Course Syllabus for ECS568S – Integrated Assessment Modeling

Overview and Objectives

The United States is at an energy crossroads. From 2009 to 2022, the share of electricity produced from coal combustion decreased from 45% to 20%, while the share met by natural gas increased from 23% to 40%. Over the same period, the costs of wind and solar power decreased dramatically, leading to combined market share of 14% in 2022. The transportation sector is also being transformed. Where electric vehicles (EVs) largely were a novelty in 2010, their share of new car sales in 2022 reached nearly 6% nationally. Developments in the buildings sector include broader adoption of LED lightbulbs, hybrid hot water heaters, geothermal heat pumps, and green roofs. This transformation is expected to increase pace, buoyed by state programs such as Renewable Portfolio Standards and federal funding provided by the Bipartisan Infrastructure Law of 2021 and the Inflation Reduction Act of 2022.

These rapid transformations have the potential to provide both environmental opportunities and challenges. Since carbon dioxide and air pollutants are often co-emitted by the same sources, efforts to decarbonize can yield air quality co-benefits. However, some decarbonization pathways can yield local disbenefits by shifting the location of pollution from one economic sector to another or from one location to another. For example, the net emission impacts of EVs are determined by direct impacts (e.g., emission savings in the transportation sector), indirect impacts (e.g., changes in electric sector and refining emissions), and tertiary impacts (e.g., life-cycle emissions and those from energy price-induced fuel switching). Many of these impacts are not stationary in time: gasoline-fueled vehicles are expected to emit less over time as a result of EPA mobile vehicle regulations, and emissions from the electric sector into the future will depend on how the composition of that sector changes.

Integrated Assessment Models provide an avenue for understanding the emissions and environmental impacts of energy transformations. They allow us to examine primary, secondary, and tertiary emission impacts, and to explore different assumptions about factors such as technology development and population and economic growth. They also provide a computational laboratory in which we can examine the efficacy of both existing and potential policies in meeting environmental goals.

The primary objective of this class is to provide students with a hands-on opportunity to use an Integrated Assessment Model – the Global Change Analysis Model with state-level resolution (GCAM-USA) – to examine the air quality and GHG implications of new and emerging energy system technologies and scenarios (http://jgcri.github.io/gcam-doc/). To facilitate the use of GCAM-USA, students will use the GLIMPSE decision support software being developed at EPA (https://epa.gov/glimpse). GLIMPSE provides a user interface for GCAM, which facilitates developing and running scenarios as well as visualizing results.

GLIMPSE framework

GLIMPSE was released to the public in 2023. In 2024, several states used GLIMPSE and/or GCAM-USA in their climate planning efforts. Many additional states have indicated an interest in using GLIMPSE in developing Comprehensive Climate Action Plans that are funded by the IRA.

In addition to states, GLIMPSE users now include faculty and students at nearly a dozen universities, as well as several consultants, environmental non-profits, and financial institutions.

GLIMPSE supports GCAM users in activities including:

- Developing representations of policy goals or measures (e.g., technology market share targets, technology or fuel subsidies, pollutant taxes or caps)
- Constructing and executing scenarios
- Monitoring GCAM progress and assisting with debugging
- Visualizing key model outputs and identifying differences in those outputs from one scenario to another
- Archiving the inputs and outputs associated with particular scenarios

GLIMPSE currently operates on Windows PCs with 16 GB or more of RAM. This course will meet in a computer lab where students can bring their own laptops or use Virtual Computers provided by the university.

Format

This course, which will meet in person, consists of lectures, weekly assignments, and individual or group projects with presentations.

A major component of the course is the project. Students will participate in individual or team projects that will culminate with each team presenting its findings. Topics may include examinations of electric vehicles, renewable electricity, energy efficiency in buildings, environmental implications of bioenergy, or others of interest to students and supported by GLIMPSE.

Past projects have included topics such as:

- NC joining the Regional Greenhouse Gas Initiative
- Comparison of economy-wide and sector-specific GHG caps in California
- Electrification of heavy-duty trucks
- System-wide energy and emission impacts of reduced beef consumption
- Alternative population scenarios that involve migration driven by climate adaptions
- Impact of greater water resources in northern Africa (e.g., through infrastructure expansion)
- GHG mitigation impacts on biomass production and use globally

Instructor

The instructor for this course is Dr. Dan Loughlin, who has been an environmental scientist in the U.S. Environmental Protection Agency's Office of Research and Development for nearly two decades. His specialties include energy system modeling, technology assessment, estimating air pollutant and greenhouse gas emissions for technology and policy scenarios, and sensitivity and uncertainty analyses. Dr. Loughlin leads the GLIMPSE project, the objective of which is to apply an integrated assessment model to support the Agency and states in long-term planning for meeting climate and air quality goals. He has been an adjunct professor at Duke University's Nicholas School of the Environment since 2019. He also holds academic appointments at the North Carolina State University and at University of North Carolina at Chapel Hill.

Grading

- 10% - Class participation, including attendance and participation in discussions
- 20% - Assignments
- 20% - Quizzes
- 50% - Team project and presentation

Lecture topics (subject to change)

- Jan 8 – Wed – Introduction to 568S
- Jan 13 - Mon – GLIMPSE software access/install/demo
- Jan 15 - Wed – Key modeling concepts and terms
- Jan 20 – Mon – No class [Martin Luther King Jr. Holiday]
- Jan 22 - Wed – Integrated Assessment Models
- Jan 27 - Mon – The Global Change Analysis Model
- Jan 29 - Wed – Example application - Setup
- Feb 3 - Mon – Example application - Analysis
- Feb 5 - Wed – Advanced analysis approaches
- Feb 10 - Mon – How does GCAM work?
- Feb 12 - Wed – More on logit / Introduction to class project
- Feb 17 - Mon – Policy levers in GLIMPSE in context of project
- Feb 19 - Wed – In the weeds: Working around the logit
- Feb 24 - Mon – Designing an experiment
- Feb 26 - Wed – Example project
- Mar 3 - Mon – Dos and don'ts when analyzing and presenting scientific data
- Mar 5 - Wed – Special topics: GCAM-USA and climate planning
- Mar 10 – Mon – No class [Spring Break]

- Mar 12 – Wed – No class [Spring Break]
- Mar 17 - Mon – Special topics: IPCC and role of IAMs
- Mar 19 – Wed – Special topics: EMF & inter-model comparisons
- Mar 24 - Mon – Special topics: Exploring health and environmental justice endpoints
- Mar 26 – Wed – Special topics: Guest lecture – Climate planning in for states
- Mar 31 – Mon – Office hours

(remaining schedule may change to accommodate departmental activities)

- Apr 2 – Wed – Office hours
- Apr 14 - Mon – Office hours
- Apr 16 – Wed – Office hours
- Apr 21 - Mon - Project presentations - Day 1
- Apr 23 - Wed - Project presentations - Day 2