

BIORENEWABLE SYSTEMS

Graduate Program Head	Suat Irmak
Program Code	BRS
Campus(es)	University Park (Ph.D., M.S.)
Degrees Conferred	Doctor of Philosophy (Ph.D.) Master of Science (M.S.) Dual-Title M.S. and Ph.D. in Biorenewable Systems and International Agriculture and Development Dual-Title M.S. and Ph.D. in Biorenewable Systems and Operations Research
The Graduate Faculty	View (https:// secure.gradsch.psu.edu/gpms/? searchType=fac&prog=BRS)

Biorenewable systems are the structures and processes that create and support sustainable biologically-based products capable of being continuously replaced through sound technology and management. The BioRenewable Systems (BRS) degree is offered as a resident instruction, research-based M.S. and Ph.D. programs. The degree requires a thesis at both levels.

The BRS graduate program encompasses renewable biologically-based materials, products, and processes and fully integrates scientific research with the principles of systems technology, business, management, marketing, leadership development, and entrepreneurship. Toward that end, the academic requirements for BRS are closely related to the disciplinary focus of agricultural and biological sciences, technological innovation and application, and business, management, and leadership within the continually evolving biobased sectors. This multidisciplinary aspect makes BRS unique from other fields of science and management. To promote and fulfill this uniqueness, the continuation of courses in science, business, management, and technology at the graduate level is encouraged and expected.

Excellent facilities, including equipment and instrumentation, are available for research in the designated areas. Collaborative arrangements allow access to a large variety of other resources:

- Materials Research Institute;
- Penn State Institutes of the Energy and Environment;
- Huck Institutes of the Life Sciences;
- Housing Research Center;
- USDA Pasture Systems and Watershed Management Research Lab;
- a mushroom research and demonstration facility;
- and a 1,500-acre agricultural research center for cooperative work with agronomic and horticultural production systems as well as animal production systems.

Admission Requirements

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

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 (<https://gradschool.psu.edu/graduate-education-policies/gcac/gcac-300/gcac-305-admission-requirements-international-students/>) for more information.

All applicants must provide official transcripts from all post-secondary institutions attended (<http://www.gradschool.psu.edu/prospective-students/how-to-apply/new-applicants/requirements-for-graduate-admission/>), a statement of purpose written by the applicant, and at least three letters of recommendation. Admission into the BRS Graduate Program is based upon a thorough review of all applicant qualifications, and the best-qualified applicants will be accepted up to the number of students for which program resources are available. GRE scores will not be accepted.

Master of Science (M.S.)

Completion of a relevant undergraduate Bachelor degree program is required for admission to the M.S. degree program; relevant programs span a diverse set of academic disciplines, including but not limited to: Agricultural Sciences, Biology, Chemistry, Business, Engineering, and Environmental Sciences. Students with junior-senior GPA of at least 3.00 (4.00 base) will be competitive in the admission process.

Doctor of Philosophy (Ph.D.)

The program requirement for acceptance to graduate study toward a Ph.D. degree in BRS is typically an M.S. degree with research thesis in BRS or related discipline such as: Agricultural Sciences, Biology, Chemistry, Business, Engineering, and Environmental Sciences, or with a B.S. degree in Agricultural Systems Management (ASM) or BRS or equivalent. Outstanding students interested in direct admission from a B.S., B.A., or M.B.A. program to the Ph.D. Program should contact the Graduate Program Coordinator for further clarification and details. Direct admission will be based on critical evaluation of the student's:

- potential to conduct publishable research,
- academic record,
- an additional language (other than the student's mother tongue),
- performance on standardized tests,
- statement of purpose,
- and reference letters.

Students who apply directly to the Ph.D. program with a B.S. degree and are deemed by the admissions committee not to meet the standards for admission to the Ph.D. program may be considered either for admission into the M.S. program or for admission to the Ph.D. program on a provisional basis (<http://gradschool.psu.edu/graduate-education-policies/gcac/gcac-300/provisional-admission/>). The student will remain in provisional status in the Ph.D. program until completing the suggested provisional courses with a minimum grade-point average of 3.00. For provisional status to change, the suggested provisional courses must be completed within the first two semesters of study.

Degree Requirements

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/>)

All candidates for the M.S. degree must:

- prepare and complete a thesis
- complete a minimum of 30 credits at the 400, 500, 600, or 800 level (including a minimum of 18 credits at the 500 and 600 level, combined, and a minimum of 6 credits of research)
- obtain a minimum grade-point average of 3.00.

Only courses in which grades of C or better are earned may be counted toward the requirements of the master's degree. Each program must include:

Code	Title	Credits
Required Courses		
BRS 500	Research Methods	3
BRS 502	Human Behavior and ethics in Management and Technology (or other Ethics course from a list of approved courses maintained by the program office, unless previously taken)	3
BRS 504	Biorenewable Systems Analysis	3
BRS 590	Colloquium	3
Electives		
Two courses from list of electives maintained by the program office		6
At least one 5XX statistics course		3
Additional 4XX or 5XX course or BRS 600 Thesis Research		3
Culminating Experience		
BRS 600	Thesis Research	6
Total Credits		30

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/>)

Official entrance into a Ph.D. program occurs upon successful completion of the Ph.D. Qualifying Examination. Ph.D. degree requirements include successful completion of the following:

- approved graduate course work,
- Ph.D. language and communication requirements,
- a comprehensive examination,
- and defense, approval, and submission of a dissertation.

No University-level (Graduate Council) minimum number of courses completed or credits earned are specified for the Ph.D.; the student's Ph.D. committee will recommend the minimum requirements as appropriate for each individual student's program of study and dissertation research. Unless previously taken for the M.S., each Ph.D. student must complete:

Code	Title	Credits
Required Courses		
BRS 500	Research Methods	3
BRS 502	Human Behavior and ethics in Management and Technology (or other Ethics course from a list of approved courses maintained by the program office, unless previously taken)	3
BRS 504	Biorenewable Systems Analysis	3
BRS 590	Colloquium	4

BRS 602	Supervised Experiences in College Teaching (at least 1 credit)	1-3
Communications or International Language/Culture		3
In addition the candidate must complete 6 credits of BRS 5XX (excluding BRS 500 and 590-596) or select from a list maintained by the program office		6

The candidate is expected to develop a program of study and submit it to the appointed Ph.D. committee for consideration and approval. All requirements for a Ph.D. degree, whether satisfied on this campus or elsewhere, must be completed within eight years after passing the qualifying examination.

Qualifying Examination

The Ph.D. Qualifying Examination Committee will administer the Qualifying Examination. This committee will consist of four BRS graduate faculty members, including the Adviser, the ABE Department Head (or annually appointed designee), the BRS Graduate Program Coordinator, and one faculty member selected by the student. In cases where a member serves two roles on the committee, an additional member will be appointed by the Graduate Program Coordinator. The Qualifying Examination will consist of developing a Ph.D. research proposal following the completion of BRS 500, presenting the proposal, and defending/discussing the proposed research with the Committee. The Qualifying Examination will be completed by the student soon after they have completed at least 18 credits but before the end of the third semester. Successful completion of the Qualifying Examination does not mean that the student's Ph.D. research proposal is approved. Rather, final approval of the candidate's research proposal will be the responsibility of the Ph.D. committee.

Ph.D. Committee

The Ph.D. committee must meet all of the Graduate Council requirements (<http://gradschool.psu.edu/graduate-education-policies/gcac/gcac-600/phd-dissertation-committee-formation/>), and:

1. the chairperson and at least one other member must be BRS Graduate Faculty members,
2. at least one member must be from a department other than ABE and s/he should be a Graduate Faculty member of a program other than BRS,
3. at least one member must represent any minor department(s) if the student selects a minor(s), and
4. the Ph.D. committee can be appointed only after the Qualifying Examination has been passed.

Ph.D. Language and Communication Requirement

The purpose of the communication requirement is to strengthen the student's professional communication skills. The candidate must take a minimum of one three-credit course and receive a grade of B or better. Course selections must be approved by the academic adviser prior to registration. Courses used to satisfy this requirement must include the substantial practice of writing and/or speaking.

Comprehensive Examination

When a Ph.D. candidate has substantially completed the course work, including the communication requirements, s/he is required to take a Comprehensive Examination covering the major, minor, and related areas of study. The Comprehensive Examination will be both written and oral. The nature and details of the Comprehensive Examination will be determined by the student's Ph.D. committee. In general, the student will be required to demonstrate ability to synthesize information

acquired through formal coursework and to use technical literature to find information required for solving biorenewable systems problems. A favorable vote of at least two-thirds of the committee is required for passing. If a candidate fails, the committee will determine whether another examination may be taken.

Final Oral Examination

Upon recommendation of the Adviser, a Ph.D. candidate who has satisfied all other requirements for the degree will be scheduled to take a Final Oral Examination. The student must be registered appropriately for the semester in which the Final Oral Examination is taken. This examination is open to the public and the student should notify all departmental faculty and graduate students. The examination is related largely to the dissertation, but may cover the candidate's entire field of study without regard to courses that have been taken either at Penn State University or elsewhere. The defense of the dissertation should be well-prepared including any appropriate visual aids. One of the aims of the preparation should be to synthesize the important conclusions in a time-efficient presentation, leaving ample time for questions and discussion. A favorable vote of at least two-thirds of the committee is required for passing. If a candidate fails, the committee will determine whether another examination may be taken.

Dual-Titles

Dual-Title M.S. and Ph.D. in BioRenewable Systems and International Agriculture and Development

Admission Requirements

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

Students must apply and be admitted to the graduate program in BioRenewable Systems 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 INTAD dual-title program. Refer to the Admission Requirements section of the INTAD Bulletin page (<https://bulletins.psu.edu/graduate/programs/majors/international-agriculture-development/>). Doctoral students must be admitted into the dual-title degree program in INTAD 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 BioRenewable Systems. In addition, students must complete the degree requirements for the dual-title in INTAD, listed on the INTAD Bulletin page (<https://bulletins.psu.edu/graduate/programs/majors/international-agriculture-development/>).

The qualifying examination committee for the dual-title Ph.D. degree will be composed of Graduate Faculty from BioRenewable Systems and must include at least one Graduate Faculty member from the INTAD 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 BioRenewable Systems and INTAD. 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/gcac-602-phd-committee-formation/>), the Ph.D. committee of a BioRenewable Systems and INTAD dual-title Ph.D. student must include at least one member of the INTAD 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 INTAD, the member of the committee representing INTAD must be appointed as co-chair. The INTAD 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 BioRenewable Systems and INTAD. 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 BioRenewable Systems and Operations Research

Admission Requirements

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

Students must apply and be admitted to the graduate program in BioRenewable Systems 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 OR dual-title program. Refer to the Admission Requirements section of the Operations Research Bulletin page (<https://bulletins.psu.edu/graduate/programs/majors/operations-research/>). Doctoral students must be admitted into the dual-title degree program in OR 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 in which they are enrolled (BioRenewable Systems). In addition, students must complete the degree requirements for the dual-title in OR, listed on the Operations Research Bulletin page (<https://bulletins.psu.edu/graduate/programs/majors/operations-research/>).

Students in the Master's dual-title program are required to write and orally defend a thesis on a topic that is approved in advance by their M S Advisory Committee and reflects their research and education in BioRenewable Systems and Operations Research. Upon completion of the Master's thesis, the student must pass a final oral examination (the thesis defense) to earn the Master's degree. The thesis must be accepted by the student's M S Advisory Committee, the head of the graduate program, and the Graduate School. The student's thesis supervisor must be a member of the Graduate Faculty recommended by the chair of the program granting the degree and approved by the Operations Research committee as qualified to supervise thesis work in operations research.

Students in the doctoral 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 BioRenewable Systems 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. The qualifying examination committee for the dual-title Ph.D. degree must include at least one Graduate Faculty member from the Operations Research program. The chair and at least two members of the Ph.D. committee of an Operations Research dual-title Ph.D. student must be members of the Operations Research Graduate Faculty.

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 (<https://gradschool.psu.edu/graduate-education-policies/>) and GCAC-700 Professional Degree Policies (<https://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 (<https://gradschool.psu.edu/graduate-funding/>) section of The Graduate School's website. Students on graduate assistantships must adhere to the course load limits (<https://gradschool.psu.edu/graduate-education-policies/gsad/gsad-900/gsad-901-graduate-assistants/>) set by The Graduate School.

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.

Biorenewable Systems (BRS) Course List (<https://bulletins.psu.edu/university-course-descriptions/graduate/brs/>)

Learning Outcomes

Master of Science (M.S.)

1. **KNOW:** Graduates will demonstrate knowledge of sustainable, renewable biologically-based systems including their life-cycle assessment and technoeconomic analyses.
2. **THINK:** Graduates will be able to critically and creatively conceptualize and evaluate biorenewable industry problem formulations, analyses, and solutions.
3. **APPLY/CREATE:** Graduates will demonstrate proficiency in biorenewable industry problem formulation, planning, organization and implementation of appropriate methods of analyses and solutions.
4. **COMMUNICATE:** Graduates will be able to effectively communicate technical knowledge, including ideas, data analysis, findings, or decision justification in written and oral presentation appropriate to the audience.
5. **PROFESSIONAL PRACTICE:** Graduates will be able to apply analytical skills for effective decision making in the biorenewable resource industries. Graduates will demonstrate a knowledge of ethics, equity, diversity and inclusivity and the application of these concepts and principles to the profession.

Doctor of Philosophy (Ph.D.)

1. **KNOW:** Graduates will demonstrate knowledge of sustainable, renewable biologically-based systems, including their life-cycle assessment and technoeconomic analyses.
2. **APPLY/CREATE:** Graduates will demonstrate knowledge of one or more of the following: technologies and systems analysis, science, safety, marketing, business, or management principles and methodologies as they pertain to biorenewable systems.
3. **APPLY/CREATE:** Graduates will be able to communicate, both orally and in-writing, business and/or technical concepts within the context of biorenewable industries. Graduates will be able to analyze and interpret data and demonstrate an ability to draw sound conclusions from data.
4. **THINK:** Graduates will be able to independently analyze and critique motivations for conducting research, the research process, research results, and the implications of research and its results to our world.
5. **COMMUNICATE:** Graduates will be able to actively listen, convey accurately and clearly ideas and results both orally and in writing, and engage in positive, effective deliberation.
6. **PROFESSIONAL PRACTICE:** Graduates will be prepared to become leaders in our society by being able to apply the skills acquired to engage in effective decision making in the operations and/or management of biorenewable resource industries. Graduates will demonstrate a knowledge of ethics, equity, diversity and inclusivity and the application of these concepts and principles to the profession.

Contact

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Program Website	View (http://abe.psu.edu/ graduateprograms/)