Duke | MASTER of ENGINEERING MANAGEMENT

Energy Transitions 590.07 — Fall 2022

Thursdays, 3:30pm to 6:15pm – 115A Hudson Hall

Instructor

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Course Description

Energy generation and use by global industries, governments and society involves complex, frequently competing goals involving economic growth and environmental stewardship. Industry and organizations need brave & smart energy engineers with key skills to achieve complex energy transition & decarbonization strategies. **Critically thinking about these challenges and solving them requires solid: engineering, economic, and environmental science skills. We will call these the "3Es"**. This Energy Transition course focuses on teaching students practical career skills in fossil fuel asset decarbonization, carbon-capture utilization & storage (CCUS) solutions and renewable energy technologies (wind, solar, hydro, nuclear, hydrogen, biomass & geothermal). The course begins by reviewing applicable energy aspects within a 3Es analysis framework of:

1) Engineering (thermodynamics, mass balance, energy conversion, etc)
2) Economics principles (macroeconomics, financial valuation, etc.),
3) Environmental considerations (emissions, regulations, incentives, etc.).

This course broadly reviews 3E fundamentals that most students likely have seen in undergraduate engineering, economics or environmental courses. Although the course requires strong analytical abilities, it purposefully focuses on pragmatic applications of theory and industry problem solving techniques to integrate 3Es principles versus in-depth theoretical problems typical in advanced core engineering classes. As an example, most students have studied energy & mass conservation laws in high school or undergraduate physics courses, however, students may not be as clear about how to

apply these to the real world problems in the energy industry. The class team industry project illustrates some typical energy transition/decarbonization skills to be taught & practiced in this class:

> Imagine you work at an energy consulting firm and are asked by a client company to determine an energy transition/decarbonization strategy for a company fossil fuel energy asset. How do you baseline existing asset performance? (fuel use/cost, efficiency, electricity+heat output, emissions, etc.) What energy revenue is needed to achieve a profitable rate of return to operate and fuel the asset over 20 years? What future economic incentives or penalties for renewable energy or emissions should be considered? What (if any) carbon capture, utilization, and storage solutions are viable to mitigate emissions? What (if any) renewable energy generation solutions are viable to substitute fossil fuel/emissions given the asset geographic region? Out of the many possible solution paths, what are a few high level design concept configurations showing most promise? Could you work with peers on a project team, research solutions, develop 3E fundamentals model analysis frameworks, organize your information, and present these findings to the company client in an executive-like manner?

After 3Es fundamentals lectures in the first several weeks of the semester, collaborative 4-6 person teams with diverse undergraduate technical backgrounds & work experiences will be formed to work on the described industry energy transition/decarbonization project. Initial project aspects involve: establishing team charter, establishing baseline assumptions/goals, framing project context, researching candidate solutions, and performing 3E fundamentals estimation calculations. The initial project goal is to assess viability & select a few promising: CCUS or renewable energy solutions amongst many brainstormed possibilities. Later project aspects involve more in-depth 3Es research & analysis on the few most promising, chosen solutions. During the project, teams will interact with industry mentors, learn practical project management skills, and conduct in-class project reviews culminating in a final executive summary presentation/report.

The Energy Transitions technical elective is appropriate for graduate students from: the Master's of Engineering Management Department, other Pratt Engineering Departments or the Nicholas School of Environment Departments who have interest in energy-related careers as project/product managers, systems engineers or technical consultants.

Prerequisites

3Es concepts related to energy are reviewed in the early part of this course. However, given the technical aspects of Energy Transition/Decarbonization, this course is targeted to students who have had previous undergraduate coursework in: physics/chemistry, economics and environmental science.

Learning Objectives

By the end of the semester, students will be able to:

- Identify, analyze & provide strategies for an energy transition/decarbonization project using carbon capture & storage and renewable energy technologies.
- Critically evaluate & compare/contrast global macro energy strategy effectiveness with a variety of 3Es analysis techniques.
- Be able to describe, explain and apply analytical best practice tools and steps of an energy transition/decarbonization industry consulting process.
- Practice client interaction, project management, teamwork, communications, and executive summary/presentation skills

Course Delivery Format, Etiquette and Semester Activities

This is an in-person class (not recorded). *If a student with a valid absence excuse (per course policy) would like a course ZOOM live-streamed, please let TA know before class begins.*
This course uses Sakai, if you are registered for the class, you will have complete access to our Sakai. All course materials, including syllabus, readings & assignments are on Sakai.
Please arrive at class on time and refrain from checking email, working on other courses, social media, texting, and web-surfing while we are together. These activities are more obvious than you might think, and I will not hesitate to cold call anyone who appears to be using their device for anything other than note taking or researching the occasional discussion questions. If I feel that electronic media are becoming too much of a distraction, I will ask everyone to turn off and store all phones, laptops, and other devices during class.

Course Activities & Assignments - First Several Weeks of Semester:

1) **In-class**
    a) Lectures, active class discussions/exercise
    b) 5-6 Weekly Quizzes *(< 10 min @beginning of classes)*
    c) Duke Power Plant Field trip *(contingent on current Duke policy)*
2) **Out of class**
    a) Passing the 5 week Online Coursera Course "Renewable Energy Technology Fundamentals" from Univ of Colorado (Beginner, ~13hrs total). Available for free to Duke Students registering with their .edu mail address.
    b) Readings/multimedia materials
    c) 5-6 Weekly Homework Assignments

Course Activities - Rest of Semester:

1) **In-class**
    a) Lectures, Industry Guest Lectures & active class discussions/exercises
    b) Project Reviews with Industry Mentors & PEER Project Evaluations
2) **Out of Class**
    a) Readings/Multimedia materials
    b) Team Project Work

Coursework Assignments & Grading: I = Individual Graded, T = Team Graded

5-6 Homework Assignments	**I**	**15%**	***1 lowest HW grade dropped***
5-6 Quizzes *(<10min ea)*	**I**	**15%**	***1 lowest Quiz grade dropped***
Coursera Course	**I**	**10%**	***Pass = 10pts, Fail = 0pts.***
In-Class Participation	**I**	**10%**	
Team Project	**T**	**50%**	*An individual student's grade for each team project grade event may be modified per Team PEER Feedback & instructor observation*

Grading Scale

This rubric will be used to translate your cumulative weighted % score into a final grade.

100	**A+**		**77 to 80**	**C+**
95 to 99	**A**		**73 to 76**	**C**
90 to 94	**A-**		**70 to 73**	**C-**
87 to 89	**B+**		**60 to 69**	**D**
83 to 86	**B**		**< 60**	**F**
80 to 83	**B-**			

Homework Assignments

5-6 individual homework assignments during the first several weeks of the course involving problem solving, critical evaluation of real world scenarios or answering questions based on course materials/readings/multimedia.

Quizzes

5-6 quizzes (< 10min, short answer/problem solving/multiple choice) will be given during the first several weeks of the semester at the BEGINNING of class. Quizzes are designed to encourage staying up to date with class materials and assignments.
This course has no midterm or other tests. The final team project executive summary presentation is done during the final exam timeslot alongside submitting a written

report.

Course Deliverables Timeline

A course deliverables timeline with assigned readings, materials, etc. is available on Sakai.

In-Class Participation

Effective learning experiences require class participation from every student and allows you to develop idea articulation skills. To help ensure participation is more widespread, students may be randomly selected to discuss course aspects in each class. TA & instructor observations will evaluate participation per guidelines below. At ¼ and ¾ time points in semester (approx. halfway between the two participation grading events, TA will PRIVATELY email students a "tentative" participation score + feedback giving students an opportunity to improve in-class participation before participation grade events.

Contribution Expectations

	Excellent **5/5**	**Good** **4/5**	**Satisfactory** **3/5**	**Below Satisfactory** **0/5**
Quantity **and** **Quality**	Attends class regularly *Frequently contributes* to the in-class discussions (>75% of classes) Excellent achievement of contribution quality items 1-3.	Attends class regularly *Usually contributes* to in-class discussions (50-75% of classes.) Good achievement of contribution quality items 1-3.	Attends class regularly but frequently late. *Sometimes contributes* to in(25-50% of classes) Satisfactory achievement of contribution quality items 1-3	Attends class irregularly or frequently late to class. *Rarely contributes* to the in-class discussion (<25% of classes)) Frequently doesn't achieve contribution quality items 1-3.

Contribution Quality Expectations (Items 1-3):

1. Are your comments accurate, reflecting facts but not merely restating them? Do comments exhibit 3E thinking & synthesizing class or outside assignment readings/research?
2. Do your comments show you listen to classmates, TA & instructor? Does your comment advance ideas made by others or class insight? yields new perspectives?
3. Do your comments reflect a concern for maintaining a constructive and comfortable classroom atmosphere? Do you ensure you don't overly dominate class discussions?

Project Assignment

Teams of 4-6 students will work on a decarbonization project following an industry methodology to evaluate decarbonization and renewable energy strategies for the company based on 3Es rationale. Teams will conduct periodic project reviews with industry mentors & give a final project powerpoint executive presentation + written report with recommendations & plans for a couple most promising options.

50% Project Grade contribution will be divided into 4 Milestone Grades

- **10% - Separate Grade for each Project Review (1,2,3)**
- **20% - Project 4 Review/Final Presentation/Written Report Grade**

Project Grades involve two aspects

1) Overall Project Team Grade

An overall Project Team Grade will be determined based on in-class **Inter-Team PEER Project Review Assessments** alongside Instructor/Mentor observation. Students will fill out a survey in class evaluating each other's team project reviews based on quantity + quality of per project milestone deliverables and project presentation/communications. Feedback to be anonymously shared between teams.

2) Potential Individual Student Adjustments to Project Grade

Individual student project team grades may be adjusted to ensure grading fairness and equitable contributions are occurring from each team member. Each student will fill out an **Individual Self & PEER Intra-Team Teammate Assessment** form at each project grading event. Students will evaluate: quantity + quality of contributions & team interaction effectiveness for themselves and each teammate. Self & team feedback is evaluated by the instructor who may use it to adjust an individual student's project grade up or down based on the feedback as well as instructor or mentor observation.

Self & PEER Intra-Team Teammate Assessment

Effective teamwork is important. To ensure equitable grading consideration, students will periodically fill out Self and Team PEER assessments evaluating themselves & other teammates': contribution quantity, contribution quality and team interactions.

1st Self & IntraTeam Assessment - after Project 1 Review (nongraded feedback only)
2nd Self & IntraTeam Assessment - after Project 2 Review (potential grade impact)
3rd Self & IntraTeam Assessment - after Project 3 Review (potential grade impact)
4th Self & IntraTeam Assessment - after Final Presentation (potential grade impact)

Course Resources

Coursera - "Renewable Energy Technology Fundamentals" Online Course

Each student needs to individually complete & pass the 5 week COURSERA (Beginner,~13hrs total) online course "**Renewable Energy Technology Fundamentals"** by Univ of Colorado during the first half of the semester. This course is available to Duke University Students for free. **You must register with your duke.edu email address**. I took this course and found its renewable energy videos interesting & well done. Complete weekly Coursera videos/readings/quizzes (easy multiple choice allowing retakes) per our course's Sakai syllabus schedule. Some class homework material or in-class quiz questions may be based on assigned Coursera content for the week.

10pts	Passing Coursera Course	> 80% on each Coursera quiz module & final course quiz (multiple choice, multiple retakes allowed). Submit completed Coursera Certificate with your first & last name to Sakai by due date.
0pts	Failing Coursera Course	**NOT** submitting completed Coursera Certification with your first and last name by the syllabus due date .

LATE COURSERA SUBMISSIONS WILL ONLY BE ACCEPTED IN CASES OF A DOCUMENTED EMERGENCY per absence policy. Students are expected to work ahead on Coursera Materials when they have any non-emergency conflicts (interviews, university travel, etc.) affecting weekly Coursera Course completion tasks.

You are free and encouraged to discuss any Coursera non-quiz material with each other, however, completing the Coursera content & quizzes must be your own work per the Duke Community Standard.

Readings

Readings & multimedia assignment weblinks are listed on the syllabus for each week and are all publicly available. Students should complete assigned materials before the next class as homework & in-class quizzes are often based on these assignments. Besides public weblinks, readings are from an eLib textbook are available from Duke Libraries Online

"Sustainable Energy, 2nd Ed, Choosing Amongst Options", Tester, et al. MIT Press c2012
https://find.library.duke.edu/catalog/DUKE010140394

I may also assign other materials based on needs for project or student interest.

Policies on Late Additions, Late Assignments, Class Attendance and Illnesses

Late Class Additions

Any late class student additions are responsible for any previous class lecture materials, homeworks or quizzes. Separate arrangements will be made for homeworks & taking quizzes for late adds but the expectation will be that significant extra time must be spent to catch up on past items within 1 week of the late addition alongside the expectation to stay up to date with the rest of the class for current lecture materials, homework & quiz deliverables.

Policy on Class Attendance & Late Assignments/Quizzes

In-class attendance & being on time is expected (consistent with Duke policy expectations in place at the time). If you miss class, the learning experience suffers. If you must miss class, be sure that you clear the absence with me **BEFORE** the class except in cases of unanticipated emergency. Unexcused absences will have a negative impact on your grade. Absences must be documented to be considered excused and any communication of these events is expected to follow the Duke Community Standard. These include:

- Illness - documented by a doctor's note.
- Company Interviewing, University Official engagement - documented with a company or university letter
- Unanticipated emergency (family or personal trauma, vehicular accident, etc.) - documented with a letter explaining emergency.

All homework assignments must be uploaded to Sakai by the posted due date. No late homework assignments are accepted unless a student has a documented excuse per the same policies as provided above for in class absences.

Individual missed Homework Assignments or In-class quizzes can be made up outside of class only if an absence has a documented excuse per the same policies provided above.

Missed Project reviews require the same excused absence documentation per policies provided above. However, given their nature, Project Reviews cannot be made up. Thus, if a student misses a project review their grade will be based on the Team Grade achieved for the project review adjusted per the Intra-Team self/PEER Assessment guidelines. As such, it is wise for a student to complete additional work to help their team prepare Project Review materials if a student has anticipated absences.

If any larger out-of-class traumatic events or emergencies occur and you cannot complete assigned work for a longer period of time, please contact me and also contact the MEMP student coordinator as well as your Department's student coordinator if you are a student in another Duke department.

Objectivity and Respecting Perspective Diversity

Energy supply and its global use impacts everyday lives profoundly. Class tenets are:

- Efficient energy generation and use touches our lives in many ways. Whether in the past or in the future, it enables substantial global Gross Domestic Product (GDP) economic prosperity and enhanced societal lifestyles. ("Energy is life.")
- Environmental impacts associated with energy creation have serious planetary repercussions we must understand and address. ("Climate change is real")
- A plethora of future careers need smart & brave students like you who have solid energy transition and decarbonization job skills.

Many topics we will discuss have geopolitical and personal emotional aspects. Often it is hard to see through the subjective aspects regarding how information is presented or communicated (including by many media sources). My goal is to help you learn to critically think objectively about energy transition & decarbonization challenges. We will do this by applying 3Es fundamentals towards more open-ended energy transition & decarbonization problems that have challenging constraints and often conflicting goals. It is tempting to see the issues we will encounter this semester in either-or terms (e.g., "fossil fuels are always bad", "renewable energy is always good"). However, real-world issues faced by companies, organizations & society are more complex and nuanced. While I will respect the individual conclusions you reach, it is important you support your rationale *with objective evidence and 3Es principled robust analysis rather than subjective opinions.* I will try to model this perspective in class. Let's strive to be analytical engineers, financial economists and environmental scientists in our energy transition journey while respecting the enormous value of diverse personal and cultural preferences. Having many globally diverse experiences & backgrounds becomes a terrific asset for our energy transition course learning journey & richness of class interactions.

Pratt School Honor Code/Duke Community Standard

Homework assignments, in-class quizzes & Coursera course quizzes are explicitly to be your own work without any outside discussion, work or engagement with others to complete.

Team assignments should involve collaboration WITHIN your team outside of class. However, there should be NO outside of class discussions or collaboration involving any aspects of the project BETWEEN teams. There will be ample Q&A time within class for BETWEEN team interactions.

Activities as a part of this class are governed by the Duke Community Standard https://studentaffairs.duke.edu/conduct/about-us/duke-community-standard which states:

"Duke University is a community dedicated to scholarship, leadership, and service and to the principles of honesty, fairness, respect, and accountability. Citizens of this community commit to reflect upon and uphold these principles in all academic and nonacademic endeavors, and to protect and promote a culture of integrity.:

To uphold the Duke Community Standard:

• I will not lie, cheat, or steal in my academic endeavors;
• I will conduct myself honorably in all my endeavors; and
• I will act if the Standard is compromised."

Please add the following affirmation to the end of all assignments, and sign your names beside it: "I have adhered to the Duke Community Standard & course individual/team collaboration expectation standards in completing this assignment."

Safety Measures

While I am excited to be in the classroom, all of us (including me) will need to observe Duke's current policy classroom rules to keep us safe. (we will adapt these rules per any Duke policy changes during the semester)

- Each of us must be cleared to come to campus each day
- Mask wearing will be per Duke's current classroom policy.
- You may not eat or drink in the classroom
- You should clean your desk area before and after class with the disinfecting solution provided in the classroom
- You must sit in same designated seats each class
- All of us should maintain social distance (i.e. a minimum 6 foot separation) from each other at all times
- We all should do our best to maintain a positive attitude towards our situation.