Economic Input-Output Environmental Life Cycle Assessment
Spring 2016  
1.5 Credit Units

Nicholas School of the Environment  
Duke University

Time  
Fridays 10:05-11:20AM

Location  
Environment Hall 1111

Instructor  
Dalia Patiño Echeverri  
dalia.patino@duke.edu

Office hours: Fridays after class  
Office: EH 3118

Responsibilities of Teaching Assistant. The teaching assistant is responsible primarily for helping you to understand the concepts in lectures, readings, and assignments, to grade your assignments and to help administer the course. He can answer your questions by email.

Course Description

Environmental Life Cycle Assessment (LCA) is a tool to identify the magnitude, type and location of the environmental impacts caused by all the stages of a production process, from the gathering of raw materials, to the disposal of the product at the end of its life. This course presents the Economic-Input Output LCA (EIO-LCA) method which was theorized and developed by economist Wassily Leontief in the 1970s and applied to the U.S. economy in the 1990s by researchers from Carnegie Mellon University.

Special emphasis is made on the understanding and estimation of the environmental impacts associated to electricity generation.

Prerequisites  
College-level calculus, elementary matrix algebra, and a good understanding of the inputs and outputs of electricity and other energy products. It is also highly desirable to have taken Energy and Environment (ENV211), Energy Technology (ENV298.23), and LCA. Admission by permission of instructor.
Syllabus as of 11/24/2015. Please see Sakai for updates.

LCA requires only elemental arithmetic operations, but you need to be comfortable doing operations for units conversion. Also, to understand the mechanics of the Input-Output models you need to be familiar with matrix algebra (how to add and multiply vectors and matrices, and how to solve systems of linear equations in matrix form). If you are concerned about this but have a strong interest in the class and a positive attitude towards learning at a fast pace I encourage you to take the class and interact often with me on how to keep up with this and other concepts and tools unfamiliar to you.

Textbooks and Readings


Supplemental readings as indicated in class schedule below, many available on the internet, and others available via Sakai.

Sakai and PC compatibility

Readings, class announcements, schedule changes, grades, power point slides and working files (excel) will all be posted to the course Sakai site. Students are also encouraged to use Sakai’s discussion boards to continue the discussion of course issues beyond the classroom. Anyone having trouble working with the Sakai site should seek help from their fellow students, or contact Information Technology (http://Sakai.duke.edu/home.do).

Occasionally I will post excel files that illustrate some quantitative analysis. I use a windows PC with MS Office 2007 and it is your responsibility to solve all the compatibility issues to keep up with the materials posted.

Course Assignments
Syllabus as of 11/24/2015. Please see Sakai for updates.

Written assignments should be presented using Times Roman 12 pt font, single-spaced text, 1” margins. Please save paper by printing double sided and not using a cover sheet. Problem sets can be hand-written if the text and math are written clearly.

There will be four assignments. The assignments will ask you to apply the concepts of LCA, sometimes in the form of a numerical problem. I encourage you to work in study groups of up to three people on these and help each other learn. However, each student must submit his or her own copy of the assignment and you are not allowed to directly copy another student’s work. An example of appropriate problem set collaboration would be for Student A to explain the math used in the problem to Student B. Then Student B goes off by himself and completes the problem again and writes up his own explanation. It would be inappropriate for Student B to directly copy the math or the explanation/interpretation directly from Student A. Study groups are most effective when everyone attempts to do the problem sets BEFORE meeting as a group. Only if you really try to solve the problem on your own will you realize whether you understand the problem and its solution. It is very easy to hear someone’s explanation and think you understand the problem, but you may not. This will also help insure that you are using study groups in ways that are consistent with the Nicholas School Honor Code.

Assignment #1  
Goal and scope definition.  
Posted 1/21; Due 1/28

Assignment #2  
LCIA  
Posted 2/4; Due 2/11

Assignment #3  
Streamlined LCA of US electricity using NREL database- Dealing with circularity  
Posted 2/18; Due 3/4

Assignment #4  
Hybrid LCA  
Posted 3/11; Due 3/19

Final Project (in groups)  
You will have the opportunity to frame and conduct an LCA study to shed information for a current energy policy debate. The last two classes will be devoted to groups presentations (please use power point). Your grade will be based on assessment both from the instructor and your peers.  
Posted 3/18; Due 4/21
Syllabus as of 11/24/2015. Please see Sakai for updates.

Grading
Each assignment will be evaluated using a numbered grade (0-100) and your overall numbered grade will be determined using the following weights:

Assignments (3): 60% (20% each)
Final Project (teams of 3 students): 20% (10% report - 10% in class presentation)
*Participation and quizzes: 20%
Total: 100%

Letter grades of A, A-, B+, B-, C+, C, C-, or F will be assigned according to numbered grades in the following way:

Above 100: A+
(95-100] A
(90-95] A-
(85-90] B+
(80-85] B
(75-80] B-
(70-75] C+
(65-70] C
(60-65] C-
60 or below F

*Participation. You are expected to prepare for class by reading the assigned reading prior to the class. The first 5-10 minutes of each session there will be a quiz on the assigned readings and/or the concepts and tools discussed in previous classes. Occasionally I will ask you to prepare the quiz in advance (e.g. write a short summary -less than a page- of the assigned readings). Your grade from class participation will depend on the quality and quantity of your interventions in class, participation in Sakai discussions, and your written summaries and quizzes. Please post these summaries to BB. You will not receive graded feedback on summaries or quizzes.

Policy on late assignments. All assignments are due at the beginning of class on the posted due date. Late assignments will not be accepted. If you are ill or have a family emergency that prevents you from being able to complete the assignment on time, please submit the web-based short-term illness form prior to the class in which the assignment is due. The short-term illness form can be found at: http://www.duke.edu/flu/getting_sick/index.html#students, or www.aas.duke.edu/trinity/t-reqs/illness/. You are governed by the Nicholas School Honor Code in completing this form (see below). If you do not complete this form before class, the standard late policy will apply. An assignment that is not submitted because of illness or family emergency will be excluded from your grade calculation (so the 48% of assignments will be based on 3 instead of 4 assignments, 16% each). Any other missed assignments will receive a grade of zero.

Policy on late final project report. The final project will receive a penalty of 10% per day late. If you are ill or have a family emergency that prevents you from being able to complete the computer based analysis on time, please submit the web-based short-term illness form prior to
Syllabus as of 11/24/2015. Please see Sakai for updates.

the class in which the assignment is due (see above). There will not be a penalty if the analysis report is submitted as soon as your illness or emergency is over.

Nicholas School Honor Code and the Duke Community Standard

All activities of Nicholas School students, including those in this course, are governed by the 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 name beside it: “I have adhered to the Duke Community Standard in completing this assignment.”

Class etiquette

1. Please make sure you do everything you can to make our classroom culture a comfortable learning environment for everyone. We will likely have people from many different backgrounds in this class and you should all feel comfortable and make each other comfortable while participating.

2. Please take responsibility for making the class successful. As the instructor I assure you I will try to do my best, but what you learn in the class will be largely dependent on your attitude and work. Ask yourself what you can do during each class to move the course forward in a positive way.

3. If you must enter the class late, please do so quietly. If for any reason the door is locked please knock. I prefer this short disruption than you missing an entire class.

4. Cell phones, beepers, eating, and other distracting activities are not appreciated.

5. Please refrain from browsing the internet and/or checking your email in class. I prefer if you do not use a laptop in class.

Class Topic and Readings Schedule

*Required readings are indicated with an asterisk* and should be completed before the class on which they are listed. Other readings offer supplementary material and/or an alternative presentation of similar information.
1. **Introduction to LCA**
   Brief history of LCA. Phases of an LCA.

2. **Goal and scope definition - Functional Unit**
   Quiz # 1
   Assignment #1 posted

3. **Allocation methods - Boundary definition - Circularity**
   Quiz # 2

4. **Streamlined LCA - Example: Streamlined LCA of Electricity generation in the US using NREL LCI data base**
   * U.S. LCI database project - User's Guide
   Assignment #1 due at the beginning of class.

5. **Introduction to Input Output LCA**
   * Hendrickson et al. 2006. Chapter 1: Introduction to EIO-LCA Model
   In class exercise: Soda production: Simulation of transactions in an economy with 4 sectors
   Quiz # 3
   Assignment #2 posted

6. **Building an Input-Output model**
   *Basics of matrix and vector algebra
   Quiz # 4 (On matrix algebra)

7. **Process based vs EIO-LCA - Hybrid LCA**
   *Hendrickson et al. 2006. Chapter 2: Hybrid LCA analysis
   Assignment #2 due at the beginning of class.
   Assignment #3 posted

8. **Thursday February 4 - LCIA: Life Cycle Impact Assessment. EPA's TRACI (Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts (TRACI)**
   -Developing a Consistent Decision-Making Framework by Using the U.S. EPA's TRACI
Syllabus as of 11/24/2015. Please see Sakai for updates.


Quiz # 5

9. Thursday March 18 - Environmental valuation for LCA. Uncertainty
*Hendrickson et al. 2006. Chapter 3: Environmental Valuation for Life Cycle Assessment
*Hendrickson et al. 2006. Chapter 4: Uncertainty in estimating impacts
Assignment #3 due at the beginning of class.
Final Project Assigned

10. LCA of PHEV
Quiz # 6

11. Comparing LCA GHG emissions of Natural Gas and Coal
Assignment #3 due at the beginning of class.
Quiz # 7

12. Final Project Presentations
Final Project due at the beginning of class

13. Final Project Presentations