



Department At A Glance

DEPARTMENT CHAIR

Prof. Peter Schlosser
842C Mudd, (212) 854-0306
schlosser@ldeo.columbia.edu

GRADUATE PROGRAMS COMMITTEE

Prof. Gentine (Chair), Prof. Duby,
Prof. Farrauto, Prof. Themelis
(MS Program)

DEPARTMENTAL ADMINISTRATOR

Anna Kovács
918A Mudd, (212) 854-7065
ak3421@columbia.edu

ADMINISTRATIVE ASSISTANT

Elizabeth Allende
918 Mudd, (212) 854-2905
ea2516@columbia.edu

BUSINESS MANAGER

Marietta Bell
918B Mudd, (212) 854-0015
mb2258@columbia.edu

FINANCIAL ASSISTANT

Karen Del Aguila
918 Mudd, (212) 854-3724
kd2552@columbia.edu

Laboratory Supervisor

Hong Yuan
926A Mudd, (212) 854-0017
hy2176@columbia.edu

ON EARTH: YOUR GUIDE TO EARTH AND ENVIRONMENTAL ENGINEERING

WELCOME **NEW GRADUATE STUDENTS!!**

M.S. Students

Michael Liang
Anthony Armao
Chen Zhang

Vasileios Foivo Axiotis

Ph.D Students

Shuoxun Wang
Dongping Song

UPCOMING EVENTS

IMPORTANT:

EAEE SEMINAR SERIES FRIDAYS FROM 10:10a-11:25a.

ALL GRADUATES MUST ATTEND THE SEMINARS AS PART OF THEIR CURICUULUM.

A full schedule of the seminar series will be made available on the website—www.eee.columbia.edu and click on the Upcoming Events tab on the side panel.
If you have any questions about the seminar series, please contact Dr. Yip at nyy2002@columbia.edu.

THE DEPARTMENT OF EARTH AND ENVIRONMENTAL ENGINEERING

**COLUMBIA | ENGINEERING**
The Fu Foundation School of Engineering and Applied Science

ACADEMIC CALENDAR

Spring Term 2016

Monday, Jan. 18– Martin Luther King Jr. Birthday Observed - University Holiday

Tuesday, Jan. 19– First Day of Classes

Friday, Jan. 29- End of Change of Program Period, Last Day to Add Class, Last Day to Receive Tuition Refund for Class Dropped

Wednesday, Feb. 10- February Degrees Conferred

Monday, March 7– Midterm Date

Monday, March 14 - Friday, March 18– Spring Recess

Thursday, March 24- Last Day to Drop Class: Architecture, Business, Global Programs, Journalism, SEAS graduate and under-graduates, Social Work. Last Day to Pass/Fail

Monday, May 2– Last Day of Classes

Tuesday, May 3 - Thursday, May 5– Study Days

Friday, May 6– Senior Design Project

Friday, May 6 - Friday, May 13– Final Examinations

Wednesday, May 18– Commencement

Degree Requirements and Courses in our Department

All students must consult a member of the faculty about specific course selection as each student's degree trajectory will be slightly different

Degree requirements for each program can be found in the SEAS Bulletin 2015-2016, pages 119-132. A hard copy of the bulletin can be found in the main office, Room 918 Mudd or at the link below:

<http://bulletin.engineering.columbia.edu/>

Graduate Advisors

An individual advisor must be chosen during the first term of study. If you do not yet have an advisor you can read up on the various faculty research interest on pages 4-6. Once you find a faculty member whose research aligns with your interests, you can meet with them and request that they be your advisor and approve your course schedule.

Brief Overview of Graduate Requirements

Master of Science (M.S.)

At least 30 points (letter grade) of graduate coursework are required. Depending on your background, you may also need to take some undergraduate level courses to bone up on the basics.

EAAE MS candidates have three options:

To take 24 points in the form of lecture courses recommended by the Department (see a later section of this document) plus 6 points in the form of research (EAAE E9721) culminating in a Master's Thesis consisting of original, publication-quality research. Their thesis will be published on the web page of their research group and enrich their professional dossier.

To take 27 points in the form of lecture courses plus 3 points of research (EAAE E9272) by arranging with a member of the faculty to assist in ongoing analytical or experimental research and write a Term Paper describing their part in that research. A 3-point report may be accepted in case of candidates for some joint degree (e.g., MS/MBA).

With permission of their faculty advisor, to take 30 points in the form of lecture courses recommended by the Department.

M.S. candidates may select one of the following three concentrations within the M.S. degree program:

- Water Resources and Climate Risks
- Sustainable Energy
- Sustainable Waste Management

Alternatively, you may be able to design your own concentration around a specific interest, but be sure it is approved by your faculty advisor.

For questions relating to M.S. thesis, please contact Prof. Nickolas Themelis (njt1@columbia.edu)

Doctoral Degree: Eng. Sc. D. and Ph.D (Directly from the Bulletin)

Two doctoral degrees in engineering are offered by the University: the Doctor of Engineering Science administered by the Fu Foundation School of Engineering and Applied Science, and the Doctor of Philosophy, administered by the Graduate School of Arts and Sciences. The Eng. Sc.D and Ph.D programs have identical academic requirements with regards to courses, thesis and examinations, but differ in residence requirements and in certain administrative details.

A student must obtain the master's degree (M.S.) before enrolling as a candidate for either the Ph.D. or Eng. Sc. D degree. Application for admission as a doctoral candidate may be made while a student is enrolled as a master's degree candidate. The minimum requirement in course work for either doctoral degree is 60 points of credit beyond the bachelor's degree.

Candidates for the Ph.D. degree must register full time and complete six Residence Units. A master's degree from an accredited institution may be accepted in the form of advanced standing as the equivalent of one year of residence (30 points of credit or two Residence Units) for either doctoral degree. An application for advanced standing must be completed during the first semester of study. Candidates for the Eng.Sc.D. degree must (in addition to the 60-point requirement) accumulate 12 points of credit in the departmental course E9800: Doctoral research instruction. A holder of the professional degree who wishes to continue work toward the Eng.Sc.D. degree will be required to complete not less than 30 additional points of credit in residence. All doctoral programs are subject to review by the Committee on Instruction of the School. In no case will more than 15 points of credit be approved for the dissertation and research and studies directly connected therewith without special approval by this Committee. Normally, a doctoral candidate specializes in a field of interest acceptable to a department of the School.

For more information on proceeding with the dissertation, please visit the Graduate School for Arts and Sciences' Dissertation Office's website at <http://gsas.columbia.edu/dissertations>

Master of Science in Earth and Environmental Engineering Concentration in Water Resources and Climate Risks

Scope:

Climate induced risk is a significant component of decision making for the planning, design and operation of Water Resource Systems, and related sectors such as Energy, Health, Agriculture, Ecological Resource, and Natural Hazards Control. Climatic uncertainties can be broadly classified into two areas – (1) those related to anthropogenic climate change; (2) those related to seasonal to century scale natural variations. The climate change issues impact the design of physical, social and financial infrastructure systems to support the sectors listed above. The climate variability and predictability issues impact systems operation, and hence design. The goal of the MS Concentration in *Water Resources and Climate Risks* is to provide (1) a capacity for understanding and quantifying the projections for climate change and variability in the context of decisions for water resources and related sectors of impact; and (2) skills for integrated risk assessment and management for operations and design, as well as for regional policy analysis and management. Specific areas of interest include:

- Numerical and statistical modeling of global and regional climate systems and attendant uncertainties
- Methods for forecasting seasonal to interannual climate variations and their sectoral impacts
- Models for design and operation of water resource systems, considering climate and other uncertainties
- Integrated risk assessment and management across water resources and related sectors

Audience:

The MS Concentration in *Water Resources and Climate Risks* is aimed at professionals working in or interested in careers in the application of quantitative risk management methods in any of the sectors listed above. The program is particularly appropriate for engineers and planners who are interested in continuing education in climate and risk management with an interest in water resources. Employment opportunities are anticipated with Engineering Consultants; Federal, State and Local Resource Management, Environmental Regulation, Hazard Management and Disease Control Agencies; the Insurance and Financial Risk Management Industry; and International Development and Aid Agencies. A complementary degree (Master of Arts in *Climate and Society*) is available through Columbia University for students who are more directly interested in social or planning aspects of climate impacts, and are not quantitatively oriented.

Requirements:

The MS in Earth and Environmental Engineering requires a minimum of 30 credits beyond a Bachelor's degree, preferably in a science or engineering discipline (up to 48 credits may be required to allow for make-up undergraduate courses). Also required is original research culminating in a M.S. Thesis, to which 6 credits are applied. Students typically enroll in two semesters of graduate-level inter-disciplinary coursework in the Fall and Spring Terms, and complete the M.S. Thesis in the Summer Term.

Required Classes:

EAAE E4257y Environmental Data Analysis and Modeling

EAAE E6240x Physical Hydrology

EESC W4404y Regional Climate and Climate Impacts

Master of Science in Earth and Environmental Engineering Concentration in Water Resources and Climate Risks

Electives:

A minimum of 1 class is required from each group below. Selections should be made in consultation with the student's advisor. A suggested program is shown with the courses in bold.

Group A: Data Analysis and Solution Techniques

EAAE E4009	Geographic Information Systems for Resource, Environment, and Infrastructure Management
EAAE E6210	Quantitative Environmental Risk Analysis
APMA E4300	Numerical Methods
STAT W4419	Decision Analysis
STAT W4437	Time Series Analysis
STAT G6101	Statistical Modeling for Data Analysis
IEOR E4004	Introduction to Operations Research: Deterministic Models
IEOR E4007	Optimization Models and Methods for Financial Engineering
IEOR E4106	Introduction to Operations Research: Stochastic Models
EESC W4401x	Quantitative Models of Climate-Sensitive Natural and Human Systems
EESC W4950	Mathematical Methods in the Earth Sciences
EESC G6908	Quantitative Methods of Data Analysis

Group B: Applied Sciences

EAAE E4001	Industrial Ecology of Earth Resources
EAAE E4150	Air Pollution Prevention and Control
EAAE E4160	Solid and Hazardous Waste Management
EAAE E4900	Applied Transport and Chemical Rate Phenomena
EAAE E6240	Physical Hydrology
CIEE E4252	Environmental Engineering
CIEE E4257	Contaminant Transport in Subsurface Systems
APPH E4210	Geophysical Fluid Dynamics
EESC W4030	Climatic Change
EESC W4925	Principles of Physical Oceanography
EESC W4930	Earth's Oceans and Atmosphere
EESC G6921	Atmospheric Dynamics
EESC G6927	Tropical Oceanography
EESC G6928	Tropical Meteorology
EESC G6930	Ocean Dynamics
MSPH P8475	Emerging Infectious Diseases

Group C: Socioeconomic Decision Making

EAAE E4100	Management and Development of Water Systems (alternate years)
EAAE E4361	Economics of Earth Resource Industries (alternate years)
CIEE E4133	Capital Facility Planning and Financing
EESC G4402/3	Integrative Seminar: Managing Climate Variability and Adapting to Climate Change
ECON E4329	Economics of Sustainable Development
ECON W4625	Economics of the Environment
MSPH P8325	Risk Assessment, Management and Communication
MSPH P8380	Urban Environmental Planning: The Basis in Public Health
MSPH P9317	Case Studies in Risk Assessment and Environmental Policy

Master of Science in Earth and Environmental Engineering Concentration in Sustainable Energy

Scope:

Energy and economic well being are tightly coupled. Fossil fuel resources are still plentiful, but access to energy is limited by environmental and economic constraints. A future world population of ten billion people trying to approach the standard of living of the developed nations cannot rely on today's energy technologies and infrastructures without severe environmental impacts. Concerns over climate change and changes in ocean chemistry require reductions in carbon dioxide emissions but most alternatives to conventional fossil fuels, including nuclear energy, are too expensive to fill the gap. Yet, access to clean, cheap energy is critical for providing mineral resources, water, food, housing and transportation.

Building and shaping the energy infrastructure of the 21st century is one of the central tasks for modern engineering. The purpose of the Sustainable Energy Concentration is to expose students to modern energy technologies and infrastructures and to the associated environmental, health and resource limitations. Emphasis will be on energy generation and use technologies that aim to overcome the limits to growth that are experienced today.

Concentration specific classes will sketch out the availability of resources, their geographic distribution, the economic and environmental cost of resource extraction, and avenues for increasing energy utilization efficiency, such as co-generation, district heating and distributed generation of energy. Classes will discuss technologies for efficiency improvement in the generation and consumption sector, energy recovery from solid wastes, alternatives to fossil fuels including solar and wind energy, nuclear fission and fusion, and technologies for addressing the environmental concerns over the use of fossil fuels and nuclear energy. Classes on climate change, air quality and health impacts focus on the consequences of energy use. Policy and its interactions with environmental sciences and energy engineering will be another aspect of the concentration. Additional specialization may consider region-specific energy development.

Audience:

This concentration is aimed at engineers with a minimum background of a BS degree in an engineering discipline. The objective is to gain a better understanding of present day energy infrastructures, their strength and weaknesses and to scope out future technology developments for a world with seemingly insatiable demand for energy. The master degree aims at preparing a new generation of engineering professionals who will be involved with the rebuilding of a world energy infrastructure that today is stretched nearly beyond the limits of its capacity.

The program aims at young engineers and active professionals who see their future in the large and international energy development markets. Since the challenges are global in nature, this program addresses energy infrastructure engineering for all types of economies. Problems facing the industrialized countries, the emerging economies and the poor countries of the world differ substantially and a one size fits all solution is unlikely to work.

Expected employment opportunities are in extractive industries and energy processing companies, such as oil companies, mining industry, power producers, and equipment builders. Employment is also likely to be found in environmental consulting companies, with NGOs interested in environmental and energy issues, as well as local, national and international government agencies. In short, the program aims to educate technology experts for all stakeholders in the development of the energy backbone of society.

Prerequisites and Requirements:

The Master Degree is offered to students with a bachelor degree in engineering or equivalent science background. Candidates with technical strengths in physics, chemistry, chemical, electrical or mechanical engineering are preferred. A total of 30 credits, including a 3-credit research course or a 6-credit thesis, are required.

Any changes should be done in consultation with the student's advisor. For students with a B.S. or a B.A., preferably with a science major, up to 48 points are required to allow for make-up undergraduate courses.

Required courses for Sustainable Energy concentration:

EAAE E4001: Industrial Ecology

EAAE E4550: Catalysis for Emission Control

MECE E4211: Energy: sources and conversion

Master of Science in Earth and Environmental Engineering Concentration in Sustainable Energy

Electives:

A minimum of 1 class is required from each group below. Selections should be made in consultation with the student's advisor. A suggested program is shown with the courses in bold.

Mathematical modeling:

APMA E4300: Numerical Methods

EAAE E6210: Quantitative Environmental risk analysis

EAAE E4257: Environmental Data Analysis and Modeling

Pollution Prevention of Air and Water:

E4150: Air pollution control and prevention

EAAE E4003: Introduction to Aquatic Chemistry

EAAE E4160: Solid and hazardous waste management

EAAE E6212: Carbon Sequestration

EAAE E4302: Carbon Capture

EAAE E4301: Carbon Storage

CIEE E4257: Contaminant transport in subsurface systems

Engineering Sciences

EAAE E4252: Introduction to Surface and Colloid Chemistry

EACH E4560: Particle Technology

EAAE E4900: Applied transport and chemical rate phenomena

MECE E4212: Microelectromechanical systems

Resource Management (optional):

EAAE E4200: Production of Inorganic Materials

EAAE E4361: Economics of Earth resource industries

EAAE E4100: Management and Development of Water Systems

E4980: Urban Environmental Technology and Policy

Health impacts (optional):

P6309: Biochemistry Basic to Environmental Health

P6530: Issues and Approaches in Health Policy

P6700: Introduction to Sociomedical Sciences

Master of Science in Earth and Environmental Engineering Concentration in Sustainable Waste Management (SWM)

Scope:

Humanity generates nearly two billion tons of solid wastes annually. Traditionally, these wastes have been discarded in landfills that have a finite lifetime and then must be replaced by converting greenfields to new landfills. This method is not sustainable because it wastes land and valuable resources and is a major source of greenhouse gases and also of various other pollutants of air and water. The SWM concentration prepares engineers to deal with this major problem by exposing them to environmentally better means for dealing with solid wastes: Waste minimization, recycling, composting, and waste-to-energy via combustion, anaerobic digestion, gasification, or pyrolysis. Students are exposed not only to the technical aspects of sustainable waste management but also to the associated economic, policy, and urban planning issues.

Since the initiation of the Earth and Environmental Engineering program in 1997, there have been over sixty graduate research projects and theses that exemplify the engineering problems that will be encompassed in this concentration:

- Design of an automated materials recovery facility
- Analysis of the bioreactor landfill
- Generation of methane by anaerobic digestion of organic materials
- Design of corrosion inhibitors
- Flocculation modeling
- National factors influencing environmentally conscious waste management
- Analysis formation of dioxins in high temperature processes
- Combination of waste-to-energy and anaerobic digestion
- Application of GIS in siting new WTE facilities
- Corrosion phenomena in WTE combustion chambers
- Mathematical modeling of transport phenomena in a combustion chamber
- Effect of oxygen enrichment on combustion of paper and other types of solid wastes
- Feasibility study and design of a WTE facility for Santiago, Chile

Audience:

The MS Concentration in Sustainable Waste Management is aimed at professionals already working or interested in industry, government or education careers in what has become the most costly sector of urban management. Past graduates have been engaged by engineering firms (e.g., Malcolm Pirnie, GBB, Hydroqual, etc.), government agencies in the U.S. and abroad (e.g., U.S.A.C.E., Federal Energy Commission, Federal Transportation Commission, Ministry of Energy of Chile, Ministry of the Environment of Greece, NYCED, etc.) or continued with higher studies.

Requirements:

A total of 30 credits beyond a Bachelor's degree are required including the 6-credit MS thesis. Students must start work on their thesis project after the first semester of courses. Any changes should be made in consultation with the student's advisor. Guidelines for thesis are described in a later section of this document.

Recommended courses for Sustainable Waste Management concentration (in course numerical order):

EAAE E4001: Industrial Ecology of Earth Resources

EAAE E4004: Physical Processing and Recovery of Solids

EAAE E4009: GIS for Resource, Environment, and Infrastructure Management

Master of Science in Earth and Environmental Engineering Concentration in Sustainable Waste Management (SWM)

The following courses are recommended for this track:

EAAE E4001: Industrial Ecology of Earth Resources
EAAE E4009: Geographic Information Systems (GIS)
EAAE E4011: Industrial Ecology for Manufacturing
EAAE E4150: Air Pollution Prevention and Control
EAAE E4160: Solid and Hazardous Wastes
EAAE E4210: Thermal Processing of Waste and Biomass
EAAE E4550: Catalysis for Emission Control
EAAE E4560: Particle Technology

Any approved SEAS course at the 4000 or higher level may be used to fulfill the elective course requirements. With permission of their advisor, appropriate courses from other departments or schools (e.g., School of International and Public Affairs, Mailman School of Public Health, Graduate School of Arts and Sciences) may be counted towards the degree. Available courses include the following:

Mathematical modeling:

APMA E4300y: Numerical methods
EAAE E4257: Environmental data analysis and modeling
EAAE E6210: Quantitative environmental risk analysis

Pollution prevention of air and water:

EAAE E4003: Introduction to aquatic chemistry
CIEE E4163: Environmental engineering: Wastewater
CIEE E4257: Contaminant transport in subsurface systems
EAAE E4300: Introduction to Carbon Management
EAAE E4301: Carbon Storage
EAAE E4302: Carbon Capture
EAAE E6212: Carbon sequestration

Engineering Sciences:

EAAE E4252: Introduction to surface and colloid chemistry
EAAE E4900: Applied transport and chemical rate phenomena
EAAE E4901: Environmental microbiology

Resource Management:

EAAE E4200: Production of inorganic materials
EAE436J: Economics of Earth resource industries
EAAE E4100: Management and development of water systems
E4980: Urban environmental technology and policy

Health impacts:

P6309: Biochemistry basic to environmental health
P6530: Issues and approaches in health policy
P6700: Introduction to sociomedical sciences

Doctoral Qualifying Examination and Research Proposal

Before the end of your first semester in the doctoral program, you and your advisor need to set up an advisory committee of two or three faculty members. This committee will meet at least once a semester to assess your academic and research progress and to recommend corrective action in case of emerging or existing deficiencies.

You are required to pass a qualifying exam soon after the completion of your first year in the doctoral program (May or December). Next, you will submit and defend your doctoral research proposal before the fourth semester in the program. Submission of the dissertation and thesis defense will follow general university rules.

The **qualifying exam** is an oral exam administered by three faculty members. Your advisor will be a member of the exam committee but will not be the chair. You will be examined on your understanding of fundamentals as they apply to the four general areas of research of the department: water resources, materials processing, energy, and chemical and biochemical processes. There will be no presentations given by the student. It is expected that each question period will last about 20 minutes, of which 15 minutes will be led by the faculty member from the area and the remaining five minutes will be open for questions by all faculty present at the exam. There will be a final period of 20 minutes for general questions. The **proposal defense** will start with 20 min presentation by the candidate followed by an extensive Q&A session. Three faculty members from the EEE department are required for the dissertation committee.

The first step in setting up your exam is to speak to our Administrative Assistant. Information is provided on the front page of this packet.

All EAEE graduate students are expected to have a background equivalent to the required core of our undergraduate program. MS/Ph.D students have an opportunity to make up for any deficiencies during the MS program. In order to prepare for the exam, you will be required to take at least one course in each core area during your first two semesters in the graduate program. Below are listed courses representatives of each specific area.

ENERGY

- EAEE E4001 Industrial Ecology
- EAEE E4550 Catalysis for Emission Control
- MECE E4211 Energy: sources and conversion

WATER RESOURCES

- EAEE E4257y Environmental Data Analysis and Modeling
- EAEE E6240x Physical Hydrology
- EESC W4404y Regional Climate and Climate Impacts

MATERIALS

- CHEE E4252 Introduction to Surface and Colloid Chemistry
- EACH E4560 Particle Technology
- EAEE E4200 Production of Inorganic Material

ENVIRONMENTAL PROCESSES

- EAEE E4257 Environmental Data Analysis and Modeling
- EAEE E4901 Environmental Microbiology
- EAEE E4150 Air Pollution Prevention and Control

EAAE E9271: M.S. Thesis

GUIDELINES FOR WRITING M.S. THESIS IN EARTH AND ENVIRONMENTAL ENGINEERING, COLUMBIA UNIVERSITY

As specified in the SEAS Bulletin, “EEE M.S. Candidates are required to carry out a research project and write a master’s thesis on it”. The following Guidelines are to assist you in conducting this very important part of your MS-EAAE degree. M.S. Theses are published on the EAAE Research Centers web and can be a big plus on your CV. Many high quality theses are also published as technical papers, co-authored by the M.S. candidate and his/her advisor.

SUBJECT: What will be the subject? In consultation with your advisor select a subject of intense interest to you. Something you will work on not only because it is part of your M.S. degree but also as a favorite hobby.

TITLE: Write the title, no matter how crude it is at the beginning, it can be improved later. The same goes for everything else below. It is better to put something imperfect down in writing then have the perfect concept in your head and maybe forget it later. Make the title short but informative; it should express the specific thing you plan to work on.

PLAN STATEMENT: Write a very preliminary statement (less than one page) that explains in brief and clear sentences:

- 1.) Why do you think it is useful to carry out such a project: Gap in knowledge? Environmental problem that needs more investigation? Problem in the future that we should prepare for? Think and express some good reasons for undertaking this work
- 2.) Objectives of the research project (so as to meet the above need); this is something like an expanded title of your project
- 3.) HOW you plan to go about attaining the objectives of the project and WHAT resources you plan to use: Literature review? Experiments? The web? Visits? Calculations? Physical or mathematical modeling? Etc., etc. Remember that a plan is made to be changed with time and as new information comes in. The fact that there will be changes and that the plan is based on very preliminary information does not mean that you shouldn’t put down a plan at the very beginning of your undertaking.
- 4.) Scheduling of the above activities and also dovetailing them with courses you have to take, time you want off to visit family, date you want to graduate, etc.

SUBMIT PLAN TO YOUR ADVISOR FOR COMMENT. CONSENSUS TO BE REACHED WITH ADVISOR RE SUBJECT AND PLAN OF WORK

5. EXECUTION OF PLAN:

You are now ready to proceed with carrying out the plan. As new information is collected, the plan statement changes accordingly, “will do” is changed to “have done” so that by the end of the project, the Plan Statement will change gradually to the “Executive Summary” of your thesis. It is called “Executive Summary” to remind you that it should be as informative, inclusive, easy to read and short as possible. Assume that it will be submitted to the busy head of a research institute or the CEO of a company who has only ten minutes to glance at it and also, “does not suffer fools gladly”.

6. THE MS THESIS

After the Title Page and the Executive Summary, there is a list of Contents, a list of Figures and a list of Tables. You can show "Acknowledgments" to people who helped you getting in the MS program and in the course of your work, including any fellow students who have helped. These are then followed by the "chapters" of your thesis, all numbered sequentially and titled appropriately, such as

1. Introduction or Background Information, 2. Subject A, 2.1 Subtitle, 2.3 Subtitle; 3. Subject B...etc, etc. 6. Discussion of Results, 7. Conclusions and Recommendations, 8. References, and finally any Appendices.

The end result should be something that you can be proud of during your career and include in your CV as one of your technical publications. Some EAEE Research Centers also produce hard copies of M.S.-EAEE Theses.

7. Figures and Tables

Each Figure has a number and a caption shown at the bottom of the Figure. A reference must be given for any Figure that was obtained from some earlier thesis or publication. Don't hesitate to redraw poor reproductions of Figures. If you produced the Figure from the data of someone else, give the reference as "Source: ref. x". Make sure the titles and units of the x and y axis are shown clearly. If there are more than one set of data, give nomenclature either in Figure or in caption between parentheses. For Tables, same guidelines as Figures, except numbers and captions go on top of the Table.

8. References

Any time you mention any numerical facts you should note the source ("experimentally"; "calculated", "(Hackett 1998)", "(2). References to other people's work in text can be noted by name and year (e.g., Hackett 1998) or by number (e.g. 2). Then, under References show the full reference, either as

Hackett 1998: Hackett, J.P. and L.A. Johnson, 1998, paper title, *J. of Waste M'g't*, Vol 42, p.13-18 (1998).

OR

2. Hackett, J.P. and Johnson, L.A. 1998, paper title, *J. of Waste M'g't*, Vol 42, p.13- 18. (1998)

If a different format may be required for a particular journal, your thesis advisor will tell you.

9. General

Do not wait for the very end of your research to start writing the thesis. Start from the very beginning to accumulate in the same computer folder, the title, summary statement and any sections, as you write them, plus the list of references. Write down your ideas even if the first write up is crude and unpolished. Think of your writing as a sculptor: She starts with a piece of clay that, by shaping and reshaping, changes from a lump of clay and little by little becomes the object she wants it to be.

Do not be satisfied with the order and form of a sentence as you wrote it the first time. Read it and re-write it and re-read it till it satisfies you. Do not use superfluous words or sentences, it can be annoying to the readers and they decrease the value of your report. Show a section of your work to a colleague and ask for frank opinion. Bring your report draft to your advisor only after you have done all this and you are satisfied that you have done your level best. She/he will then add their input.

Remember that you have chosen to make your living in a profession where your only direct product will be a report and an oral presentation. The written word offers more opportunities for improving the final product. Therefore, even oral presentations must be well prepared in PowerPoint presentations and notes.

Who Does What: A List of Faculty and Research

William Becker (212) 539-7161 wbecker@hazenandsawyer.com

Adjunct Professor

Physical chemical process, drinking water treatment, wastewater treatment, watershed protection.

Athanasios Bourtsalas ab3129@columbia.edu

Adjunct Assistant Professor

Thermal treatment resource efficiency, industrial ecology, and waste-to-energy.

Kartik Chandran (212) 854-9027 kc2288@columbia.edu

Associate Professor

Environmental microbial ecology, bacterial response to stress and stimuli, applied bacterial genomics in public health, mathematical modeling and optimal experimental design to characterize microbial transformations.

Xi Chen (212) 854-3787 xichen@columbia.edu

Associate Professor

Nanotechnology, biotechnology, energy/environment, and computation, Mechanobiology and molecular biomechanics, Novel nanoporous energy absorption and harvesting materials, Nanomechanics of nanostructures, Nanoindentation theory and experiment, Mechanical self-assembly, Multi-phase solid-fluid interactions, Multi-scale computational mechanics, and Mechanics of thin films and small material structures.

Paul Duby (212) 854-2928 pfd1@columbia.edu

Professor of Mineral Engineering

Electrochemical and hydrometallurgical processes, corrosion of metals, water chemistry, mineral waste treatment and recovery.

Raymond Farinato Raymond.Farinato@kemira.com

Adjunct Professor

Robert Farrauto (212) 854-6390 rf2182@columbia.edu

Professor of Professional Practice

Catalysts for pollution control, catalysts for fuel cells and the hydrogen economy.

Vasilis Fthenakis (516) 344-2830 fthenakis@bnl.gov

Senior Research Scientist, Director for the Center for Life Cycle Analysis

Air pollution & Adjunct Professor

Pierre Gentine, (212) 854 4953, pg2328@columbia.edu

Assistant Professor

Applied mathematics, land-atmosphere interactions, soil-vegetation-transfer-atmosphere models, applications of stochastic processes to hydrology and atmospheric boundary-layer, stochastic rainfall and soil moisture, data-assimilation (filtering) of remote sensing measurements to estimate land-surface variables.

Yuri Gorokhovich (845)365-8970 yg119@columbia.edu

Adjunct Assistant Professor, Associate Research Scientist, CIESIN

Environmental application of Geographic Information Systems.

Upmanu Lall, (212)854-8905 ula2@columbia.edu

Silberstein Professor of Earth and Environmental Engineering and Civil Engineering and Engineering Mechanics, Senior Research Scientist, IRI-CP, & Director of Columbia Water Center

Hydroclimatology, nonlinear dynamics and applied statistics, natural hazards and risk management, water systems management, water technologies for developing countries.

Klaus Lackner,(212) 854-0304 kl2010@columbia.edu

Adjunct Senior Research Scientist and Adjunct Professor

Carbon management, alternative fuels and energy management, fluid mechanics and transport processes, applied physics.

Wade McGillis (212) 854-7441 wrm2102@columbia.edu

Adjunct Associate Professor

Water and land surface fluxes; global carbon cycle; air, water, and land quality observational techniques.

Who Does What: A List of Faculty and Research

Christoph Meinrenken (212) 854-5194 cjm2177@columbia.edu

Adjunct Assistant Professor

Sustainable energy research, with focus area computer modeling and system's/feasibility analysis, ranging from Life Cycle Analysis to synthetic fuels and electric vehicle propulsion.

D. R. Nagaraj, (203) 321-2793 d.r.nagaraj@cytec.com

Adjunct Professor

Flotation, hydrometallurgy and solvent extraction, metal complexation and effluent treatment, reagent-mineral interactions, applied surface and colloid chemistry, water soluble polymers, applied electrochemistry.

Ismail C. Noyan, (212) 854-8919 icn2@columbia.edu

Professor

Characterization and modeling of mechanical and micromechanical deformation; residual stress analysis and nondestructive testing; x-ray and neutron diffraction, microdiffraction analysis, materials science, Applied Physics and Applied Mathematics.

A.-H. Alissa Park (212.854-8989) ap2622@columbia.edu

Lenfest Associate Professor in Applied Climate Science & Director of Lenfest Center for Sustainable Energy

Carbon sequestration, clean fossil energy conversion, alternative energy production, particle technology, electrostatic tomography, multiphase flow systems.

Sri Rangarajan (212) 854-7441 srangarajan@hydroqual.com

Adjunct Assistant Professor

Urban wet weather flow management, watershed hydrology, water resource management, and water quality management.

Peter Schlosser (212) 854-0306; (845)365-8707 schlosser@ldeo.columbia.edu

Department Chair, Maurice Ewing and J. Lamar Worzel Professor of Earth and Environmental Engineering & Professor of Earth and Environmental Sciences

Studies of water movement and its variability in natural systems, ocean/atmosphere gas exchange, reconstruction of paleotemperature records, anthropogenic impact on natural systems.

Ponisseril Somasundaran (212) 854-2926 ps24@columbia.edu

LaVon Duddleson Krumb Professor & Director of C-PASS

Surface and colloid science, nanoparticles (drug/toxics/sensory attributes extraction/release), biosurfaces and biosensors, deposition/dispersion/flotation, enhanced oil and coal recovery, polymer/surfactant/protein interactions, arsenic remediation, waste treatment.

Nickolas J. Themelis (212) 854-2138 njt1@columbia.edu

Stanley-Thompson Professor Emeritus of Chemical Metallurgy, Director, Earth Engineering Center and Waste-To-Energy Research and Technology Council (WTERTC)

Transport phenomena in high temperature processes, energy and material recovery from solid wastes, cogeneration of electricity and heat, industrial ecology.

N.Y. Yip (212) 854-2905 nyy2002@columbia.edu

Assistant Professor

Sustainable production of water and energy, water-energy-environment nexus, osmotically-driven membrane processes, ion-exchange membrane processes, vapor pressure-driven membrane processes, desalination, wastewater treatment and reclamation, salinity energy, low-grade heat conversion, novel membrane technologies.

Tuncel M. Yegulalp (212) 854-2984 yegulalp@columbia.edu

Professor Emeritus of Mining Engineering

Mineral economics, systems analysis using operation research methods, extreme value statistics applications in environmental engineering and earth science, zero-emission power plant modeling and design, CO2 sequestration.

IN THE NEWS...

CURRICULUM CHANGES

EAAE E4900 Applied Transport and Chemical Rate Phenomena offered by Dr. Xi Chen is now offered under course number EAAE E3200

GRADUATE STUDENT REPRESENTATIVE OPEN POSITION

We are currently looking for a Graduate Student Representative to lead the EEE graduate student body along with the current representative, Qinghe (Angela) Zheng. Duties include bringing the student body together to maintain a healthy community and relationship with faculty; represent the needs and desires of graduate students in the faculty meetings, and to participate in the planning of student events. This is a great opportunity to get to know the faculty and staff of the EEE department. If you are interested, please email Elizabeth Allende (ea2516@columbia.edu).

THE COLUMBIA WATER CENTER

Under the direction of Prof. Upmanu Lall, Director of the Columbia Water Center (CWC) and the Alan and Carol Silberstein Professor of Engineering at Columbia University, the CWC's current research covers five major research areas; The Global Flood Initiative, America's Water Initiative, Data Science and Multi-Scale Predictions, Risk and Financial Instruments and Water-Food-Energy Nexus. These programmatic initiatives are backed by research on systems level modeling of hydrology, climate, agronomy and economics. The CWC researchers frequently publish their work in journals that focus on hydrology, water resources, climate, physics, applied mathematics and statistics, development, policy and management science and engage in high level public and scientific discussion through the media, the World Economic Forum, and with governments, foundations, development banks, and corporations interested in sustainability.

Over the summer, the team at the CWC has been busy conducting research, mentoring interns, and preparing for another exciting year. A few notable mentions include:

The Center was founded in 2008 with a \$6 million grant from the PepsiCo Foundation to research and develop water sustainability initiatives in India, Brazil, Mali, and China. This project team reached their original objectives by the grant's end date, June 2013, and positively affected millions of people on a global level. In January 2014, a couple of new projects, also funded by the PepsiCo Foundation, will research innovations in sustainable agriculture and water management practices to enhance the health and income of rural populations in Brazil and Peru.

The Aquanauts student group and internship program is made up of an interdisciplinary group of undergraduate and graduate students that focus research efforts on creative and effective solutions to global water issues. To learn about this summer's research projects and how to get involved, please check out the Aquanauts' webpage on the CWC's website

The Certificate in Sustainable Water Management - offered through the Earth Institute / School of Continuing Education - is a new program that equips professionals with the skills to conduct integrated water management and water systems analysis. To learn about the courses offered through this program, please visit the website at <http://www.earth.columbia.edu/articles/view/3033>

Please connect with us on Facebook, <http://www.facebook.com/pages/Columbia-Water-Center/90696088246>, Twitter, @columbiawater, and visit our website, www.water.columbia.edu, to learn about the Water Center's work, read water-related news stories, sign up to receive our newsletter, and find publications from the Water Center staff.

CENTERS IN THE EARTH & ENVIRONMENTAL ENGINEERING DEPARTMENT**CENTER FOR LIFE CYCLE ANALYSIS**

Vasilis Fthenakis—Director

926 S.W. Mudd

Phone: 212.854.8885

Fax: 212.854.7081

Email: vmf5@columbia.edu

Website: <http://www.seas.columbia.edu/cica>

COLUMBIA WATER CENTER—COLUMBIA EARTH INSTITUTE

Upmanu Lall—Director

Margo Weiss—Director of Admissions

Lisa Mucciaccito—Program Coordinator

842A S.W. Mudd

Phone: 212.854.1694

Fax: 212.854.7081

Website: <http://www.water.columbia.edu>

INDUSTRY/UNIVERSITY CENTER FOR SURFACTANTS

Ponisseril Somasundaran—Director

Janet Thomas—Administrative Coordinator

905 S.W. Mudd

Phone: 212.854.8812 or 212.854.2926

Fax: 212.854.7081

Website: <http://www.columbia.edu/cu/iucrc/index.html>

LENFEST CENTER FOR SUSTAINABLE ENERGY—COLUMBIA EARTH INSTITUTE

Ah-Hyung (Alissa) Park—Director

1038 S.W. Mudd

Phone: 212.851.0241

Fax: 212.854.7081

Website: <http://www.energy.columbia.edu>

WASTE-TO-ENERGY RESEARCH AND TECHNOLOGY COUNCIL

Nickolas Themelis—Director

926 S.W. Mudd

Phone: 212.854.2905

Fax: 212.854.7081

Website: <http://www.columbia.edu/cu/wtert>

THE LENFEST CENTER FOR SUSTAINABLE ENERGY

Mission:

The mission of the Lenfest Center for Sustainable Energy (LCSE) is to develop innovative technologies to ensure a sufficient supply of environmentally sustainable energy for all humanity. LCSE searches for sustainable energy solutions to satisfy the world's future energy needs without threatening to destabilize the Earth's natural systems. Our interdisciplinary systems approach allows us to frame our work in a larger context by blending research in technology, policy, environment, and economics with education and public outreach. We seek solutions that will satisfy increasing demands for energy while reducing environmental footprints.

Example Research Projects:

Carbon Capture and Utilization. LCSE researchers have recently developed a novel membrane for the separation of carbon dioxide (CO₂) from other flue gases for high-efficiency energy conversion systems and more effective CO₂ capture in power plants. We are also developing technology to extract carbon dioxide directly from the air. When combined with carbon sequestration, air capture could support transition to renewable energy sources by decreasing the environmental impact of fossil fuels and by providing an efficient means to convert the captured CO₂ into carbon-neutral synthetic fuels.

Carbon Storage. LCSE researchers are researching geologic carbon storage in collaboration with Lamont-Doherty Earth Observatory, Barnard College, and Rutgers University. The project aims to develop an innovative tagging and laser-based detection system which will improve public trust in the reality, safety, and permanence of geologic storage. While geologic storage is considered the most economical method of carbon sequestration, mineral carbonation is relatively new and less-explored. LCSE's mineralization research has the potential to permanently and safely store CO₂ into a solid, fixing it in a stable form that will not leak or deteriorate.

Scales and Systems. Power generation facilities have traditionally been characterized by large installations, long lifetimes, and substantial capital commitments. Smaller units that are mass-produced, modular, and automated represent a new approach in energy production and conversion that could lead to a more nimble energy infrastructure. LCSE researchers are testing these scaling laws by modeling the viability and cost-saving potential of producing liquid hydrocarbons from synthesis gas in small-scale reactors. They are also investigating a new wind energy system using small-scale automated turbines.

Advanced Fuel Concepts. We can alleviate dependencies on fossil fuels by developing sustainable, compact energy conversion systems that produce hydrogen and electricity from various biomass and municipal solid waste streams. When combined with air capture, such a system would be carbon negative. LCSE researchers are also working on a system to utilize non-fossil energy sources to recycle captured CO₂ to produce carbon-neutral liquid fuels that can be directly substituted into the existing infrastructure.

Energy Storage. Energy storage can allow sustainable energy technologies to complement and potentially displace traditional energy technologies. Working with Denmark's DTU Department of Energy Conversion, we study the feasibility of long-term electricity storage in liquid hydrocarbons via reversible, grid-level fuel cells. At building level, we analyze technologies and utility tariffs to design smart building control systems to reduce energy purchased during peak hours, taking advantage of lower rates at non-peak hours and storing the energy for later use.

Lifecycle Analysis. The LCSE is partnering with PepsiCo to develop carbon reduction initiatives for a wide range of PepsiCo products in collaboration with industry and standardization groups. The objective of this initiative is to develop methodologies to measure the carbon footprint for PepsiCo's products, facilitate climate-conscious purchasing behavior for consumers, and identify modifications to reduce carbon intensity for manufacturers and suppliers.

For further information about LCSE projects or to learn how to partner with us, please visit: www.energy.columbia.edu

SAFETY FIRST

Laboratories can be dangerous places. Everyone planning to work inside or otherwise occupy a laboratory must receive Laboratory Safety and Hazardous Waste Management Training before beginning work.

INITIAL TRAINING

The initial training must be the live or classroom version that is offered by the Environmental Health & Safety Office on a monthly basis. Training may be received at the Morningside or Medical Center campus. The training schedule is available <http://www.ehs.columbia.edu/TrainingSchedule.html>.

Other, more specialized training courses may also be required. Please consult your principal investigator for specifics **prior to working in the lab**. A helpful matrix for determining your training requirements can be found attached.

If extenuating circumstances prevent you from attending the regularly scheduled training sessions, please contact Ms. Hong Yuan, Laboratory Supervisor. Ms. Yuan will assist you with alternate arrangements.

Hong Yuan
Laboratory Supervisor
926A Mudd
212.854.0017
hy2176@columbia.edu

After your training is completed, forward a copy of your training certificate to Ms. Yuan. Your training certificate may be printed through the Research Compliance and Administration System (RASCAL) found on the university website.

REFRESHER TRAINING

Laboratory Safety and Hazardous Waste Management Training **must** be refreshed **every two years**. The refresher can be taken in the live, classroom session or online through RASCAL. The choice is yours.

Other, more specialized courses may have varying refresher requirements. Please see the attached training requirements matrix for details.

SAFETY INFORMATION

For more safety information, please be sure to visit the Environmental Health & Safety Website:
<http://www.ehs.columbia.edu>

LAB SAFETY TIPS

1. Use the chemical storage areas. If you remove a chemical from the cabinet or shelf, please be sure that it is returned. Store your flammable chemicals in a flammable storage cabinet. Store your corrosive chemicals in secondary containment, like a bottle carrier or plastic storage container.
2. Please use good housekeeping practices. Keep your work areas neat and clean. Do not clutter the benches with chemicals, hazardous waste containers, or other equipment that you aren't using.
3. Educate yourself before using chemicals. Locate and read the Material Safety Data Sheet (MSDS) to become familiar with a chemical's hazards and how to protect yourself. MSDS are available through the Environmental Health & Safety website, or by searching the internet.
4. Follow the [5 L's of waste collection](#). Collect all of your hazardous waste in a chemically compatible container. Properly fill out the orange hazardous waste labels with full chemical names (no abbreviations!) and amounts. If you are not actively filling a hazardous waste container, the container must be kept CLOSED; parafilm wax, aluminum foil, and funnels are NOT acceptable lids! When the container is near 90% full, fill out a chemical waste pickup request at this website: <http://vesta.cumc.columbia.edu/ehs/wastepickup/>. **NEVER POUR ANYTHING DOWN THE DRAIN!**
5. The cardboard broken glass containers are for clean, recyclable glass ONLY. Never place chemically contaminated glass, vials with liquid or chemical bottles in this container.
6. Empty chemical bottles must be placed in the yellow bins in the hallway. DO NOT break the bottles when you deposit them in the yellow bin. The bottles must be [rinsed](#) before disposal. If the chemical is acutely toxic (The bottle will have a pink sticker on it), pyrophoric or water reactive, the bottle must be treated as a hazardous waste.
7. Keep incompatible chemicals separated. Store your chemicals by compatibility, not alphabetically! Do not mix incompatible wastes, such as acids and bases, in the same hazardous waste container they can react and cause the container to be damaged or even explode.
8. You should contact Maytal Rand, Research Safety Specialist, with questions about lab safety and hazardous waste.
Kathy Somers, MPH
Senior Research Safety Specialist
212.854.8749
kmh2191@columbia.edu
9. Hydrofluoric acid cannot be ordered until you have a Hydrofluoric acid safety training certificate, Calcium Gluconate First Aid Gel and approval from lab supervisor – Ms. Hong Yuan.
10. **In an emergency, please contact with EH&R department 212- 854-8749 (9:00AM -5:00PM, M-F) or Public Safety Department 212-854-5555 (anytime) right away. Also, please alert Hong Yuan.**

ESSENTIAL LAB RULES

No eating or drinking allowed

No sandals, shorts, or skirts allowed

Remove gloves before leaving the lab

Never dump waste into a sink even if the solution is nontoxic

Before starting an experiment, all waste containers must be labeled with the following:

Full chemical name (not an abbreviation or formula)

Room number

Phone number

Label wash-bottles and all other containers, even if they contain water.

Acid bottles should be put into plastic containers or safety bottles. Nitric acid (oxidizer) should never be stored near flammable /combustible materials, such as acetic acid.

Flammable gas cylinders and oxidizing gas cylinders storage separation distances must be 25'. Flammable gas cylinders cannot be stored or used in the basement labs.

Never put flammable chemicals in a regular refrigerator. Flammable chemicals should only be stored in the "explosion proof" refrigerator, Located in 906 Mudd

Do not obstruct walkways in the lab.

Update your safety training online every two years. <https://www.rascal.columbia.edu/>

You must clean your working area, label the wastes, and fill waste pick up request online when you are finished working in the lab.

Please clean up after yourself.

Thank you for your cooperation!

PROFESSIONAL ORGANIZATIONS

You may find it interesting and profitable to associate with others in your field in an organized fashion. Here are a few suggestions for professional organizations to consider joining:

The American Geophysical Union (AGU) - www.agu.org

Society for Mining, Metallurgy and Exploration (SME), Environmental Division—www.smenet.org

American Academy of Environmental Engineers (AAEE) - www.aaee.org

American Society of Mechanical Engineers—www.asme.org

American Institute of Chemical Engineers—www.aiche.org

FOOD

The EAEE has a pantry set up in 915 S.W. Mudd (located between the bathrooms). A refrigerator is available for all faculty and students to use. You are responsible for cleaning the pantry. **Any food left in the pantry will be disposed of every Friday.**

CAMPUS MAP

