



THE UNIVERSITY OF ARIZONA
COLLEGE OF AGRICULTURE & LIFE SCIENCES
COLLEGE OF ENGINEERING

Biosystems Engineering

Integrated Engineered Solutions in the Food-Water-Energy Nexus BE 482/582 (3 units)

[Tue/Thu 2:00-3:15 PM Fall 2021]

Shantz 440

Description of Course

Designing sustainable integrated engineered solutions to meet the increased global demand for food, water and energy in the next decades -- as spurred by population growth, urbanization, environmental degradation and climate change -- represents arguably the greatest engineering challenge of the 21st century. Food production through agriculture currently accounts for 70 percent of total global freshwater withdrawals, while food production and supply chain consume approximately 30 percent of total global energy consumption. With the United Nations projecting that food production will have to increase by 70 percent to feed the world population by 2050, the use of the already severely limited freshwater and energy for food production is only expected to spike.

The Food-Water-Energy Nexus pertains to the intersection zone among these three vital resources, and constitutes an analytical concept that describes and addresses their critical interrelatedness and interdependence. Integrated engineered solutions in the Food-Water-Energy Nexus pertain to integrated engineered designs for food production that is made environmentally sustainable and cost-effective through coordinated management, built synergies and trade-offs in the generation/regeneration and use/reuse/recycling of water and energy. Integrated engineered solutions in the Food-Water-Energy Nexus are deliberately transformational integrated designs -- drivers of change -- that are necessary to make feeding an increased global population this century possible, environmentally sustainable, and cost-effective.

Course Prerequisites

Advanced standing

Course Co-requisites

None

Instructor and Contact Information

Dr. Joel Cuello, Professor of Biosystems Engineering
Department of Biosystems Engineering, Shantz Building, Room 507, 1177 E. 4th Street
The University of Arizona, Tucson, AZ 85721
CELL (520) 360-7688; cuelloj@arizona.edu
Office Hours: TTh 3:30-4:30 PM or by appointment

Course Communications

Students can communicate with instructor outside of class via email or telephone.
Instructor Homepage: <https://be.arizona.edu/person/joel-cuello>

Course Format and Teaching Methods

The course is taught through lectures, discussions, viewing of pertinent videos and student team presentations. The students, grouped in teams, work collaboratively on assigned projects for which they give team oral presentations in class as well as submit written team reports. The course fosters industry-style team work and collaboration. There are also homeworks and a midterm test that is given for individual work.

Course Objectives and Expected Learning Outcomes

The specific objectives of this course include:

- (1) To gain practical understanding of the interrelatedness and interdependence among food, water and energy in an engineering context within bio-production systems;
- (2) To gain technical familiarity with the broad suite of technologies (referred to here as “Technology nexus apps” or “Nexus apps”) that serve as technology modules or building blocks that can be combined together in numerous possible permutations in designing cost-effective and environmentally sustainable integrated engineered solutions in the Food-Water-Energy Nexus; and,
- (3) To design specific cost-effective and environmentally sustainable integrated engineered solutions or systems in the Food-Water-Energy Nexus through team-based effort.

As expected learning outcomes, the students upon completing this course will be able to:

- (1) For graduate students – Design a chosen specific component of two of his/her team’s designed integrated engineered food-water-energy systems;
- (2) Identify and describe the various types or embodiments of integrated engineered solutions in the food-water-energy nexus, including vertical farms, controlled-environment greenhouses, etc.; and,
- (3) Identify and describe the various technology modules that serve as building blocks that can be combined together in specific ways to design specific cost-effective and

environmentally sustainable integrated engineered solutions in the Food-Water-Energy Nexus.

Required Texts or Readings

Given that the subject matter of this course evolves quickly with current innovations in technology and design, there is not a required and set textbook for the course.

Required Extracurricular Activities

None

Assignments and Examinations: Schedule/Due Dates

The written midterm examination is given in class. Homeworks are due typically a week after they are assigned, while team reports and design projects are typically due three weeks after they are assigned.

Grading:

Team Designs (3)	45%
Team reports	30%
Tests	25%

Additional Requirement for Graduate Students:

Graduate students and undergraduate students will be mixed in teams, and each team designs integrated engineered solutions in the Food-Water-Energy Nexus. Each graduate student will be further required to provide detailed design for a chosen specific component of two of his/her team's designed integrated engineered food-water-energy systems. The grade for each graduate student for the two selected Team Designs (which accounts for 30% of the final grade as shown above) will be 50% of the team design grade and 50% of his/her individual component design grade.

Grading Scale and Policies

DETERMINATION OF CLASS GRADES:

Score	Grade
90-100%	A
80-89%	B
70-79%	C
60-69%	D
Below 60%	E

Requests for incomplete (I) or withdrawal (W) must be made in accordance with University policies, which are available at <http://catalog.arizona.edu/policy/grades-and-grading-system#incomplete> and <http://catalog.arizona.edu/policy/grades-and-grading-system#Withdrawal> respectively.

Dispute of Grade Policy

Students will have one week to dispute a grade on a project, quiz or exam.

Scheduled Topics/Activities

Course Contents:

Part I. The Food-Water-Energy Nexus

1. Problem Definition: Global challenge in Food directly linked to Water and Energy
2. Food-Water-Energy Nexus as an analytical concept for cost-effective and environmentally sustainable engineered design
3. What is an Integrated Engineered Solution in the Food-Water-Energy Nexus?
4. NASA's Controlled Ecological Life Support System (CELSS) as an Integrated Engineered Solution in the Food-Water-Energy Nexus for space application

Part II. Technical Survey of Food-Water-Energy Nexus Apps (Available Building Blocks for Integrated Engineered Solutions)

1. Plant factories
2. Vertical farms
3. Greenhouses
4. Algae production systems
5. Aquaculture
6. Bioreactor production of cell cultures
7. Meat tissue culture
8. Solar photovoltaics and thermal systems
9. Anaerobic digestion
10. Desalination
11. UV/Ozone water treatment
12. Water catchment
13. Hydropower
14. Other

Part III. Technical Case Studies of Integrated Engineered Solutions or Systems in the Food-Water-Energy Nexus

1. Sahara Forest Project – Integrated desert food-water-energy system in Qatar
2. Seawater Farms Eritrea – Integrated salicornia-fish-livestock system in Eritrea, Africa
3. Sky Greens Vertical Farm – Integrated vertical farm in Singapore
4. Fujitsu Plant Factory – Integrated plant factory in Japan

Part IV. Designs of Integrated Engineered Solutions or Systems in the Food-Water-Energy Nexus

Team designs of integrated engineered solution or system in the Food-Water-Energy Nexus

Absence and Class Participation Policy

The UA's policy concerning Class Attendance, Participation, and Administrative Drops is available at: <http://catalog.arizona.edu/policy/class-attendance-participation-and-administrative-drop>

The UA policy regarding absences for any sincerely held religious belief, observance or practice will be accommodated where reasonable, <http://policy.arizona.edu/human-resources/religious-accommodation-policy>. Absences pre-approved by the UA Dean of Students (or Dean Designee) will be honored. See: <https://deanofstudents.arizona.edu/absences>

Threatening Behavior Policy

The UA Threatening Behavior by Students Policy prohibits threats of physical harm to any member of the University community, including to oneself. See <http://policy.arizona.edu/education-and-student-affairs/threatening-behavior-students>.

Accessibility and Accommodations

At the University of Arizona we strive to make learning experiences as accessible as possible. If you anticipate or experience physical or academic barriers based on disability or pregnancy, you are welcome to let me know so that we can discuss options. You are also encouraged to contact Disability Resources (520-621-3268) to explore reasonable accommodation. For additional information on the Disability Resource Center and reasonable accommodations, please visit <http://drc.arizona.edu>.

If our class meets at a campus location: Please be aware that the accessible table and chairs in this room should remain available for students who find that standard classroom seating is not usable.

Code of Academic Integrity

Students are encouraged to share intellectual views and discuss freely the principles and applications of course materials. However, graded work/exercises must be the product of independent effort unless otherwise instructed. Students are expected to adhere to the UA Code of Academic Integrity as described in the UA General Catalog. See:

<http://deanofstudents.arizona.edu/academic-integrity/students/academic-integrity>.

The University Libraries have some excellent tips for avoiding plagiarism, available at <http://www.library.arizona.edu/help/tutorials/plagiarism/index.html>.

Selling class notes and/or other course materials to other students or to a third party for resale is not permitted without the instructor's express written consent. Violations to this and other course rules are subject to the Code of Academic Integrity and may result in course sanctions. Additionally, students who use D2L or UA e-mail to sell or buy these copyrighted materials are

subject to Code of Conduct Violations for misuse of student e-mail addresses. This conduct may also constitute copyright infringement.

UA Nondiscrimination and Anti-harassment Policy

The University is committed to creating and maintaining an environment free of discrimination; see <http://policy.arizona.edu/human-resources/nondiscrimination-and-anti-harassment-policy>
Our classroom is a place where everyone is encouraged to express well-formed opinions and their reasons for those opinions. We also want to create a tolerant and open environment where such opinions can be expressed without resorting to bullying or discrimination of others.

Additional Resources for Students

UA Academic policies and procedures are available at <http://catalog.arizona.edu/policies>

Student Assistance and Advocacy information is available at

<http://deanofstudents.arizona.edu/student-assistance/students/student-assistance>

University of Arizona's Basic Needs Resources page: <http://basicneeds.arizona.edu/index.html>

Campus Pantry

Any student who has difficulty affording groceries or accessing sufficient food to eat every day, or who lacks a safe and stable place to live and believes this may affect their performance in the course, is urged to contact the Dean of Students for support. In addition, the University of Arizona Campus Pantry is open for students to receive supplemental groceries at no cost. Please see their website at: campuspantry.arizona.edu for open times.

Furthermore, please notify me if you are comfortable in doing so. This will enable me to provide any resources that I may possess.

Title IX

The University of Arizona is committed to removing educational barriers created by sex discrimination and sexual harassment. Sex discrimination under Title IX can include acts of violence based on sex, such as sexual assault, domestic violence, dating violence, and stalking. If you (or someone you know) has experienced or experiences any of these incidents, you have options for help at the University. The University of Arizona has staff members trained to support you in navigating campus life, accessing health and counseling services, providing academic and housing accommodations, helping with legal protective orders, and more.

Please be aware that UA faculty and instructors who work with students are required to report allegations of sex discrimination to the Title IX Office. This means that if you tell me about a situation involving sexual harassment, sexual assault, dating violence, domestic violence, or stalking that involves another student or employee, or that happens on campus or in a UA program, I **must** share that information with the Title IX Coordinator. Although I have to make that notification, you will have choices regarding whether or not you want to pursue a formal complaint against anyone on campus. Our goal is to make sure you are aware of the range of options available to you and have access to the resources you need.

If you wish to speak to someone privately, you can contact any of the following on-campus resources:

- Counseling & Psych Services (CAPS), <https://health.arizona.edu/counseling-psych-services>, 520-621-6490, 520-570-7898 (after hours)
- Oasis Sexual Assault, Relationship Violence, and Trauma Services, <https://health.arizona.edu/counseling-oasis> (same phone as CAPS)
- Campus Health, <https://health.arizona.edu/home>, (520) 621-6490
- University of Arizona Ombuds, <https://ombuds.arizona.edu/>, (520)-626-5589
- Title IX section on sexual assault support & resources (<https://titleix.arizona.edu/title-ix/sexual-harassment-violence>) has more information, as well as a link explaining options if you have a concern, need assistance/support, or would like to file a complaint.

Preferred Gender Pronoun

This course affirms people of all gender expressions and gender identities. If you prefer to be called a different name than what is on the class roster, please let me know. Feel free to correct instructors on your preferred gender pronoun. If you have any questions or concerns, please do not hesitate to contact me directly in class or via email (instructor email). If you wish to change your preferred name or pronoun in the UAccess system, please use the following guidelines:

Preferred name: University of Arizona students may choose to identify themselves within the University community using a preferred first name that differs from their official/legal name. A student's preferred name will appear instead of the person's official/legal first name in select University-related systems and documents, provided that the name is not being used for the purpose of misrepresentation. Students are able to update their preferred names in UAccess.

Pronouns: Students may designate pronouns they use to identify themselves. Instructors and staff are encouraged to use pronouns for people that they use for themselves as a sign of respect and inclusion. Students are able to update and edit their pronouns in UAccess.

More information on updating your preferred name and pronouns is available on the Office of the Registrar site at <https://www.registrar.arizona.edu/>.

Confidentiality of Student Records

Grades will be posted on the D2L website for the class. If you have any questions regarding your student record confidentiality rights, please refer to: <http://www.registrar.arizona.edu/personal-information/family-educational-rights-and-privacy-act-1974-ferpa?topic=ferpa>

Subject-to-Change Notice

Information contained in the course syllabus, other than the grade and absence policy, may be subject to change with advance notice, as deemed appropriate by the instructor.

Extra Syllabus Language Fall 2020 Specific

Face Covering Policy:

Face coverings are required in our classroom: Per UArizona's Administrative Directive, face coverings that cover the nose, mouth, and chin are required to be worn in all learning spaces at the University of Arizona (e.g., in classrooms, laboratories, and studios). Any student who violates this directive will be asked to immediately leave the learning space, and will be allowed to return only when they are wearing a face covering. Subsequent episodes of noncompliance will result in a Student Code of Conduct complaint being filed with the Dean of Students Office, which may result in sanctions being applied. The student will not be able to return to the learning space until the matter is resolved. Students who forget or refuse a face covering will be given a

disposable mask to wear. Refusal to wear a face covering (mask) will then involve asking the student to leave the room and connect remotely. Refusal to wear a face covering or leave the room may result in class-session cancellation.

Physical Distancing:

Physical distancing is required in our classroom: During our in-person class meetings, we will respect CDC guidelines, including restricted seating to increase physical distancing and appropriately-worn face coverings. Per UArizona's Administrative Directive, face coverings that cover the nose, mouth, and chin are required to be worn in all learning spaces at the University of Arizona (e.g., in classrooms, laboratories and studios). Any student who violates this directive will be asked to immediately leave the learning space, and will be allowed to return only when they are wearing a face covering. Subsequent episodes of noncompliance will result in a Student Code of Conduct complaint being filed with the Dean of Students Office, which may result in sanctions being applied. The student will not be able to return to the learning space until the matter is resolved.

The Disability Resource Center is available to explore face coverings and accessibility considerations if you believe that your disability or medical condition precludes you from utilizing any face covering or mask option. DRC will explore the range of potential options as well as remote course offerings. Should DRC determine an accommodation to this directive is reasonable, DRC will communicate this accommodation with your instructor.

Classroom Attendance:

- If you feel sick, or may have been in contact with someone who is infectious, stay home. Except for seeking medical care, avoid contact with others and do not travel.
- Notify your instructors if you will be missing an in person or online course.
- Campus Health is testing for COVID-19. Please call (520) 621-9202 before you visit in person.
- Visit the UArizona COVID-19 page for regular updates.

Academic Advising:

If you have questions about your academic progress this semester, or your chosen degree program, please note that advisors at the Advising Resource Center can guide you toward university resources to help you succeed.

Life Challenges:

If you are experiencing unexpected barriers to your success in your courses, please note the Dean of Students Office is a central support resource for all students and may be helpful. The Dean of Students Office can be reached at 520-621-2057 or DOS-deanofstudents@email.arizona.edu.

Physical and Mental-health Challenges:

If you are facing physical or mental health challenges this semester, please note that Campus Health provides quality medical and mental health care. For medical appointments, call (520-621-9202). For After Hours care, call (520) 570-7898. For the Counseling & Psych Services (CAPS) 24/7 hotline, call (520) 621-3334.

Class Recordings:

For lecture recordings, which are used at the discretion of the instructor, students must access content in D2L only. Students may not modify content or re-use content for any purpose other than personal educational reasons. All recordings are subject to government and university regulations. Therefore, students accessing unauthorized recordings or using them in a manner inconsistent with UArizona values and educational policies are subject to suspension or civil action.

Fall 2020 UA Sick Policy:

In accord with CDC guidance, it is required that UA Arizona students, faculty, and staff who are sick with COVID-19, or who have recently had a [close contact](#) with a person with COVID-19, must stay home or in their living quarters (e.g., dorm room).

However, the requirement to stay home may impact a student's class participation, which often has implications for their course grades. It is critical that students feel that they can miss one class, or a series of classes, without penalty in order to adhere to public health guidance to limit disease spread.

- Please actively encourage students to stay at home if they feel sick or have any of the [symptoms of COVID-19](#).
- Students who need to miss a class, or series of classes, due to illness or the need to quarantine/isolate are responsible for emailing their course instructor, with copy to the Dean of Students at DOS-deanofstudents@email.arizona.edu, to let them know of the need, as soon as possible. There is no need for a medical excuse to be provided for absence of up to a week (see more below).
- Students are responsible for completing any work that they might miss due to illness or the need to quarantine/isolate, including assignments, quizzes, tests and exams.
- Students are responsible for communicating with their instructor(s) via the means of communication established by the instructor(s), e.g., via D2L, email, text message, etc.
- Students who need to miss more than one week of classes in any one semester will be required to provide a doctor's note of explanation to DOS-deanofstudents@email.arizona.edu. The Dean of Students Office will communicate the receipt of the note (with expected end date) out to the relevant faculty.

Students who adhere to these processes should not be penalized per the attendance policy for the course.

Instructors are to make every effort to work with and provide modifications for students who cannot come to class due to illness.

- Provide students an opportunity to join a live lecture via Zoom and/or recording of lectures through Zoom and making these recorded lectures available on D2L.
- Request that students who join via Zoom or who watch recorded lectures provide feedback through mandatory discussions, quizzes or essays on the material covered in order to receive credit for attendance and participation.
- Make-up exams or tests might be administered through D2L.

Wildcat Wellcheck

<https://wellcheck.arizona.edu> (Instructions for signing up for Wellcheck)

Text JOIN to 1-833-339-0504

Questions on Wellcheck:

1. Do you have a temperature of 100.4 or above?
Yes, 100.4 or above
No, below 100.4
Don't know/don't have a thermometer
2. Do you or close contacts have any of the following symptoms that could be related to COVID-19?

Fever or chills, cough, shortness of breath or difficulty breathing, fatigue, muscle or body aches, headache, new loss of taste or smell, sore throat, congestion or runny nose, nausea or vomiting, diarrhea.

Reporting Positive COVID-19 test:

Information Website: <https://health.arizona.edu/SAFER>

Have you tested positive for COVID-19? <https://redcap.link/CovidReporting>

<http://www.registrar.arizona.edu/personal-information/family-educational-rights-and-privacy-act-1974-ferpa?topic=ferpa>

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