

ENERGY AND MINERAL ENGINEERING

Graduate Program Head	Sanjay Srinivasan
Program Code	EME
Campus(es)	University Park (Ph.D., M.S.)
Degrees Conferred	Doctor of Philosophy (Ph.D.) Master of Science (M.S.) Dual-Title Ph.D. and M.S. in Energy and Mineral Engineering and Human Dimensions of Natural Resources and the Environment Dual-Title Ph.D. and M.S. in Energy and Mineral Engineering and Operations Research Integrated B.S. in Energy Business and Finance and M.S. in Energy and Mineral Engineering Integrated B.S. in Energy Engineering and M.S. in Energy and Mineral Engineering Integrated B.S. in Environmental Systems Engineering and M.S. in Energy and Mineral Engineering Integrated B.S. in Mining Engineering and M.S. in Energy and Mineral Engineering Integrated B.S. in Petroleum and Natural Gas Engineering and M.S. in Energy and Mineral Engineering View (https://secure.gradsch.psu.edu/gpms/?searchType=fac&prog=EME)

The Graduate Faculty

The John and Willie Leone Family Department of Energy and Mineral Engineering provides a vertically integrated approach to research and education in all aspects of the energy and mineral industries, including scientific and engineering issues, health and safety, and maintenance of high environmental standards. The department's mission is to forge an intellectual and scientific cohesiveness in energy and mineral resource technology. This objective is achieved by exploiting the natural synergy between the exploration, extraction, processing, and utilization of energy and mineral resources so as to cater to the emerging needs of society.

The Energy and Mineral Engineering (EME) program is a single graduate program with a focus on the production of energy and minerals in an economic, safe and efficient manner. The program provides flexible education of students in energy and mineral sciences and engineering, with focus on both non-renewable and renewable resource and energy industries. The program is designed to resolve the sometimes competing goals of flexible education of requisite breadth while still providing in-depth study; students are required to follow a focused curriculum that combines the requisite rigor with flexibility in a rapidly changing field of endeavor. Participating students take select from core program and required option courses and additional courses from a broad array of courses to meet the total credit requirements. Students are not required to choose an option and may complete the base program in EME. However, a student who desires disciplinary identity may choose from among the five following available graduate options:

- Petroleum and Natural Gas Engineering,
- Mining and Mineral Process Engineering,
- Fuel Science, and
- Energy Systems Engineering.

Admission Requirements

Applicants apply for admission to the program via the Graduate School application for admission (<http://gradschool.psu.edu/prospective-students/how-to-apply/>). Requirements listed here are in addition to Graduate Council policies listed under GCAC-300 Admissions Policies (<http://gradschool.psu.edu/graduate-education-policies/>).

Scores for the Graduate Record Examinations (GRE) are required for admission. The best-qualified applicants will be accepted by the Energy and Mineral Engineering graduate program up to the number of spaces available for new students.

Admission to the Energy and Mineral Engineering graduate program is competitive. Entering students must hold a bachelor's degree in a science or engineering discipline, unless they are admitted to the Integrated Undergraduate-Graduate (IUG) program. Students with 3.00 or better (out of 4.00) junior/senior cumulative grade-point averages and appropriate course backgrounds will be considered for admission. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests, at the program's discretion. Letters of recommendation and an applicant's statement of purpose are also required.

The language of instruction at Penn State is English. English proficiency test scores (TOEFL/IELTS) may be required for international applicants. See GCAC-305 Admission Requirements for International Students (<http://gradschool.psu.edu/graduate-education-policies/gcac/gcac-300/gcac-305-admission-requirements-international-students/>) for more information.

Degree Requirements

All graduate students are expected to attend general Department seminars. Graduate students may be asked to contribute to the instructional programs of the Department by assisting with undergraduate laboratory and lecture courses.

Master of Science (M.S.)

Requirements listed here are in addition to Graduate Council policies listed under GCAC-600 Research Degree Policies. (<http://gradschool.psu.edu/graduate-education-policies/>)

The M.S. degree program in Energy and Mineral Engineering is designed for students to gain advanced knowledge for research, analysis, and design in Energy and Mineral Engineering.

M.S. students must take at least two (2) courses (6 credits of core courses) from the list of prescribed (core) courses:

Code	Title	Credits
EME 501	Design Under Uncertainty in Energy and Mineral Systems	3
EME 511	Interfacial Physical-Chemical Systems, Processes, and Measurements	3
EME 521	Mathematical Modeling of Energy and Mineral Systems	3
EME 531	Thermodynamics of Energy and Mineral Systems	3

EME 551	Safety, Health and Environmental Risks in Energy and Mineral Production	3
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An additional set of prescribed twelve (12) option credits (as a minimum) must be taken if the student chooses to pursue an EME disciplinary option (petroleum and natural gas engineering, mining and mineral process engineering, fuel science, or energy systems engineering). Students are not required to choose an option and may complete the base program in EME.

Students pursuing an M.S. degree in EME will be required to complete a prescribed culminating research experience and the minimum amount of credits associated with each experience, which include the completion of minimum core and option (if any) course requirements. The thesis and non-thesis M.S. culminating experience tracks are:

THESIS-BASED M.S. in EME (30 credits total): Students are required to complete a minimum of 30 credits total (at least 18 at the 500 or 600 level) including: 24 credits in course work, 6 thesis credits (EME 600 Thesis Research), and a thesis accepted by the adviser(s) and committee members, the head of the graduate program, and the Graduate School. The student must pass a thesis defense.

NON-THESIS BASED M.S. in EME (36 credits total): Students are required to complete a minimum of 36 credits in total (at least 24 at the 500 level) including: 33 credits in course work and 3 credits for the completion of a culminating research experience. Within the 33 credits of coursework, M.S. students must take at least two extra courses (6 credits) from the EME core course list (beyond the six credit M.S. core requirement) or chosen graduate option (beyond the option's 12-credit minimum option requirement). The non-thesis culminating research experiences are:

- **Paper-based M.S.:** Students take three (3) credits of non-thesis research (EME 596 Individual Studies) and complete a satisfactory scholarly paper evaluated by adviser(s) and a reader.
- **Course-based M.S.:** Students take a capstone research course (EME 580 Methodology of Research in EME (3 cr.) where they will create a work product demonstrating evidence of analytical thinking and synthesis of knowledge in the Energy and Mineral Engineering field.

Doctor of Philosophy (Ph.D.)

Requirements listed here are in addition to Graduate Council policies listed under GCAC-600 Research Degree Policies. (<http://gradschool.psu.edu/graduate-education-policies/>)

The Ph.D. program in Energy and Mineral Engineering emphasizes scholarly research and helps students prepare for research and related careers in industry, government and academe. The Ph.D. program in Energy and Mineral Engineering requires completing a minimum of twelve (12) post-M.S. course credits, which must include the completion of all minimum core and option (if any) course requirements, and twelve (12) research credits. For students without an M.S. degree, 24 additional course credits must be taken to complete a total of 36 course credits and 48 credits total overall. At least 18 credits of these must be at the 500 or 600 level. A student's Ph.D. committee can require additional course work based on the student's background and research plans.

Ph.D. students must take at least one (1) course (3 credits of core courses) from the following list of prescribed (core) courses. Ph.D. students without an M.S. are required to take three (3) courses (9 credits of core courses) from this list:

Code	Title	Credits
EME 501	Design Under Uncertainty in Energy and Mineral Systems	3
EME 511	Interfacial Physical-Chemical Systems, Processes, and Measurements	3
EME 521	Mathematical Modeling of Energy and Mineral Systems	3
EME 531	Thermodynamics of Energy and Mineral Systems	3
EME 551	Safety, Health and Environmental Risks in Energy and Mineral Production	3

An additional set of prescribed twelve (12) option credits (as a minimum) must be taken if the student chooses to pursue an EME disciplinary option (petroleum and natural gas engineering, mining and mineral process engineering, fuel science, or energy systems engineering). Students are not required to choose an option and may complete the base program in EME.

Acceptance into the Ph.D. degree program in Energy and Mineral Engineering is based on the student's performance on the Ph.D. qualifying examination administered by the Graduate Faculty of the EME graduate program. The Ph.D. Qualifying Examination in EME is a written examination which will measure the student's fundamental knowledge of subjects covered in the program and interest area(s) of the individual candidate. It is intended to determine whether a student has the preparation, intellectual capacity, and professional attitude to complete a Ph.D. program successfully.

A Ph.D. comprehensive examination is required of all Ph.D. candidates and should be taken after substantial completion of all Ph.D. course work requirements. To earn the Ph.D. degree, doctoral students must also write a dissertation that is accepted by the Ph.D. committee, the head of the graduate program, and the Graduate School. In addition, the student must pass a final oral examination (the dissertation defense).

Options

EME students are not required to choose a graduate option and may complete the base program in EME. However, M.S. and Ph.D. students of the EME graduate program who desire disciplinary identity may choose from among the following available graduate options:

- Energy systems engineering (ESySE)
- Fuel science (FSc)
- Mining and mineral process engineering (MMPE)
- Petroleum and natural gas engineering (PNGE)

The mandatory minimum course requirement for each of these options is 12 credits (4 courses) selected from the list of option-specific courses provided below. Student may apply the option to either the M.S. or Ph.D. degrees, or both, provided that new and appropriate substitute courses are taken as approved by the EME graduate program officer.

Energy Systems Engineering Option

Code	Title	Credits
Required Courses		
Select 12 credits from the following:		12
EME 522	Computational Methods for Electric Power Systems Analysis	
EME 523	Stochastic Optimization Methods of Energy and Environmental Systems	

EME 524	Machine Learning for Energy and Mineral Engineering Problems	
EME 526	Solar Utility and Portfolio Management	
EME 527	Stochastic Modeling of Spatial Variability in Energy and Environmental Systems	
ENNEC 540	Economic Analysis of Energy Markets	
IE 505	Linear Programming	
IE 516	Applied Stochastic Processes	
Total Credits		12

Fuel Science Option

Code	Title	Credits
Required Courses		
Select 12 credits from the following:		12
CHE 544	General Transport Phenomena	
or CHE 546	Transport Phenomena II	
EME/MATSE 570	Catalytic Materials	
or CHE 536	Heterogeneous Catalysis	
FSC 503	Analytical Methods in Fuel Science	
or CHE 510	Surface Characterization of Materials	
FSC 504	Problems in Fuels Engineering	
FSC 506	Carbon Reactions	
ME 523	Numerical Solutions Applied to Heat Transfer and Fluid Mechanics Problems	
Total Credits		12

Mining and Mineral Process Engineering Option

Code	Title	Credits
Required Courses		
Select 12 credits from the following:		12
MNG 512	Valuation of Mineral Properties and Mining Projects	
MNG 541	Surface Mine Equipment Selection Analysis	
MNG 554	Rock Mechanics Design	
MNPR 505	Particle Separation	
MNPR 507	Hydrometallurgical Processing	
Total Credits		12

Petroleum and Natural Gas Engineering Option

Code	Title	Credits
Required Courses		
Select 12 credits from the following: ¹		12
PNG 501	Flow in Porous Media	
PNG 502	Coupled Flow and Deformation in Porous Media	
PNG 512	Numerical Reservoir Simulation	
PNG 518	Design of Miscible Recovery Projects	
PNG 520	Thermodynamics of Hydrocarbon Fluids	
PNG 526	Well Stimulation	
PNG 530	Natural Gas Engineering	
PNG 555	Unconventional Resources Analysis	
PNG 566	Reservoir Characterization	
PNG 577	Production and Completions Engineering	

PNG 597	Special Topics (when taught, may be used to partially satisfy the PNGE option minimum credit requirement)	
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Total Credits **12**

¹ PNG 596 Individual Studies credits may not be used within this option course credit count.

Dual-Titles

Dual-title M.S. and Ph.D. in Human Dimensions of Natural Resources and the Environment

Requirements listed here are in addition to requirements listed in GCAC-208 Dual-Title Graduate Degree Programs (<http://gradschool.psu.edu/graduate-education-policies/gcac/gcac-200/gcac-208-dual-title-graduate-degree-programs/>).

Admission Requirement

Students must apply and be admitted to the graduate program in EME and The Graduate School before they can apply for admission to the dual-title degree program. After admission to their primary program, students must apply for admission to and meet the admissions requirements of the HDNRE dual-title program. Refer to the Admission Requirements section of the Human Dimensions of Natural Resources and the Environment Bulletin page (<http://bulletins.psu.edu/graduate/programs/majors/human-dimensions-natural-resources-environment/>). Doctoral students must be admitted into the dual-title degree program in EME prior to taking the qualifying examination in their primary graduate program.

Degree Requirements

To qualify for the dual-title degree, students must satisfy the degree requirements for the degree they are enrolled in EME, listed above. In addition, students must complete the degree requirements for the dual-title in HDNRE, listed on the HDNRE Bulletin page (<http://bulletins.psu.edu/graduate/programs/majors/human-dimensions-natural-resources-environment/>).

The qualifying examination committee for the dual-title Ph.D. degree will be composed of Graduate Faculty from EME and must include at least one Graduate Faculty member from the HDNRE program. Faculty members who hold appointments in both programs' Graduate Faculty may serve in a combined role. There will be a single qualifying examination, containing elements of both EME and HDNRE. Dual-title graduate degree students may require an additional semester to fulfill requirements for both areas of study and, therefore, the qualifying examination may be delayed one semester beyond the normal period allowable.

In addition to the general Graduate Council requirements for Ph.D. committees (<http://gradschool.psu.edu/graduate-education-policies/gcac/gcac-600/phd-dissertation-committee-formation/>), the Ph.D. committee of an EME and HDNRE dual-title Ph.D. student must include at least one member of the HDNRE Graduate Faculty. Faculty members who hold appointments in both programs' Graduate Faculty may serve in a combined role. If the chair of the Ph.D. committee is not also a member of the Graduate Faculty in HDNRE, the member of the committee representing HDNRE must be appointed as co-chair. The HDNRE representative on the student's Ph.D. committee will develop questions for and participate in the evaluation of the comprehensive examination.

Students in the dual-title program are required to write and orally defend a dissertation on a topic that is approved in advance by their Ph.D. committee and reflects their original research and education in EME and

HDNRE. Upon completion of the doctoral dissertation, the candidate must pass a final oral examination (the dissertation defense) to earn the Ph.D. degree. The dissertation must be accepted by the Ph.D. committee, the head of the graduate program, and the Graduate School.

Dual-title M.S. and Ph.D. in Energy and Mineral Engineering and Operations Research

Requirements listed here are in addition to requirements listed in GCAC-208 Dual-Title Graduate Degree Programs (<http://gradschool.psu.edu/graduate-education-policies/gcac/gcac-200/gcac-208-dual-title-graduate-degree-programs/>).

Admission Requirements

Students must apply and be admitted to the graduate program in EME and The Graduate School before they can apply for admission to the dual-title degree program. After admission to their primary program, students must apply for admission to and meet the admissions requirements of the Operations Research dual-title program. Refer to the Admission Requirements section of the Operations Research Bulletin page (<http://bulletins.psu.edu/graduate/programs/majors/operations-research/>). Doctoral students must be admitted into the dual-title degree program in Operations Research prior to taking the qualifying examination in their primary graduate program.

Degree Requirements

To qualify for the dual-title degree, students must satisfy the degree requirements for the degree they are enrolled in EME, listed above. In addition, students must complete the degree requirements for the dual-title in Operations Research, listed on the Operations Research Bulletin page (<http://bulletins.psu.edu/graduate/programs/majors/operations-research/>).

The qualifying examination committee for the dual-title Ph.D. degree will be composed of Graduate Faculty from EME and must include at least one Graduate Faculty member from the Operations Research program. Faculty members who hold appointments in both programs' Graduate Faculty may serve in a combined role. There will be a single qualifying examination, containing elements of both EME and Operations Research. Dual-title graduate degree students may require an additional semester to fulfill requirements for both areas of study and, therefore, the qualifying examination may be delayed one semester beyond the normal period allowable.

In addition to the general Graduate Council requirements for Ph.D. committees (<http://gradschool.psu.edu/graduate-education-policies/gcac/gcac-600/phd-dissertation-committee-formation/>), the Ph.D. committee of an EME and Operations Research dual-title Ph.D. student must include at least one member of the Operations Research Graduate Faculty. Faculty members who hold appointments in both programs' Graduate Faculty may serve in a combined role. If the chair of the Ph.D. committee is not also a member of the Graduate Faculty in Operations Research, the member of the committee representing Operations Research must be appointed as co-chair. The Operations Research representative on the student's Ph.D. committee will develop questions for and participate in the evaluation of the comprehensive examination.

Students in the dual-title program are required to write and orally defend a dissertation on a topic that is approved in advance by their Ph.D. committee and reflects their original research and education in EME and Operations Research. Upon completion of the doctoral dissertation, the candidate must pass a final oral examination (the dissertation defense)

to earn the Ph.D. degree. The dissertation must be accepted by the Ph.D. committee, the head of the graduate program, and the Graduate School.

Integrated Undergrad-Grad Programs

The EME graduate program offers integrated B.S./M.S. programs designed to allow academically superior and research-focused undergraduate students in five B.S. degree programs—Energy Business and Finance; Energy Engineering; Environmental Systems Engineering; Mining Engineering; and Petroleum and Natural Gas Engineering—also to obtain an M.S. degree in Energy and Mineral Engineering (EME) within five years of study.

Integrated B.S. in Energy Business and Finance and M.S. in Energy and Mineral Engineering

Requirements listed here are in addition to requirements listed in GCAC-210 Integrated Undergraduate-Graduate (IUG) Degree Programs (<http://gradschool.psu.edu/graduate-education-policies/gcac/gcac-200/gcac-210-integrated-undergraduate-graduate-degree-programs/>).

Admission Requirements

Applicants apply for admission to the program via the Graduate School application for admission (<http://gradschool.psu.edu/prospective-students/how-to-apply/>). Requirements listed here are in addition to Graduate Council policies listed under GCAC-300 Admissions Policies (<http://gradschool.psu.edu/graduate-education-policies/>).

Students must apply to the program via the Graduate School application for admission (<http://gradschool.psu.edu/prospective-students/how-to-apply/>), and must meet all the admission requirements of the Graduate School and the EME graduate program for the Master of Science degree. Undergraduate students with sixth semester standing and minimum grade-point average of 3.5 who wish to complete the Integrated B.S./M.S. program should apply to the Graduate School and the EME IUG program before the end of their junior year. Before applying to the Graduate School, students must have completed entrance to their undergraduate major and have completed no less than 60 credits. Students must be admitted no later than the end of the second week of the semester preceding the semester of expected conferral of the undergraduate degree. Transfer students must have completed at least 15 credits at Penn State to enroll in an IUG.

Three faculty letters of recommendation are required. A statement of purpose and a plan of study covering the five year period, prepared in consultation with an adviser, and approved by the program officers of the B.S. major and the EME graduate program must accompany the application. The plan should be presented to the undergraduate and graduate program officers prior to being admitted into the program. The plan should cover the entire time period of the integrated program, and it should be reviewed periodically with an adviser as the student advances through the program. Graduate Record Examination (GRE) scores may be submitted by IUG applicants but are not required. The application will be reviewed by the Admissions Committee of the EME Graduate program and acted upon by the EME Graduate Program Officer.

Degree Requirements

Students must fulfill all degree requirements for each degree in order to be awarded that degree, subject to the double-counting of credits as outlined below. Degree requirements for the Bachelor of Science degrees are listed in the Undergraduate Bulletin (<https://bulletins.psu.edu/undergraduate/>). Degree requirements for the Master of Science in EME are listed in the Master of Science Degree Requirements section above. Students must sequence their courses so all undergraduate

degree requirements are fulfilled before taking courses to count solely towards the graduate degree. Students are expected to complete the undergraduate degree requirements within the typical time to degree for the undergraduate major. In the semester in which the undergraduate degree requirements will be completed, IUG students must apply to graduate, and the undergraduate degree should be conferred at the next appropriate Commencement. If students accepted into the IUG program are unable to complete the M.S. degree, they are still eligible to receive their undergraduate degree if all the undergraduate degree requirements have been satisfied.

Up to 12 credits may be double-counted towards the degree requirements for both the graduate and undergraduate degrees; a minimum of 50% of the double-counted courses must be at the 500 or 800 level. Independent study courses and credits associated with the culminating experience for the graduate degree cannot be double-counted.

The courses that will double count are: six (6) credits of the two 500-level EME core courses taken to satisfy M.S. core requirement and an additional six (6) credits of 400-level courses taken to satisfy 7th and 8th semester core courses from the undergraduate degree:

Code	Title	Credits
Courses Eligible to Double Count for Both Degrees		
EBF 401	Strategic Corporate Finance for the Earth, Energy, and Materials Industries	3
EBF 473	Risk Management in Energy Industries	3
EME 501	Design Under Uncertainty in Energy and Mineral Systems	3
EME 511	Interfacial Physical-Chemical Systems, Processes, and Measurements	3
EME 521	Mathematical Modeling of Energy and Mineral Systems	3
EME 531	Thermodynamics of Energy and Mineral Systems	3
EME 551	Safety, Health and Environmental Risks in Energy and Mineral Production	3

Integrated B.S. in Energy Engineering and M.S. in Energy and Mineral Engineering

Requirements listed here are in addition to requirements listed in GCAC-210 Integrated Undergraduate-Graduate (IUG) Degree Programs (<http://gradschool.psu.edu/graduate-education-policies/gcac/gcac-200/gcac-210-integrated-undergraduate-graduate-degree-programs/>).

Admission Requirements

Applicants apply for admission to the program via the Graduate School application for admission (<http://gradschool.psu.edu/prospective-students/how-to-apply/>). Requirements listed here are in addition to Graduate Council policies listed under GCAC-300 Admissions Policies (<http://gradschool.psu.edu/graduate-education-policies/>).

Students must apply to the program via the Graduate School application for admission (<http://gradschool.psu.edu/prospective-students/how-to-apply/>), and must meet all the admission requirements of the Graduate School and the EME graduate program for the Master of Science degree. Undergraduate students with sixth semester standing and minimum grade-point average of 3.5 who wish to complete the Integrated B.S./M.S. program should apply to the Graduate School and the EME IUG program before the end of their junior year. Before applying to the Graduate School, students must have completed entrance to their undergraduate major and have completed no less than 60 credits. Students must be

admitted no later than the end of the second week of the semester preceding the semester of expected conferral of the undergraduate degree. Transfer students must have completed at least 15 credits at Penn State to enroll in an IUG.

Three faculty letters of recommendation are required. A statement of purpose and a plan of study covering the five year period, prepared in consultation with an adviser, and approved by the program officers of the B.S. major and the EME graduate program must accompany the application. The plan should be presented to the undergraduate and graduate program officers prior to being admitted into the program. The plan should cover the entire time period of the integrated program, and it should be reviewed periodically with an adviser as the student advances through the program. Graduate Record Examination (GRE) scores may be submitted by IUG applicants but are not required. The application will be reviewed by the Admissions Committee of the EME Graduate program and acted upon by the EME Graduate Program Officer.

Degree Requirements

Students must fulfill all degree requirements for each degree in order to be awarded that degree, subject to the double-counting of credits as outlined below. Degree requirements for the Bachelor of Science degrees are listed in the Undergraduate Bulletin (<https://bulletins.psu.edu/undergraduate/>). Degree requirements for the Master of Science in EME are listed in the Master of Science Degree Requirements section above. Students must sequence their courses so all undergraduate degree requirements are fulfilled before taking courses to count solely towards the graduate degree. Students are expected to complete the undergraduate degree requirements within the typical time to degree for the undergraduate major. In the semester in which the undergraduate degree requirements will be completed, IUG students must apply to graduate, and the undergraduate degree should be conferred at the next appropriate Commencement. If students accepted into the IUG program are unable to complete the M.S. degree, they are still eligible to receive their undergraduate degree if all the undergraduate degree requirements have been satisfied.

Up to 12 credits may be double-counted towards the degree requirements for both the graduate and undergraduate degrees; a minimum of 50% of the double-counted courses must be at the 500 or 800 level. Independent study courses and credits associated with the culminating experience for the graduate degree cannot be double-counted.

The courses that will double count are: six (6) credits of the two 500-level EME core courses taken to satisfy M.S. core requirement and an additional six (6) credits of 400-level courses taken to satisfy 7th and 8th semester core courses from the undergraduate degree:

Code	Title	Credits
Courses Eligible to Double Count for Both Degrees		
EGEE 441	Electrochemical Engineering Fundamentals	3
EGEE 451	Energy Conversion Processes	3
EGEE 464W	Energy Design Project	3
EME 460	Geo-resource Evaluation and Investment Analysis	3
EME 501	Design Under Uncertainty in Energy and Mineral Systems	3
EME 511	Interfacial Physical-Chemical Systems, Processes, and Measurements	3
EME 521	Mathematical Modeling of Energy and Mineral Systems	3
EME 531	Thermodynamics of Energy and Mineral Systems	3

EME 551	Safety, Health and Environmental Risks in Energy and Mineral Production	3
FSC 432	Petroleum Processing	3

Integrated B.S. in Environmental Systems Engineering and M.S. in Energy and Mineral Engineering

Requirements listed here are in addition to requirements listed in GCAC-210 Integrated Undergraduate-Graduate (IUG) Degree Programs (<http://gradschool.psu.edu/graduate-education-policies/gcac/gcac-200/gcac-210-integrated-undergraduate-graduate-degree-programs/>).

Admission Requirements

Applicants apply for admission to the program via the Graduate School application for admission (<http://gradschool.psu.edu/prospective-students/how-to-apply/>). Requirements listed here are in addition to Graduate Council policies listed under GCAC-300 Admissions Policies (<http://gradschool.psu.edu/graduate-education-policies/>).

Students must apply to the program via the Graduate School application for admission (<http://gradschool.psu.edu/prospective-students/how-to-apply/>), and must meet all the admission requirements of the Graduate School and the EME graduate program for the Master of Science degree. Undergraduate students with sixth semester standing and minimum grade-point average of 3.5 who wish to complete the Integrated B.S./M.S. program should apply to the Graduate School and the EME IUG program before the end of their junior year. Before applying to the Graduate School, students must have completed entrance to their undergraduate major and have completed no less than 60 credits. Students must be admitted no later than the end of the second week of the semester preceding the semester of expected conferral of the undergraduate degree. Transfer students must have completed at least 15 credits at Penn State to enroll in an IUG.

Three faculty letters of recommendation are required. A statement of purpose and a plan of study covering the five year period, prepared in consultation with an adviser, and approved by the program officers of the B.S. major and the EME graduate program must accompany the application. The plan should be presented to the undergraduate and graduate program officers prior to being admitted into the program. The plan should cover the entire time period of the integrated program, and it should be reviewed periodically with an adviser as the student advances through the program. Graduate Record Examination (GRE) scores may be submitted by IUG applicants but are not required. The application will be reviewed by the Admissions Committee of the EME Graduate program and acted upon by the EME Graduate Program Officer.

Degree Requirements

Students must fulfill all degree requirements for each degree in order to be awarded that degree, subject to the double-counting of credits as outlined below. Degree requirements for the Bachelor of Science degrees are listed in the Undergraduate Bulletin (<https://bulletins.psu.edu/undergraduate/>). Degree requirements for the Master of Science in EME are listed in the Master of Science Degree Requirements section above. Students must sequence their courses so all undergraduate degree requirements are fulfilled before taking courses to count solely towards the graduate degree. Students are expected to complete the undergraduate degree requirements within the typical time to degree for the undergraduate major. In the semester in which the undergraduate degree requirements will be completed, IUG students must apply to graduate, and the undergraduate degree should be conferred at the next appropriate Commencement. If students accepted into the IUG program are unable to complete the M.S. degree, they are still eligible to receive

their undergraduate degree if all the undergraduate degree requirements have been satisfied.

Up to 12 credits may be double-counted towards the degree requirements for both the graduate and undergraduate degrees; a minimum of 50% of the double-counted courses must be at the 500 or 800 level. Independent study courses and credits associated with the culminating experience for the graduate degree cannot be double-counted.

The courses that will double count are: six (6) credits of the two 500-level EME core courses taken to satisfy M.S. core requirement and an additional six (6) credits of 400-level courses taken to satisfy 7th and 8th semester core courses from the undergraduate degree:

Code	Title	Credits
Courses Eligible to Double Count for Both Degrees		
EME 501	Design Under Uncertainty in Energy and Mineral Systems	3
EME 511	Interfacial Physical-Chemical Systems, Processes, and Measurements	3
EME 521	Mathematical Modeling of Energy and Mineral Systems	3
EME 531	Thermodynamics of Energy and Mineral Systems	3
EME 551	Safety, Health and Environmental Risks in Energy and Mineral Production	3
ENVSE 404W	Surface and Interfacial Phenomena in Environmental Systems	3
ENVSE 427	Pollution Control in the Process Industries	3
ENVSE 450	Environmental Health and Safety	3
ENVSE 457	Industrial Hygiene Measurements	3
ENVSE 470	Engineering Risk Analysis	3
ENVSE 480	Environmental Systems Engineering Process Design	3

Integrated B.S. in Mining Engineering and M.S. in Energy and Mineral Engineering

Requirements listed here are in addition to requirements listed in GCAC-210 Integrated Undergraduate-Graduate (IUG) Degree Programs (<http://gradschool.psu.edu/graduate-education-policies/gcac/gcac-200/gcac-210-integrated-undergraduate-graduate-degree-programs/>).

Admission Requirements

Applicants apply for admission to the program via the Graduate School application for admission (<http://gradschool.psu.edu/prospective-students/how-to-apply/>). Requirements listed here are in addition to Graduate Council policies listed under GCAC-300 Admissions Policies (<http://gradschool.psu.edu/graduate-education-policies/>).

Students must apply to the program via the Graduate School application for admission (<http://gradschool.psu.edu/prospective-students/how-to-apply/>), and must meet all the admission requirements of the Graduate School and the EME graduate program for the Master of Science degree. Undergraduate students with sixth semester standing and minimum grade-point average of 3.5 who wish to complete the Integrated B.S./M.S. program should apply to the Graduate School and the EME IUG program before the end of their junior year. Before applying to the Graduate School, students must have completed entrance to their undergraduate major and have completed no less than 60 credits. Students must be admitted no later than the end of the second week of the semester preceding the semester of expected conferral of the undergraduate

degree. Transfer students must have completed at least 15 credits at Penn State to enroll in an IUG.

Three faculty letters of recommendation are required. A statement of purpose and a plan of study covering the five year period, prepared in consultation with an adviser, and approved by the program officers of the B.S. major and the EME graduate program must accompany the application. The plan should be presented to the undergraduate and graduate program officers prior to being admitted into the program. The plan should cover the entire time period of the integrated program, and it should be reviewed periodically with an adviser as the student advances through the program. Graduate Record Examination (GRE) scores may be submitted by IUG applicants but are not required. The application will be reviewed by the Admissions Committee of the EME Graduate program and acted upon by the EME Graduate Program Officer.

Degree Requirements

Students must fulfill all degree requirements for each degree in order to be awarded that degree, subject to the double-counting of credits as outlined below. Degree requirements for the Bachelor of Science degrees are listed in the Undergraduate Bulletin (<https://bulletins.psu.edu/undergraduate/>). Degree requirements for the Master of Science in EME are listed in the Master of Science Degree Requirements section above. Students must sequence their courses so all undergraduate degree requirements are fulfilled before taking courses to count solely towards the graduate degree. Students are expected to complete the undergraduate degree requirements within the typical time to degree for the undergraduate major. In the semester in which the undergraduate degree requirements will be completed, IUG students must apply to graduate, and the undergraduate degree should be conferred at the next appropriate Commencement. If students accepted into the IUG program are unable to complete the M.S. degree, they are still eligible to receive their undergraduate degree if all the undergraduate degree requirements have been satisfied.

Up to 12 credits may be double-counted towards the degree requirements for both the graduate and undergraduate degrees; a minimum of 50% of the double-counted courses must be at the 500 or 800 level. Independent study courses and credits associated with the culminating experience for the graduate degree cannot be double-counted.

The courses that will double count are: six (6) credits of the two 500-level EME core courses taken to satisfy M.S. core requirement and an additional six (6) credits of 400-level courses taken to satisfy 7th and 8th semester core courses from the undergraduate degree:

Code	Title	Credits
Courses Eligible to Double Count for Both Degrees		
EME 501	Design Under Uncertainty in Energy and Mineral Systems	3
EME 511	Interfacial Physical-Chemical Systems, Processes, and Measurements	3
EME 521	Mathematical Modeling of Energy and Mineral Systems	3
EME 531	Thermodynamics of Energy and Mineral Systems	3
EME 551	Safety, Health and Environmental Risks in Energy and Mineral Production	3
GEOSC 470W	Introduction to Field Geology	3
MNG 410	Underground Mining	3

MNG 441	Surface Mining Systems and Design	3
MNG 451W	Mining Engineering Project	1-5

Integrated B.S. in Petroleum and Natural Gas Engineering and M.S. in Energy and Mineral Engineering

Requirements listed here are in addition to requirements listed in GCAC-210 Integrated Undergraduate-Graduate (IUG) Degree Programs (<http://gradschool.psu.edu/graduate-education-policies/gcac/gcac-200/gcac-210-integrated-undergraduate-graduate-degree-programs/>).

Admission Requirements

Applicants apply for admission to the program via the Graduate School application for admission (<http://gradschool.psu.edu/prospective-students/how-to-apply/>). Requirements listed here are in addition to Graduate Council policies listed under GCAC-300 Admissions Policies (<http://gradschool.psu.edu/graduate-education-policies/>).

Students must apply to the program via the Graduate School application for admission (<http://gradschool.psu.edu/prospective-students/how-to-apply/>), and must meet all the admission requirements of the Graduate School and the EME graduate program for the Master of Science degree. Undergraduate students with sixth semester standing and minimum grade-point average of 3.5 who wish to complete the Integrated B.S./M.S. program should apply to the Graduate School and the EME IUG program before the end of their junior year. Before applying to the Graduate School, students must have completed entrance to their undergraduate major and have completed no less than 60 credits. Students must be admitted no later than the end of the second week of the semester preceding the semester of expected conferral of the undergraduate degree. Transfer students must have completed at least 15 credits at Penn State to enroll in an IUG.

Three faculty letters of recommendation are required. A statement of purpose and a plan of study covering the five year period, prepared in consultation with an adviser, and approved by the program officers of the B.S. major and the EME graduate program must accompany the application. The plan should be presented to the undergraduate and graduate program officers prior to being admitted into the program. The plan should cover the entire time period of the integrated program, and it should be reviewed periodically with an adviser as the student advances through the program. Graduate Record Examination (GRE) scores may be submitted by IUG applicants but are not required. The application will be reviewed by the Admissions Committee of the EME Graduate program and acted upon by the EME Graduate Program Officer.

Degree Requirements

Students must fulfill all degree requirements for each degree in order to be awarded that degree, subject to the double-counting of credits as outlined below. Degree requirements for the Bachelor of Science degrees are listed in the Undergraduate Bulletin (<https://bulletins.psu.edu/undergraduate/>). Degree requirements for the Master of Science in EME are listed in the Master of Science Degree Requirements section above. Students must sequence their courses so all undergraduate degree requirements are fulfilled before taking courses to count solely towards the graduate degree. Students are expected to complete the undergraduate degree requirements within the typical time to degree for the undergraduate major. In the semester in which the undergraduate degree requirements will be completed, IUG students must apply to graduate, and the undergraduate degree should be conferred at the next appropriate Commencement. If students accepted into the IUG program are unable to complete the M.S. degree, they are still eligible to receive

their undergraduate degree if all the undergraduate degree requirements have been satisfied.

Up to 12 credits may be double-counted towards the degree requirements for both the graduate and undergraduate degrees; a minimum of 50% of the double-counted courses must be at the 500 or 800 level. Independent study courses and credits associated with the culminating experience for the graduate degree cannot be double-counted.

The courses that will double count are: six (6) credits of the two 500-level EME core courses taken to satisfy M.S. core requirement and an additional six (6) credits of 400-level courses taken to satisfy 7th and 8th semester core courses from the undergraduate degree:

Code	Title	Credits
Courses Eligible to Double Count for Both Degrees		
EME 501	Design Under Uncertainty in Energy and Mineral Systems	3
EME 511	Interfacial Physical-Chemical Systems, Processes, and Measurements	3
EME 521	Mathematical Modeling of Energy and Mineral Systems	3
EME 531	Thermodynamics of Energy and Mineral Systems	3
EME 551	Safety, Health and Environmental Risks in Energy and Mineral Production	3
PNG 420	Applied Reservoir Analysis and Secondary Recovery	3
PNG 425	Principles of Well Testing and Evaluation	3
PNG 430	Reservoir Modeling	3
PNG 440W	Formation Evaluation	3
PNG 480	Surface Production Engineering	3

Minor

A graduate minor is available in any approved graduate major or dual-title program. The default requirements for a graduate minor are stated in Graduate Council policies listed under GCAC-600 Research Degree Policies (<http://gradschool.psu.edu/graduate-education-policies/>) and GCAC-700 Professional Degree Policies (<http://gradschool.psu.edu/graduate-education-policies/>), depending on the type of degree the student is pursuing:

- GCAC-611 Minor - Research Doctorate (<https://gradschool.psu.edu/graduate-education-policies/gcac/gcac-600/gcac-611-minor-research-doctorate/>)
- GCAC-641 Minor - Research Master's (<https://gradschool.psu.edu/graduate-education-policies/gcac/gcac-600/gcac-641-minor-research-masters/>)
- GCAC-709 Minor - Professional Doctorate (<https://gradschool.psu.edu/graduate-education-policies/gcac/gcac-700/gcac-709-professional-doctoral-minor/>)
- GCAC-741 Minor - Professional Master's (<https://gradschool.psu.edu/graduate-education-policies/gcac/gcac-700/gcac-741-masters-minor-professional/>)

Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the Tuition & Funding (<http://gradschool.psu.edu/graduate-funding/>) section of The Graduate School's website. Students on graduate assistantships must adhere to the course

load limits (<http://gradschool.psu.edu/graduate-education-policies/gsad/gsad-900/gsad-901-graduate-assistants/>) set by The Graduate School.

Graduate students are supported by a variety of government and industry fellowships, and research and teaching assistantships. Stipends vary depending on the source.

Courses

Graduate courses carry numbers from 500 to 699 and 800 to 899. Advanced undergraduate courses numbered between 400 and 499 may be used to meet some graduate degree requirements when taken by graduate students. Courses below the 400 level may not. A graduate student may register for or audit these courses in order to make up deficiencies or to fill in gaps in previous education but not to meet requirements for an advanced degree.

Energy and Mineral Engineering (EME) Course List (<https://bulletins.psu.edu/university-course-descriptions/graduate/eme/>)

Fuel Science (FSC) Course List (<https://bulletins.psu.edu/university-course-descriptions/graduate/fsc/>)

Petroleum and Natural Gas Engineering (PNG) Course List (<https://bulletins.psu.edu/university-course-descriptions/graduate/png/>)

Learning Outcomes

Master of Science (M.S.)

- KNOW:** Graduates will be able to demonstrate deep understanding and proficiency in project evaluation methods, optimization and application of mechanistic, thermodynamic, fluid flow, and kinetic analysis methods for integrative design of energy and mineral engineering systems.
- CREATE:** Graduates will demonstrate proficiency in designing and executing a research plan to address real-world problems in the field of energy and mineral engineering and economics.
- CRITICAL THINKING:** Graduates will be able to review and critically analyze work by others in the broad area of energy and mineral engineering and economics.
- COMMUNICATE:** Graduates will be able to effectively communicate their research findings to scholars in the field and broad audiences through formal presentations and written works.
- PROFESSIONAL PRACTICE:** Graduates will demonstrate a commitment to conduct themselves in accordance with the highest ethical standards and active engagement in service to the profession and society.

Doctor of Philosophy (Ph.D.)

- KNOW:** Graduates will demonstrate in-depth knowledge of the core theories and methods in the field of energy and mineral engineering as well as within one of the program options. This will include the application of physics, chemistry, advanced mathematics, economics and/or engineering principles to problems in energy and mineral engineering.
- CREATE:** Graduates will be able to creatively synthesize new ideas or hypotheses in energy and mineral engineering and economics, devise critical tests of hypotheses, and/or develop unique solutions to problems in energy and mineral engineering and economics.
- APPLY:** Graduates will be able to carry out independent and original research studies that address current problems in energy and mineral engineering synthesizing theory and/or experiments.

4. **CRITICAL THINKING:** Graduates will be able to review and critically analyze work by others in their field of specialty.
5. **COMMUNICATE:** Graduates will be able to convey ideas or arguments in clear, concise, well-organized proposals, papers and reports as well as in formal, oral presentations.
6. **PROFESSIONAL PRACTICE:** Graduates will demonstrate the ability to collaborate in a collegial and ethical manner with other professionals within their field and within diverse scientific backgrounds.

Contact

Campus	University Park
Graduate Program Head	Sanjay Srinivasan
Director of Graduate Studies (DGS) or Professor-in-Charge (PIC)	Mort D Webster
Program Contact	Elizabeth Sue Hyde 103 Hosler Building University Park PA 16802 esh17@psu.edu (814) 863-0373
Program Website	View (https://www.eme.psu.edu/)