Energy Systems Modeling  
Fall 2015  
ENV 716L.001

Nicholas School of the Environment  
Duke University

<table>
<thead>
<tr>
<th>Time</th>
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<tr>
<td>TuTh 8:30am – 9:45am</td>
<td>Gross Hall 107</td>
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**Lab sessions**

- F 8:30-9:45
- F 10:05-11:20

**Instructor**

Dalia Patiño-Echeverri  
dalia.patino@duke.edu  
Phone: 919-613-7461  
Office hours: Tuesdays and Thursdays 9:45-10:45 (Gross Hall 100)

**Teaching Assistants**

Ali Daraeepour  
a.daraeepour@duke.edu  
Office hours: Mondays 9:45-11:45AM (TBA)

Eric Williams  
e.l.williams@duke.edu  
Office hours: Wednesdays 9:45-11:45AM (TBA)

**Grader**

Shuo Gao  
shuo.gao@duke.edu

**Responsibilities of Teaching Assistant.** The teaching assistant is responsible for:
- Recording the grades of the students.
- Attending claims about grading.
- Helping answer questions in the forum.
- Helping design the assignments.
- Posting the answer key for each assignment.
- Answering questions posted on the discussion forums (Sakai)
- Facilitating the help sessions on Fridays.

**Course Description**

This course is an introduction to the use of computer models and the methods of optimization and simulation for students interested in the analysis of energy systems. The course makes
Syllabus as of 8/28/2015. Please see Sakai for updates.

emphasis in formulation of optimization problems and simulation models and in the
identification of the available methods to solve them.
The goal is to enable you to formulate, implement, and use your own quantitative model to
puzzle out problems related to private and public decision making in the context of our energy
system and the environment. The class presents applications and case studies that deal with
problems of energy systems, their externalities, and the government policies that affect them.

Prerequisites
College-level calculus (including partial derivatives of functions of several variables),
probability theory, and basic linear algebra (how to write -and solve- systems of linear equations
in matrix form). You should also be familiar with capital-sigma (\(\sum\)) notation for compactly
representing summation of similar terms, and know the basics of Excel.

Readings
Readings as indicated in class schedule below, many available on the internet, and others
available via Sakai. Required readings begin with RR. Optional readings begin with OR.

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). For this class you will be required to
use software that can only be installed on a windows platform. If you use a Mac, you may
borrow a windows laptop from the IT office. It is your responsibility to make arrangements for
that.
I will often post excel files with examples of quantitative analysis and macros. I use a windows
PC with MS Office 2013 (with solver add-in) and it is your responsibility to solve all the
compatibility issues to keep up with the materials posted.

Course Assignments
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 8 assignments. The assignments will ask you to apply the concepts and tools
learned in class. I encourage you to work in study groups of up to three people on these problem
sets 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 procedure 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 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**
Excel modeling and dealing with large data sets in excel

**Assignment #2**
Simple macros and functions

**Assignment #3**
More on VBA and an intro to LP

**Assignment #4**
Formulation of mathematical programs, graphical and excel solution to lp programs

**Assignment #5**
Formulation of multi-period problems. Formulation and solution of transportation problems

**Assignment #6**
Networks. Logical constraints. Unit commitment problem

**Assignment #7a**
Review of probability theory

**Assignment #7b**
Probability analysis

**Assignment #8**
Monte Carlo Simulation

**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 (8): 80% (10% each)
- Participation: 20%

Total: 100%

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

- Above 100: A+
Syllabus as of 8/28/2015. Please see Sakai for updates.

(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. Your grade from class participation will depend on the quality (and quantity) of your interventions in class and the help sessions, participation in Sakai discussions, and your quizzes. You will not receive graded feedback on quizzes.

Policy on late assignments. All assignments are due by 11:55PM on the posted due date. Assignments submitted after midnight of the posted due date will receive a grade of zero. Please do not ask for exceptions. 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 due date. 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). An assignment that is not submitted because of illness or family emergency will be excluded from your grade calculation (so the 80% of assignments will be based on 7 instead of 8 assignments). If your illness or family situation prevents you from completing more than one assignment please talk to me. I may recommend that you drop the class. An answer key for all assignments will be posted at 6:00PM of the due date. Please take the time to review the answer key and identify any mistakes you may have in your assignment and any remaining questions you may have about the material.

Bonus points. Occasionally I will provide opportunities for getting bonus points by attending and writing short commentaries on seminars and lectures on class related topics. I understand that some of you might be unable to attend these lectures and that is ok. Because this class uses an absolute grading system (e.g. your grade is unaffected by the performance of your classmates) you should not feel it is unfair that others can get bonus points and you can't.

Grade disputes. There will be a separate grade dispute folder for each assignment under the "Assignments" tab in Sakai. If you have questions about grading, please upload a written document in the relevant sub-folder, that has the following information:
1. The type of problem you found
   a) a factual error (like adding up the numbers wrong or referencing something that is not there)
   b) an inconsistency error (standards were inconsistently applied between papers)
   c) an interpretation dispute (you think you should have gotten more points)
Syllabus as of 8/28/2015. Please see Sakai for updates.

2a. Possibly including why you should get more points.
3. References that explain where to find the supporting material (e.g. "I put the graded document in your mailbox," or "my excel model is in the digital dropbox and it is named *.xls"...).

The grade dispute document needs to be uploaded no later than 7 days after the graded assignments are returned. However, discrepancies occurring when there is an error in adding up points for an assignment, or when the wrong grade has been uploaded (i.e. points appearing in your ‘Gradebook’ on Sakai are different from points you actually received) have no expiration date; let us know anytime (by e-mail/in person during TA office hours) if you see such errors.

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. 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, checking your email or working on other assignments during class.

Green Classroom Certification
Syllabus as of 8/28/2015. Please see Sakai for updates.

"This course has achieved Duke's Green Classroom Certification. The certification indicates that the faculty member teaching this course has taken significant steps to green the delivery of this course. Your faculty member has completed a checklist indicating their common practices in areas of this course that have an environmental impact, such as paper and energy consumption. Some common practices implemented by faculty to reduce the environmental impact of their course include allowing electronic submission of assignments, providing online readings and turning off lights and electronics in the classroom when they are not in use. The eco-friendly aspects of course delivery may vary by faculty, by course and throughout the semester. For more information on the Green Classroom Certification, visit: sustainability.duke.edu/action/classroom."

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Class Topic and Readings Schedule

Please try to complete the required readings (RR) before the class on which they are listed. Other readings (OR) offer supplementary material and/or an alternative presentation of similar information.

1. **Tuesday August 25 - Class Overview and introductions**

2. **Thursday August 27 - spreadsheet modeling: A simple cost model**

   Good modeling practices. IECM model. Form Controls.
   - Visit the IECM website and download the model. [http://www.cmu.edu/epp/iecm/about.html](http://www.cmu.edu/epp/iecm/about.html)
   - RR2-IECM Tutorial.pdf (Model tutorial for IECM software)
   - OR2-IECM intro.pdf (Getting started with IECM)
   - OR2- Rubin Ch 13 FinancialEng.pdf (Chapter on Economics and the Environment)
   - OR2- How to use the forms controls in Excel: [http://support.microsoft.com/kb/291073](http://support.microsoft.com/kb/291073)
   - Read excel help file as needed.

3. **Tuesday September 1 - spreadsheet modeling: Analysis of large data sets with excel.**

   eGrid database.
   - If, count, countif, sum, sumif, indirect, tables, Pivot tables
   - Lookup, vlookup, data analysis (descriptive statistics, correlation, histograms).
   - RR3- egrid_faq.pdf ([eGRID FAQ:](http://epa.gov/cleanenergy/energy-resources/egrid/faq.html))
   - OR3- Guidelines and examples of array formulas.docx (Class notes: Guidelines and examples of array formulas (from different sources))

4. **Thursday September 3 - VBA Macros in excel**

   VBA Excel Macros for Beginners.
   - RR4- Excel and VBA class notes.docx (Notes on Excel and Visual Basic)
   - RR4- Programming 101.docx (Excerpt from the blog of Guy Lecky-Thompson.)
   - OR4- VBA Excel macros for beginners.docx (Excerpt from Excel help files: Create or delete a macro.ad)
Syllabus as of 8/28/2015. Please see Sakai for updates.

5. **Friday September 4 - VBA Macros in excel II**  
   - This class is in place of the class of September 10.

6. **Tuesday September 8 - VBA Macros in excel III**

   **Thursday September 10:** No class. Dalia and Eric at the Energy Policy Research Conference.

   **Friday September 11:** Ali runs both lab sessions.

7. **Tuesday September 15 - More on VBA**

8. **Thursday September 17 - Introduction to Mathematical Programming**  
   Feasible region, feasible solution, objective function, decision variables, binding and non-binding constraints. Linear and non-linear programming. Assumptions of lp. Graphical method for lp problems with two decision variables

9. **Tuesday September 22 - Introduction to Linear Programming. Lp solutions using excel solver. Lp post-optimality and sensitivity analysis both graphically and in excel.**

10. **Thursday September 24 - Formulation of Lp programs.**

11. **Tuesday September 29 - Multi-Period lp programs. Handling inventories**
Syllabus as of 8/28/2015. Please see Sakai for updates.


13. Tuesday October 6 - Networks: Trans-shipment
   Expressing formulation in terms of vectors and matrices.

14. Thursday October 8 - Networks: Shortest path

15. Thursday October 15 - Networks: Maximum flow - Networks as an abstract representation of planning problems
   - RR15-Basic concepts of probability theory.pdf
   - Example: Planning trucks replacement

16. Tuesday October 20 - MILP - Ontario Hydro optimal investment and operating strategy I

17. Thursday October 22 - MILP - Ontario Hydro optimal investment and operating strategy II

18. Friday October 23 - Probability Analysis and Introduction to MonteCarlo simulation

19. Thursday October 29 - MC: Fitting and generating random variables in excel

20. Friday October 30 - MC: Fitting and generating random variables in excel II

Tuesday November 3 – Dalia and Ali at INFORMS. Eric runs a lab during class time
Syllabus as of 8/28/2015. Please see Sakai for updates.

21. Thursday November 5 - MC: generating correlated random variables in excel

22. Tuesday November 10: Simulating wind power
Markov Chain Monte Carlo Simulation
   • OR22- MCMC for wind power simulation.pdf (Papaefthymiou et. al (2008). MCMC for Wind Power Simulation)

23. Thursday November 12: Simulating wind power II
Markov Chain Monte Carlo Simulation
   Friday November 13: Quiz on all material covered until November 5

24. Tuesday November 17 - Fitting and generating random variables using @risk

25. Thursday November 19 - Intro to optimization under uncertainty

26. Tuesday November 24 - Optimization under uncertainty II - stochastic programming
   • OR26-China’s coal and electricity delivery system.pdf (Kuby et. al (1995), Planning China’s Coal and Electricity Delivery System. Interfaces. pp. 41-68)

Other interesting readings, on dynamic systems and Stella: