Engineering Tripos Part IIB, 4M22: Climite Change Mitigation, 2019-20

Module Leader & Lecturer

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Timing and Structure

Michaelmas term. 14 lectures. Assessment: 100% coursework

Prerequisites

None

Aims

The aims of the course are to:

- The aim of this course is to inspire students to engage with the reality of implementing meaningful climate change mitigation and to equip them with skills to help us achieve more rapid progress. By the end of the course, students should be able to:

Objectives

As specific objectives, by the end of the course students should be able to:

- By the end of the course, students should be able to:
- Give an overview of the scientific and political imperatives for action to mitigate climate change.
- Assess the likely scale of impact of mitigation options, by analysing their technical potential and rates of deployment within the whole system of global emissions.
- Apply frameworks of understanding to anticipate and evaluate likely barriers to the implementation of mitigation options and to propose means to overcome them.
- Present an assessment of a mitigation option as a poster, giving clear and evidence-based analysis of scale and challenges to implementation.

Content

(the word "Outcome" in the descriptions below should be read as "By the end of this lecture, students should be able to…")

Part I: Background and context

1: The physical system of greenhouse gas emissions

Outcome: describe several consistent decompositions of global and national greenhouse gas emissions in order to place specific proposals for mitigation in a global context.

· The greenhouse gases and the definition of a CO_2 equivalent

· The degree of scientific consensus on warming and sources of uncertainty

· Consistent decompositions of the sources of global emissions

· Consistent treatment of interacting mitigation strategies

· Emissions from Agriculture, Forestry and Other Land Uses

· National emissions – production and consumption based views

· The challenge of consistent allocation of emissions to products and activities.

2: The political context of climate mitigation

Outcome: describe the context of climate mitigation with reference to key international treaties and discuss the urgency and scale of change recommended by climate science.

· Brief history of the science of climate change, the difference between annual and accumulated emissions and current recommendations about safe limits

· The formation and terms of reference of the United Nations Framework on Climate Change including the "Conference of the Parties"

· The role and activity of the Intergovernmental Panel on Climate Change

· The role of other international agencies including the International Energy Agency, the World Bank, international trade associations etc.

· Framing of mitigation targets: descriptive v. probabilistic targets; stocks or flows; the end-point or the journey.

· The UK Climate Change act, the role of the Climate Change Committee and the UK's achievement to date.

Targets in other countries and regions and the 2015 Paris Agreement.

Part II: Physical options for mitigation

3. Supply-side options for mitigation: energy sources and conversion

Outcome: describe the main technical options for low carbon energy supply and efficient energy conversion and discuss their technical potential and rate of deployment.

- Nuclear power
- Renewable sources of electricity and other energy
- Carbon Capture and Storage
- Grid inefficiency, intermittency and load balancing: base-loads, storage and timing.
- Energy efficiency of the major devices that convert fuel to useful heat and mechanical work (burners (in industry and buildings), engines and motors (in transport and industry))
- Energy use in industrial processes
- Case study: the hydrogen economy.

4. Demand-side options for mitigation: transport, buildings and industry

Outcome: describe the services by which humans benefit from using energy, suggest how these services can be

delivered differently and discuss the determinants of preference for alternative forms of service delivery.

- Alternative decompositions of the human services delivered by energy use
- The definition of ‘passive systems’ and the range of options for their design – with more or less energy.
- Preferences and path-dependency in determining today’s choices for service delivery
- Service preferences at different stages of economic development.
- Case study: options to reduce the emissions of flying

5. Options for mitigating non-energy related emissions

Outcome: describe the major human uses of biomass and discuss options for reducing the emissions associated with its delivery.

- Human appropriation of biomass and its use in services.
- Efficiency in plant growth and conversion and the delivery of healthy diets.
- Options for alternative delivery of biomass derived services
- Related issues: Biomass waste processes, forest fires, soil quality and desertification

6. Prioritisation: choosing between mitigation options across final services

Outcome: choose appropriate tools that can be used to evaluate mitigation options and apply them to determine the relative merits and limitations of specific options

- Basis for prioritisation: scale of impact; emissions reduction potential; microeconomic cost of emissions savings; macroeconomic consequences of emissions savings; political feasibility
- Methods used for prioritisation (MFA, MRIO, MacKay-style “plans that add up”, cost metrics (MAC, LCE, LACE), energy system models, macroeconomic models, integrated assessment models…) their merits and limitations
- Different notions of cost: macro indicators (GDP relative to baseline); welfare measures (equivalent variation); carbon price required to instigate change, cost if enforced
- Other issues: time horizon, foresight, cost of inaction, distributional implications
- Case study: Carbon Capture and Storage

7: Physical constraints: limits to efficiency improvements and substitution

Outcome: Describe the technical constraints associated with different mitigation options

- Learning curves and improvements towards technical limits and cost reduction for different technologies
- Limits to substitution across factors of production: capital and energy/materials as complements not substitutes.
- Resource requirements for constructing and deploying new technologies
- Energy return on energy invested
- Build rates and geographic constraints for different technologies
- Case study: solar power in the UK

8. Group tutorials 1

In advance of the tutorial, students will (a) prepare a first draft of their assessment poster (based on a template given out in advance) in which they describe the physical mitigation option they are proposing and (b) complete a short feedback form for each other student in the group, with questions about each others' drafts. In groups of 6-8, and facilitated by experienced post-docs, students will then:

- *reflect on the mitigation potential of their proposed mitigation option and discuss and contrast the means they have used to evaluate it*
- *discuss the physical implications and constraints of their implementation and challenge each others' assumptions.*

Poster session

9. Display and review of posters

In advance of this session, each student will submit an individual poster (A3 size) proposing a physical intervention that could be deployed in the UK within 10 years leading to a reduction of at least 0.1% of current annual national emissions. This should cover all physical aspects of the recommendation: the balance of embodied and operational emissions changes; the likely time of deployment; estimates of the major costs and benefits of the change to all key groups affected by it. During the session each student will be allocated three other posters to review, to assess the completeness and plausibility of the proposal on each poster. Afterwards, each student will submit three short peer-review statements (<150 words for each poster) which will also be assessed.

Part III: Barriers to implementation and overcoming them

10. Business constraints: strategy and choices

Outcome: describe the basis by which businesses choose to invest in new assets, products or markets and discuss the development of a new offering from first trial through to widespread adoption

- Governance and the legal constraints placed by shareholders on business managers
- Technology Readiness Levels and the sources of risk in the innovation journey
- Decisions related to input substitutions
- Investment decisions – valuing projects in the face of uncertainty and risk
- Decision making along supply chains including the constraints of previous decisions
- Stranded Assets
- Case study: Electric cars

11. Government constraints: politics and the levers ministers can pull

Outcome: discuss some determinants of political acceptability and describe how these influence policy implementation at national and international scale, contrasted between developing and developed countries; discuss the use of tax, spending, regulation, targets and information options in climate mitigation to date and critically evaluate options to influence the adoption of proposed future mitigation strategies.

- Overview of government economic evaluation – the key metrics of GDP growth, jobs, bills – and their significance as determinants of policy choice
- Overt and covert processes from policy ideas to implementation and the role of 'policy entrepreneurs'
- First mover disadvantages and international policy implementation
- Mitigation policy in countries at different stages of development
- Carbon leakage: risk, rhetoric and perverse incentives
- Competing government objectives: raising the price of energy by taxing emissions, while lowering energy prices for households and large energy using businesses.

- The three-domains framework for understanding environmental policy-making
- Forms of taxation and options to adjust them
- History, variety and evaluation of carbon taxation (and other charges): why it looks like a simple mechanism but has proved problematic
- Opportunities for spending to support mitigation, and the history of spending associated with achieving the sequence of UK Carbon Budgets.
- Forms of regulation and examples of their use to address environmental problems
- The use of targets and information. Behavioural “nudges”
- Case studies: EU vehicle tailpipe emissions standards; renewable heat incentive; congestion charging or the European emissions trading scheme

12. Household constraints: preferences, lifestyles and inequality

Outcome: discuss how individuals and households make the choices that determine their energy requirements

- How the availability of energy changes jobs and spending beyond subsistence; energy as the driver of economic acceleration
- Rebound effects and Jevons’ Paradox
- Personal preferences – from Maslow’s hierarchy, to convenience, luxury, competition and status; stated and unstated preferences
- Values and/or income as the key drivers of choice
- Lock-in – the timing and nature of key decisions that determine subsequent energy use
- Case studies: car clubs, smart meters, loft insulation, low-energy light bulbs

13. Breaking out of inevitable lock-in: decision analysis

Outcome: provide a structured analysis of a mitigation opportunity by showing how design choices determine key performance metrics that are traded off against each other

- Different approaches to understanding the rationale of decision making
- Tools for evaluating trade-offs and informing better heuristics
- The failure of scenario analysis and other abstractions to motivate serious mitigation
- A structured decision analysis tool that places mitigation at the heart of choice
- Case studies: over-use and re-use in construction; small versus electric cars;

14. Breaking out of inevitable lock-in: agendas, quality and alliances

Outcome: describe and discuss wider opportunities to escape the lock-in of established choice between businesses, governments and households.

- Public agendas – how stories, in broadcasting, media and films set the agenda for public discussion ahead of policy interest
- Values and preferences in rich societies. Perceptions of priorities at different life stages
- Creating new alignments and alliances.
- Case studies: catalytic converters, fairtrade coffee; the velodrome at the London Olympics

15. Group tutorials 2

Using a similar format to the first set of group tutorials, students will in advance of the tutorial (a) prepare a bullet-point outline of their individual essay (based on a template given to them) dealing with the barriers to implementation and means to overcome them and (b) complete a short feedback form for each other student in their group. During the session, and facilitated by experienced supervisors, they will:

- *Discuss and challenge their anticipation of the barriers to implementing their proposed mitigation strategy, in business, government and households*
- *Review and brainstorm the options to break lock-in.*

Part IV: Overview, urgency and optimism

16. Action and inaction: where we are today

Outcome: summarise the world and UK response to climate change to date, discuss the relative lack of progress and propose ideas for more rapid progress.

- The preference for “invisible” action – the conspiracy of techno-optimism
- Achievements and failures in mitigation so far in the UK and world-wide
- The failure of GDP, inequality and the Pope
- Fear, societal collapse and mitigation as a problem of health and safety
- Opportunity in crisis: replacement of EU ETS; re-negotiation of trade tariffs; support for industries that are “too big to fail”
- Reasons for optimism
- Case study: steel in Europe.

Assessment

The course is intended to build on a form of ‘problem-based learning’ – by the end of Part II of the course, students will each have chosen a mitigation option that must scale to an equivalent of 0.1% of UK annual emissions within 10 years. This will be the basis of both components of their individual assignment. The remaining lectures present frameworks of understanding and case studies on the challenges of implementing mitigation, which students will apply to their chosen option.

Ahead of session 9, students will submit an A3 poster through Moodle describing all aspects of the physical basis of their proposal, including a summary of the costs and benefits of its adoption for all affected groups. During session 9, students will each complete three individual peer-review reports on three other posters. The posters will be marked based on the assessor’s assessment of the completeness and plausibility of the proposal. The peer reviews will be assessed based on the insights demonstrated.

After the Christmas vacation, students will submit an individual essay of no more than 2000 words providing a complete assessment of their proposal, using appropriate graphics and references to support their case. The essays will be assessed based on their completeness and plausibility, spanning from the physical reality of the recommended change to the depth of insight shown in discussing the reality of its implementation.

Coursework	**Format**
Coursework activity #1 **A3 poster** Learning objective:	Individual Non-anon

Coursework	**Format**
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Coursework activity #2 Peer-review reports on three other posters Learning objective: •	Individual Anonymou
Coursework activity #3 Individual essay Learning objective: •	Individual Anonymou

Examination Guidelines

Please refer to Form & conduct of the examinations [2].

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