelling the development of a distinct area of science and technology that is focused on supporting the needs of the global energy market place.

The development of future, and even present-day energy sectors holds special challenges: many supply and demand technologies have multi-decadal lifetimes, appropriate forms of governmental oversight are not widely agreed upon, and the market entry of new technologies is often effectively impeded and increasingly encumbered by national security concerns. The looming energy and climatic problems are truly global issues that complicate and accelerate other problems: many energy markets are international in nature, and over the next two decades, commercial energy use in developing nations will soon surpass that in the industrialized nations.

A deepening of the understanding of factors that affect efficiencies, more accurate modeling of systems and processes, study and discovery of new materials that enable innovative energy technologies, and effective management and policies are at the basis of continued dramatic change in a wide range of technologies. This may stimulate a revolution in energy technology systems and their management that will hopefully alleviate the pressing energy needs of our present-day society and of generations to come.

The dominant energy sectors at present either rely on electricity generation from fossil sources, or on liquid fossil fuels for transportation. The potential exists, for example, to change today's electricity systems to encourage and incorporate new supply and demand-side innovations as well as innovative management policies. This would transform an enormous and vital component of U. S. infrastructure into one that provides greatly improved energy services, ensures energy diversity, is highly secure against market manipulation and terrorist attacks, and permits the provision of energy with greatly reduced regional and global environmental impacts. High efficiency combustion systems can be devised that strongly increase the conversion from hydrocarbon fuel to energy. Based on new materials physics and materials chemistry, scientific advances and inventions in nanotechnology have opened the door to potentially affordable and efficient solar and thermoelectric power generation. Novel nuclear reactors using designer fuel with minimal waste generation can now be conceptualized, significantly reducing fossil fuel consumption and nuclear waste, that in the coming decade will generate power without the inherent global warming from CO2 emissions. Advances in the understanding of biochemistry open the door to carbon-neutral technologies from biomass. Similarly, dramatic transformations can be expected in transportation systems, where new fuels, such as hydrogen or alcohols, could be produced in mass by solar, biomass, or nuclear technologies, and be consumed in highly efficient fuel cell or battery-powered vehicles. All this is possible, but will require an unprecedented level of dedication to education and interdisciplinary energy study and research.

The Designated Emphasis in Energy Science and Technology (DEEST) advances these ongoing efforts at the University of California at Berkeley, and educates a new group of leaders for the global enterprise of creating future energy systems.

Designated Emphasis in Energy Science and Technology (DEEST)

The Graduate Group in the in Energy Science and Technology has to date eleven affiliated Ph.D. programs: Chemical Engineering, Chemistry, Nuclear Engineering, the Energy Resources Group, Materials Science and Engineering, Physics, Plant and Microbial Biology, Mechanical Engineering, EECS, the ME- Fluid Mechanics and Ocean Engineering Group, and Applied Science and Technology.

The main goal of the DEEST is to enrich student's technical education in an important field and to enhance and facilitate interactions between faculty and students in different programs by creating a flexible and integrated interdisciplinary research and teaching environment.

Academic Nature of the Designated Emphasis

Students are required to complete academic work in the DEEST in addition to or as part of the full requirements of the affiliated programs. Where appropriate, affiliated Ph.D. programs may choose to recognize the DEEST as fulfilling the requirements of an outside field in their program. The Minimum Requirements are two technical courses and one additional course on Energy Management and Policy (see Section 2.4 Curricula). In addition, it is required that the student participate in seminars relevant to the DEEST when such are offered.

To be admitted to the DE in Energy Science and Technology, an applicant must already be accepted into one of the affiliated PhD programs. Candidates must then submit a petition for admission to the DEEST Graduate Group Admissions Committee prior to taking the PhD qualifying examination in the affiliated program. A sponsoring faculty member in the student's affiliated program who is member of the DEEST Graduate Group must endorse the petition. As different affiliated programs have different examination requirements, the timeline for the application may vary.

To be considered for admission, applicants must submit:

1. The DEEST petition form (http://www.me.berkeley.edu/graduate/degree-programs/special-programs-ebs-de-deest/designated-emphasis-energy-science-and/) and the Graduate Division "Change of Major or Degree Goal (http://registrar.berkeley.edu/sites/default/files/pdf/GRAD.DEG.MAJ.CHNG.pdf)" petition to the chair of the DEEST for approval. The "Change of Major or Degree Goal" must also be signed by the vice-chair of the graduate studies of the applicant.
2. The "Change of Major or Degree Goal" petition to the Degrees Unit, 318 Sproul Hall, to indicate admission to the DEEST. Upon receipt of the appropriately signed petition, the addition of the DEEST will be entered into the Graduate Division and Registrar's databases.

It is important to submit the "Graduate Petition for Change of Major Degree Goal" since the student must be admitted to the DEEST

before the qualifying examination. In the early stages of the DE, admission after the qualifying examination might be considered by the DE admission committee in exceptional cases, where it can be certified that a member of the DEEST Graduate Group was on the student's qualifying exam committee, and that at least one of the student's qualifying topics had sufficient content in the field of energy science or energy technology and engineering to meet the requirements of the DE. Such an exception must be recommended to the Graduate Division for its approval.

The Admissions Committee of the Graduate Group for the DEEST decides on admission to the DEEST.

For further information regarding admission to graduate programs at UC Berkeley, please see the Graduate Division's Admissions website (http://grad.berkeley.edu/admissions/).

Normative Time Impact on Affiliated PhD Programs

For students who can enroll in the DE curriculum to satisfy an outside field requirement in their PhD program of study, the DE should have little impact on normative time, as it might require only one additional class, plus one seminar per semester. Only for students who decide to join the DEEST after finishing their regular PhD coursework this might require additional time, but this problem should diminish in the future, and then be of relevance only for a small number of students.

Curriculum

The curriculum of the DE will consist of graded upper division and graduate courses with the following distribution:

> One course required in Group A: Energy Policy and Management
> Two required technical courses selected from two course groups, Group B: Energy Sciences, and Group C: Energy Technology.

The selection of courses will be maintained and regularly updated by the DE Graduate Group's Curriculum Committee to follow developments in the field, and the offering of new relevant courses.

An initial list is given below. In addition, students are required to attend a seminar series and discussion forum, as arranged by the curriculum committee, which is to serve as a focal point for communication and interaction between the participants. It is expected that students who elect the DEEST will do so in fields that broaden their subjects of study beyond that of their major. It is also expected that the major programs contain sufficient background to support the choice of courses for the DEEST. While the course selections do not have to focus on one technology or one science aspect, the choices in Groups B and C have been presented so as to allow a selection of coherent sets. Variations and exemptions may be allowed upon petition to the DEEST Graduate Group's Advising Committee.

Required Group A: Energy Management and Policy		
ENE,RES C100	Energy and Society	4
ENE,RES C200	Energy and Society	4
Politics of Energy and Environmental Policy		
ENE,RES 280	Energy Economics	3
CIV ENG 107	Climate Change Mitigation	3
MBA 212	Energy and Environmental Markets	3
ESPM 261	Sustainability and Society	3
Group B: Energy Sciences		
Chemistry: graduate course sequence of three 1 unit course modules may serve as satisfying one 3 unit course in Group B.		
PHYSICS 250	Special Topics in Physics (this course may have different topics. Not all of these can be considered for the DEEST)	2-4
CHEM 143	Nuclear Chemistry	2
CHM ENG 176	Principles of Electrochemical Processes	3
MEC ENG 259	Microscale Thermophysics and Heat Transfer	3
Modeling Energy, Environmental, and Resource Systems		
MEC ENG 253	Graduate Applied Optics and Radiation	3
NUC ENG 180	Introduction to Controlled Fusion	3
NUC ENG 280	Fusion Reactor Engineering	3
NUC ENG 281	Fully Ionized Plasmas	3
CHM ENG 244	Kinetics and Reaction Engineering	3
CHM ENG 245	Catalysis	3
Group C: Energy Technology		
Electrical Power Systems:		
ENE,RES 254	Electric Power Systems	3
Nuclear Power Systems:		
NUC ENG 225	The Nuclear Fuel Cycle	3
NUC ENG 161	Nuclear Power Engineering	4
NUC ENG 167	Risk-Informed Design for Advanced Nuclear Systems	3
NUC ENG 265	Design Analysis of Nuclear Reactors	3
NUC ENG 124	Radioactive Waste Management	3
NUC ENG 224	Safety Assessment for Geological Disposal of Radioactive Wastes	3
Safety Assessment for Geological Disposal of Radioactive Wastes		
The Nuclear Fuel Cycle		
CHM ENG 183	Climate Solutions Technologies	3
Renewable Resources:		
Renewable Resources for Electric Generation		
Hazardous and Industrial Waste Treatment.		
MEC ENG 241B	Marine Hydrodynamics II	3
Photovoltaics:		
MAT SCI C226	Photovoltaic Materials; Modern Technologies in the Context of a Growing Renewable Energy Market	3
Materials Engineering:		
MAT SCI 136	Materials in Energy Technologies	4
Fuel Cells, Batteries, and Chemical Sensors: Principles, Processes, Materials, and Technology		
MAT SCI 213	Environmental Effects on Materials Properties and Behavior	3
EL ENG 290Y	Advanced Topics in Electrical Engineering: Organic Materials in Electronics	3
NUC ENG 120	Nuclear Materials	4
NUC ENG 220	Irradiation Effects in Nuclear Materials	3
NUC ENG 221	Corrosion in Nuclear Power Systems	3
Thermal Engineering:		
Thermal Environmental Control		
Computer-Aided Thermal Design		
MEC ENG 140	Combustion Processes	3
MEC ENG 246	Advanced Energy Conversion Principles	3

MEC ENG 249	Machine Learning Tools for Modeling Energy Transport and Conversion Processes	3
MEC ENG 252	Heat Convection	3
MEC ENG 253	Graduate Applied Optics and Radiation	3
MEC ENG 254	Advanced Thermophysics for Applications	3
MEC ENG 255	Advanced Combustion Processes	3
MEC ENG 256	Combustion	3
MEC ENG 257	Advanced Combustion	3
MEC ENG 258	Heat Transfer with Phase Change	3

Examination Requirements

The Qualifying Examination shall include examination of knowledge within the DEEST. The Qualifying Examination Committee shall include at least one member of the DEEST Graduate Group. If a faculty member of the student's major, the DE representative can serve either as the chair or as an inside member of the committee. If the DEEST representative is from an affiliated program, it is permissible for him or her to serve as either an additional inside or outside member. Satisfactory performance on the qualifying examination for the PhD will be judged according to the established standards in the student's major program.

Dissertation Requirements

The dissertation topic shall incorporate study within the DEEST. The Dissertation Committee shall include at least one faculty member of the DE to ensure that the dissertation contributes in significant manner to the interdisciplinary field of Energy Science and Technology.

Degree Conferral Process

Upon successful completion of the dissertation, the student's transcript and diploma will record the designation: "Ph.D. in Affiliated Program Name with a Designated Emphasis in Energy Science and Technology." This designation certifies that the student has participated in and successfully completed the DE in addition to the affiliated program's requirements for the Ph.D.