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Course Syllabus – DRAFT
VERSION 1.2

ISEN 411: Quantitative Tools for Energy and Sustainability (0.5 credit)

Northwestern University

Instructors:
Target – Jennifer Dunn
https://www.mccormick.northwestern.edu/research-faculty/directory/affiliated/Dunn-Jennifer.html

Office Hours: By appointment
Class Room: TBD
Class Timing: Winter Quarter, MSES Core Course (5 weeks)

Course Synopsis: This course aims to provide a broad overview of the widely used quantitative tools in energy and sustainability. Using a case-based and problem-set centered focus, this course will explore tools such as risk assessment and social justice metrics. Additionally, this course will delve into issues surrounding greenhouse gas quantification, discussing the core quantitative methods for measuring emissions while also touching on protocol and policy frameworks that enable the application and verification of these measurements.

Course Goals:

- **Overview of Common Quantitative Tools**: The course will introduce key metrics associated with quantifying environmental impact & sustainability including but not limited to Economic, Environment and Social measures.
- **Developing Quantitative Capabilities**: Students will learn and apply quantitative concepts to real-world situations. Use of cases and problem sets will offer students a chance to exercise the theories using real data.
- **Understanding GHG Reporting Protocols and Processes**: While there are many measures to consider, greenhouse gases (GHG) will be the primary area of focus in this course. By looking at frameworks from the EPA, IPCC and the GHG Protocol, students will learn the varied protocols that govern GHG reporting. By touching on firms such as the CDP and GRI, students will also learn about the growing market for disclosures and its importance.
- **Applying Quantitative Tools**: In addition to focus on what to measure and how to measure it, students will be engaged in conversations about how to engage stakeholders who are at various levels of their journey in sustainability measurement.

Grading/Assessment:

Grading will be based on the following rubric:

Component	Weight	Details	Due
Effort and Attendance	15%	Effort will be graded through attendance, class participation and pop quizzes on the readings for the day. This ensures that the readings are done and that students are engaged in work outside the classroom.	-
Quiz	30%	Conventional in class quiz based on the content. These will be declared beforehand and will focus on the theoretical frameworks explored in class. Questions may include definitions, analyses and multiple-choice responses. Questions may be asked from the required readings.	Week #3 Week #4
Problem Sets	20%	Students will be provided with a problem set and relevant information/sources to quantify the economic, social and environmental costs and benefits of a specified sustainability solution and will be asked to recommend an optimal implementation strategy weighing the relative costs and benefits. Students should complete the problem sets individually.	Week #1 Week #2
Final Research Paper	35%	Students will work in pairs for this paper. They will select either a corporation or a city (subject to approval by instructor) to focus on. Students will act as consultants—they will propose a viable set of sustainability goals and indicators that their chosen client can achieve by 2025. Proposed goals must be backed up by the application of quantitative tools that have been learnt in the class. Papers that engage seriously with various quantitative tools (from in-class or beyond) and provide convincing arguments will score highly. Papers must be no longer than 8-10 pages. Although the papers will be due in Week 5, students must have formed their pairs and selected their client with the help of their instructor by the end of Week 4.	Week #5

Grading Policy:

- Grades will be assigned based on all the work you have completed during the semester following the traditional practice of A=90-100, B=80-89, C=70-79, D=60-69, F<60.

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Course Readings: (all will be reformatted properly)

Quantitative tools for sustainable food and energy in the food chain

Integrated assessment models of climate change: An incomplete overview

Integrated presentation of ecological risk from multiple stressors

Economic Appraisal of Energy Efficiency in Buildings Using Cost-effectiveness Assessment

Life-cycle preferences over consumption and health: when is cost-effectiveness analysis equivalent to cost–benefit analysis?

EPA Life Cycle Assessment

Global estimates of the value of ecosystems and their services in monetary units

The value of the world's ecosystem services and natural capital

DICE/RICE Model for Cost-Benefit Integrated Assessment Modelling

IMAGE Model for Process-Based Integrated Assessment Modelling

The Use and Misuse of Models for Climate Policy (Critique of IAMs)

Assessing the State of Environmental Justice in Michigan

EPA Environmental Justice Quantification Guidelines

European Union Sustainability Impact Assessment (SIA) Tools

EPA FLIGHT Tool

IPCC Metrics Guide

Water Sustainability and Scarcity Metrics

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CLASS OUTLINE

Weekly Topic	Description
1: Introduction to Quantitative Tools & Economic Measures	● Introduction and course logistics ● Review of the UN Sustainable Development Goals. What are some of the key things we are measuring? Brief recap of six key greenhouse gases as per Kyoto Protocol being measured (CO_2, CH_4, N_2O, HFCs, PFCs and sulphur hexafluoride). ● Overview of types of quantitative measures ○ Economics / Risk ○ Environment ○ Social ● Outline of "good / better / best" concept in use of quantitative tools & level of depth ● Who are the important stakeholders in this process? Why is measurement and analysis even necessary? ● Economic Measures ○ Risk Assessment: Basic concepts in standard risk assessment such as annualized loss expectancy, single loss expectancy and annualized rate of occurrence. Extension to sustainability and energy by bringing in ERA (environmental risk assessment), discussing the effects of stressors such as chemicals on the environment. ○ Cost-Benefit Analysis: CBA versus CEA (cost-efficiency analysis). Basic concepts of CBA such as discount rates, sensitivity analysis, net present value. Discussing energy efficiency using CEA, benefits of using this method. **PROBLEM SET #1: Economic Measures**
2: Quantitative Tools - Environmental	● Overview of Environment related measures ○ GHG Emissions ○ Energy ○ Waste & recycling ○ Water ○ Product Content ○ Clean Air & Other ● Types of assessments ○ Life-Cycle Assessment: History with the EPA, procedures for conducting LCAs as per the ISO 14000 series. Well-to-wheel, cradle-to-cradle, cradle-to-grave analyses will be discussed, alongside usage in specific industries/situations. ○ Ecosystem-services valuation: Basic concepts of direct use value, indirect use value, option value, bequest value etc. Linkage to CBA, how the two are used in conjunction. History with the World Bank,

	limitations concerning anthropocentrism, difficulty in quantifying indirect use value. ○ Integrated Assessment models: Process-based IAMs versus Cost-Benefit IAMs. Calculating the social costs of carbon with a cost-benefit IAM, application to taxation policy. Use by the IPCC of process-based IAMs. Limitations of IAMs, Pindyck's critique. **PROBLEM SET #2: Assessment Tools & Environment**
3: Quantitative Tools: Environment (& GHG Deep Dive)	● Environment Measure Deep Dive on GHG: ○ GHG Protocol: Corporate Standard Protocol, understanding differences between scope 1, 2 and 3. Importance of scope 3 and the value chain in today's world, difficulties with scope 3 in particular. ○ EPA's GHG Reporting Program: distinctions between direct-emitting facilities and suppliers, process emissions and fugitive emissions. Oil and gas industry-specific concerns. Who reports to the EPA? Minimum thresholds for reporting. ○ Other GHG Protocol Standards: Product Life Cycle Standards and how they link to Scope 3 standards. GHG Protocol for Cities, intersection with policy frameworks of C40 cities. Mitigation Goal Standard may also be discussed as an example of how emissions reports link to future targets. ○ IPCC and their carbon reporting/calculation methodology: particular focus on transport (not covered in basic EPA framework). **QUIZ #1**
4: Quantitative Tools: Social & Reporting	● Social Measures ○ Health and Safety ○ Human Rights ○ Environmental Justice and Sustainable Impact Assessment ■ EPA tools for environmental justice assessment, brief overview of key components of environmental justice ■ Other measures and uses of EJ ■ EU's usage of SIA tools, analysis of methods used. Potential fields of application, difficulties in quantifying concepts of "justice". Usefulness of qualitative data such as interviews. ● CSR / Quantitative Reports ○ Disclosure Types: CDP, GRI, SASB. ○ Disclosure Stakeholders: Who uses these disclosure standards? Utility to corporates, cities, investors, supply chain. ○ Disclosure Incentives: Why to disclose? • New customer acquisition**,** Lifetime value**,** Employee engagement • Client retention • Recruitment of new employees

	• Corporate reputation/goodwill • Building relationships with a number of key stakeholder groups (e.g., community leaders, clients, investors, partners) • Growing revenue/profitability • Stakeholders, relationship to brand image and the broader market for disclosure. **QUIZ #2** Students must identify a corporation or a city for their final paper with their partner. This must be approved by the instructor by the end of Week #4.
5: Applying Quantitative Tools	● Additional Tools for consideration ○ Macro-Level Analysis: Lawrence Livermore National Laboratory Energy Flow Diagram for the US. How do you read such a diagram? Construction of such diagrams to model smaller scale processes such as energy usage of a single corporation or industry. ○ Levelized Cost of Electricity: Cost calculation under LCOE, limitations with respect to dispatchability and availability profile of market demand. ● Challenges & opportunities in utilizing quantitative tools ● How to engage stakeholders on quantitative measures ● Discuss potential models of "good / better / best" in use of quantitative tools ● Overview of types of quantitative measures ○ Economics ■ Value at Risk ($) ■ Probability (%) ○ Environment ■ Energy Intensity ■ GHG Emissions ■ Water Use ■ Waste / Recycling ■ Product Content (renewable, recycled) ○ Social ■ Health & Safety Policies ■ Human Rights Policies ■ Safety Incidents ● Tools & techniques for implementing / utilizing quantitative tools ○ Stakeholder engagement ○ Practical tools **FINAL PAPER DUE**