

# ENERGY AND MINERAL ENGINEERING

## 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. (<https://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       |

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. (<https://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 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   |
|---------------------------------------|--------------------------------------------------------------------------------|-----------|
| <b>Required Courses</b>               |                                                                                |           |
| 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 Earth and Energy Systems                                  |           |
| 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                                                   |           |
| <b>Total Credits</b>                  |                                                                                | <b>12</b> |

### Fuel Science Option

| Code                                  | Title                                                                     | Credits   |
|---------------------------------------|---------------------------------------------------------------------------|-----------|
| <b>Required Courses</b>               |                                                                           |           |
| 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 |           |
| <b>Total Credits</b>                  |                                                                           | <b>12</b> |

### Mining and Mineral Process Engineering Option

| Code                                  | Title                                               | Credits   |
|---------------------------------------|-----------------------------------------------------|-----------|
| <b>Required Courses</b>               |                                                     |           |
| 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                       |           |
| <b>Total Credits</b>                  |                                                     | <b>12</b> |

### Petroleum and Natural Gas Engineering Option

| Code                                               | Title                                                                                                     | Credits   |
|----------------------------------------------------|-----------------------------------------------------------------------------------------------------------|-----------|
| <b>Required Courses</b>                            |                                                                                                           |           |
| Select 12 credits from the following: <sup>1</sup> |                                                                                                           | 12        |
| PNG 501                                            | Flow in Porous Media                                                                                      |           |
| PNG 502                                            | Mechanics of 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) |           |
| <b>Total Credits</b>                               |                                                                                                           | <b>12</b> |

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