COURSE HANDBOOK

2024/2025

MSc Energy Systems

This handbook applies to students starting the MSc Energy Systems in October 2024.

The Examination Regulations relating to this course are available at:
https://examregs.admin.ox.ac.uk/Contents

MSc in Energy Systems (full-time):
https://examregs.admin.ox.ac.uk/Regulation?code=mosbcinenersyst&srchYear=2024&srchTerm=1&year=2024&term=1

MSc in Energy Systems (part-time):
https://examregs.admin.ox.ac.uk/Regulation?code=mosbcienersyst-p-t&srchYear=2024&srchTerm=1&year=2024&term=1

If there is a conflict between information in this handbook and the Examination Regulations, then you should follow the Examination Regulations. If you have any queries, please contact mscprogrammes@eng.ox.ac.uk.

The information in this handbook is accurate as of 9 October 2024 however, it may be necessary to make changes in course provision. For more information, please visit https://www.ox.ac.uk/admissions/graduate/courses/changes-to-courses.

MSc Energy Systems
2024: version 1.0

For the latest version of this handbook, please see https://www.eng.ox.ac.uk/mscenergy/.

Contents

1. Introduction

We are delighted to welcome you to the MSc in Energy Systems course.

The transition of worldwide energy systems towards cleaner sources is one of the biggest challenges of the twenty-first century. We aim to equip you with the best possible appreciation of the complex issues facing the development of energy systems, to ensure that industry and government policies can address these challenges most effectively.

The University of Oxford is recognised as a leader in interdisciplinary energy research, nationally and globally. The creation of the Oxford Energy Network (www.energy.ox.ac.uk) has brought together some 200 energy researchers from 19 departments and institutions from across the university.

In this multi-disciplinary course, you will be taught by energy researchers from across the University of Oxford, including academics in the departments of Engineering Science (the admitting department for the course), Physics, Materials Science, Chemistry, Economics, International Development, and the School of Geography and the Environment. Together the research carried out by these departments addresses the major technical, social, economic and policy challenges of providing secure, affordable and sustainable energy for all. We additionally engage with small and large energy companies, government agencies and NGOs around the world. Major industrial collaborators include BBOXX, Bosch, BP, British Gas, EDF, E.ON, Jaguar Land Rover, Johnson Matthey, KETEP, Mitsubishi Heavy Industries, National Grid, Nissan, Rolls-Royce, Samsung, Shell, Siemens, SSE, Statoil, and UK Power Networks.

We hope that you will be very happy at the University of Oxford, and that you will flourish academically and personally during your time here. The collegiate University provides a diverse range of opportunities to learn new skills, and we encourage you to make the most of what we offer. I trust that you will become active participants and engage with the many events and activities that we host.

Professor David Wallom
Course Director

Professor Sarah Sparrow
Deputy Course Director

1.1 Important dates

2024-2025 Academic Year

Monday 7 October 2024	Departmental Induction
Sunday 13 October	Start of Michaelmas Term
Friday 29 November	R1. Energy Sources assignment deadline
Saturday 7 December	End of Michaelmas Term
Friday 20 December	Sy1. Energy Infrastructure assignment deadline
Friday 3 January 2025	Se1. Energy Demand assignment deadline
Friday 10 January	R2. Energy Conversion 1 assignment deadline
Sunday 19 January	Start of Hilary Term
Friday 28 February	Sy2. Energy for Development assignment deadline
Friday 7 March	Se2. Energy and Society assignment deadline
Saturday 15 March	End of Hilary Term
Friday 21 March	R3. Energy Conversion 2 assignment deadline
Friday 28 March	Sy3. Digitization, Smart Energy and Communication assignment deadline
Friday 11 April	Sy4. Energy Systems: Economics and Markets assignment deadline
Friday 18 April	Se3. Energy Policy and Governance assignment deadline
Sunday 27 April	Start of Trinity Term
Friday 2 May	Whole Cohort Exercise presentation and event
Friday 16 May	Small Group Case Study video presentation and report deadline
Saturday 21 June	End of Trinity Term
Monday 1 September	Dissertation deadline

1.2 Key Contacts

Professor David Wallom, Course Director (director-energyms@eng.ox.ac.uk)

Professor Sarah Sparrow, Deputy Course Director (sarah.sparrow@oerc.ox.ac.uk)

Dr Erin Nyborg, Course Administrator (mscprogrammes@eng.ox.ac.uk)

Engineering Science IT Helpdesk: https://thehub.eng.ox.ac.uk

1.3 Disability

If you have any form of disability, we strongly encourage you to disclose this to the Head of Student Administration in Engineering Science, Christine Mitchell (christine.mitchell@eng.ox.ac.uk), so that we can make provision for you. Your college will advise you of your Disability Contact, who will be pleased to talk to you in the strictest confidence.

Students with a disability may also find useful advice and guidance on the University of Oxford Disability Office web page: www.ox.ac.uk/students/welfare/disability.

1.4 Virtual Learning Environment

This course uses Canvas, a web-based Virtual Learning Environment (VLE), to deliver information on the course's modules.

- Induction materials
- Reading lists for each module
- Hand-outs and presentations from modules
- Links to resources on academic good practice and study skills
- Forums - for tutor-student and student-student interaction

You can log onto Canvas using your Single Sign-On (SSO) at https://canvas.ox.ac.uk/. If you are unable to access Canvas, please email the course administrator with details of your SSO.

1.7 Online Presence, Virtual Meetings and Video Conferencing

Students are expected to attend all teaching sessions in person. Where necessary, we will use MS Teams to enable speakers to present remotely.

1.8 Sources of information

The University Student Handbook provides general information and guidance on making the most of the opportunities on offer at the University of Oxford. It also explains the University's codes, regulations, policies and procedures.

The Oxford Students website provides a single point of access to information, services and resources for students.

The Student Self Service portal enables you to register, view and update your personal and academic information throughout your studies at Oxford. You must complete your annual registration at the start of your course and each successive year.

The Graduate Supervision Reporting system allows you and your supervisor to record and review your progress. You can access the GSR system via the Student Self Service portal.

2. Course content and structure

2.1 Course aims and learning outcomes

The course is designed to be accessible to those who have a first degree in engineering, the physical sciences or geography. By the end of the course, you will have acquired:

- A fundamental understanding of the interdependencies in energy systems;
- A substantial base of knowledge in the processes involved from energy conversion to delivery;
- A broad knowledge of technical and societal options that could contribute towards future systems and an understanding of where more detail may be obtained;
- Economic, legal and scientific tools to weigh up and compare the relative merits and limitations of system options;
- Knowledge of key authoritative sources of information to inform decision making and the ability to question these;
- Methods to critically assess the validity and merit of energy policies and strategies;
- An ability to communicate complex energy issues across disciplines and publics;
- Experience of professionally presenting possible solutions to complex problems within energy.

2.2 Course structure

The MSc in Energy Systems can be studied full time, or part time over two or three years.

Candidates will complete and be assessed on the following parts:

1. Submission of written assignments in each of the following foundation modules:
    a. Energy Sources
    b. Energy Demand
    c. Energy Infrastructure
2. Submission of written assignments corresponding to a minimum of six and a maximum of seven further taught modules chosen from those listed in the Course Handbook
3. A group case study project
4. The whole cohort industrial case study
5. A dissertation of not more than 15,000 words and/or 75 pages on a topic selected by the candidate in consultation with the supervisor and approved by the Standing Committee.

The programme is at level 7 in the Framework for Higher Education Qualifications (England, Wales and Northern Ireland)[1], which means it is equivalent to Masters Level. It meets the subject benchmark statement for Engineering at Masters Level, published by the Quality Assurance agency.[2]

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[1] https://www.qaa.ac.uk/docs/qaa/quality-code/uk-quality-code-for-higher-education-2024.pdf
[2] https://www.qaa.ac.uk/docs/qaa/sbs/sbs-engineering-23.pdf

3. Taught modules

3.1 Teaching and Learning

The course is split into three core themes:

- Resources – How is energy produced, converted, and traded? What energy technologies are available, what energy differences are there between different parts of the world?
- Systems – How is energy distributed so that it is usable and what are the considerations that need to be made for bridging between producers and consumers?
- Services – What, why and how is energy provided or made available to society and how may it change or be changed by society? This theme concentrates on the interface between people and energy, and considers the consumptive end of the energy chain.

Each theme includes a set of taught modules. The three mandatory foundation modules (starred below) are each two weeks long, and the remaining seven modules are one week long. Modules are delivered using a mixture of lectures, tutorials, classroom discussion and external speaker seminars. Energy Infrastructure is taught wholly in a tutorial style and therefore it is not possible to supply notes beforehand. An example completed set of notes will be made available at the end of the module.

Students on the full-time course will take all taught and non-taught elements over the course of one year.

In Year 1, students on the 24-month part-time course, must complete the Resources theme modules (indicated in **red**). They are also free to choose to complete either, or neither, of the Systems (elements indicated in **blue**) or Services (elements indicated in yellow) theme modules in that year. In Year 2, students on the 24-month programme will complete all modules in those themes (either Systems and/or Services) that they did not complete in Year 1, and the dissertation (indicated in green). The Small Group Case Study and Whole Cohort Exercise can be taken in either year. Students can complete one group exercise in each year or complete both group assessments in the same year. The two skills training weeks are not assessed, but are to be completed at the prescribed time due to dependencies of taught elements on the skills given.

Students on the 36-month part-time course will complete the Resources theme modules during their first year (indicated in **red**). In the second year, part-time students (36 months) may take either the Systems (indicated in **blue**) or Services (indicated in yellow) theme modules. In the final year, part-time students (36 months) will complete modules from the theme that they did not complete in Year 2, and the dissertation (indicated in **green**). The Small Group Case Study and Whole Cohort Exercise can be taken during any year of the course. We would recommend completing one group assessment during each of the first two years of the course. The two skills training weeks are not assessed but are to be completed at the prescribed time due to dependencies of taught elements on the skills given.

Term	Week 0	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
Michaelmas	Induction and Research Challenge	Resources 1: Energy Sources (CORE)		Skills 1	Systems 1: Energy Infrastructure (CORE)		Services 1: Energy Demand (CORE)		Resources 2: Energy conversion 1, Fixed generation sources
Hillary	Dissertation Planning 1 Small group case study preparation	Systems 2: Energy for Development	Services 2: Energy and Society	Skills 2	Resources 3: Energy conversion 2, distributed and renewable generation	Systems 3: Energy digitiisation, smart energy and communication	Whole Cohort Exercise Planning	Systems 4: Energy Systems: Economics and Markets	Services 3: Energy policy and governance
Trinity	Whole Cohort Exercise Preparation, presentations and event (Weeks -1 to 1) Dissertation Planning 2		Small group case study, including report presentation		Dissertation (Weeks 4 to 16)				

	Full time	2 year part time	3 year part time
Red	Year 1	Year 1	Year 1
Blue	Year 1	Year 1 or Year 2	Year 2 or Year 3
Yellow	Year 1	Year 1 or Year 2	Year 3 or Year 2
Grey	Year 1	Year 1 or Year 2	Year 1, 2 or 3
Green	Year 1	Year 2	Year 3

2-Year PT students may choose the year in which to complete Systems & Services themes. The course must be notified of the choice of order by MT WK2 in year 2

3-Year Part-time students may choose the order of studying the Systems or Services themes in years 2 & 3. The course must be notified of the choice of order by MT WK2 in year 2.

Part-time students may begin the development of their dissertation projects at any point up until wk1 TT of their final year.

[Hatched weeks are not assessed]

All modules of an individual theme must be taken in the same academic year unless special dispensation is applied for which will only be given in very limited circumstances.

Module descriptions can be found in Appendix 1.

All teaching will be held in the ground floor Teaching Room at Holywell House, Osney Mead. Space for independent study and collaborative working in groups will be available within the Department of Engineering Science.

During the induction week, students will be placed into small groups and asked to address a specific research challenge which covers the disciplinary breadth of the course. Each group will contain at least one student with a particular strength in each of the subject areas, who will be able to explain concepts to fellow students where needed. This exercise is not assessed but encourages a better appreciation of the subject and helps to develop successful working relationships among students.

3.2 Assessment of taught modules

The taught module assessments combined contribute 50% of the overall marks for the degree.

Students must attend and submit assessments for **all** taught modules. Of these, the three foundation modules and the best six results from the remaining modules will be taken by the Board of Examiners to contribute towards your overall degree result.

Each taught module will be followed by an assessment. Assessments may take different forms: written essay-type questions, consultant style reports and worked problems, video presentations or poster designs. The form of the assignment being chosen by the module leader may not be consistent year by year. Students are expected to spend approximately twice the amount of time on their foundation module assessments as on the seven single-week modules. A rule of thumb is that for each week of taught program a student should spend approximately 20 hours completing a related assignment.

Each module assessment question paper will be distributed at 12.00 noon on Inspera on the penultimate teaching day of the module and will include the format of the assessment. Students have five weeks to complete the exercise and submit it electronically through Inspera, the University's secure submissions portal.

We have introduced a system of indicative deadlines to help students better plan their time and avoid becoming overwhelmed by successive deadlines. For each foundation module assignment, we recommend that you aim to spend no longer than 4 weeks. For all other single-week modules, you should aim to spend a maximum of 2 weeks.

Online submission

During the course you will be required to submit work through Inspera, a secure submissions portal, which you can access using your SSO at https://oxford.inspera.com/. **You must** submit your assignments online using Inspera by the date specified on the assessment question paper. You are required to submit a declaration of authorship, confirming that the work you are submitting is your own. You should keep copies of all submitted work.

All submitted written assignments must include a word count on the title page. Where applicable, students should also indicate their observance of other limitations and requirements (for example, the running time of a video presentation should be stated, along with the time limit stipulated in the assignment question paper).

There are penalties for work submitted late without prior agreement. Details are set out in Section 3.6 of the course's Examination Conventions.

If you submit your work late, or do not expect to be able to meet a forthcoming deadline, the University Students website provides a helpful guide that explains the steps to take: https://www.ox.ac.uk/students/academic/exams/problems-completing-your-assessment.

If you are unsure about any element of the procedure for submitting your work, or are encountering difficulty submitting your work, please contact the MSc Programmes Administrator.

Please refer to the course's Examination Conventions for procedures relating to assignment resubmission.

Provisional Marks and Feedback

Six weeks after the assignment deadline, you will receive a provisional mark and qualitative feedback from the assessors. Please note that these marks will remain provisional until approved by the final Board of Examiners meeting

Marks and feedback for each assignment will be uploaded to each student's private SharePoint folder. The MSc Programmes Administrator will send you an access link.

This taught module assignment feedback will take the form of statements describing the top 3 improvements that could be made to the submission in the opinion of the assessor.

It is intended that a more standard rubric of comments will be developed to simplify the feedback process.

No feedback will normally be given for the Small Group Case Study, Whole Cohort Exercise or Dissertations.

3.3 Programming and data skills

We hold skills training sessions in Week 3 of Michaelmas and Hilary terms. Although not assessed, these sessions provide important material relating to the taught modules and contribute to students' overall development. This year's topics are:

Michaelmas Term, Week 3	Topic
Day 1	Systems Thinking
Day 2	Scientific Programming in Python
Day 3	Scientific Programming in Python
Day 4	Scientific Programming in Python
Day 5	Essay Writing and Critical Thinking; Presentation Bootcamp

Hilary Term, Week 3	Topic
Day 1	Research Ethics
Day 2	Project Management
Day 3	Project Finance
Day 4	Data Management
Day 5	Scientific Visualisation

4. Group work

4.1 Small Group Case study

During Hilary term, students begin planning an energy transition case study in small groups. Topics will be made available at the start of the course. The content of lectures in the modules and skills training will provide important context for these case studies.

During Weeks 2 and 3 of Trinity term, each group will produce a video presentation and report. At the end of Week 3, each group will submit their video presentation and report, which will be assessed by the course director and assessors. The outputs each comprise 50% of the total mark and will constitute 15% of the overall degree mark. Full details of the guidance given are in Appendix 3.

4.2 Whole Cohort Exercise

During Hilary term, the cohort will partner with an external stakeholder to begin planning the shape and context of their agreed energy-related problem. The exercise will be overseen by the course director, with a team of academic supervisors contributing their expertise to the group where requested.

During Week -1 to Week 1 of Trinity term, the cohort will finalise a coherent series of presentations, posters and a multi-chapter report. Each cohort member is expected to submit contributions to the assigned author of each chapter.

The Whole Cohort Exercise constitutes 10% of students' overall degree mark. Students cannot pass the course without successfully completing it.

The entire cohort will receive the same mark, awarded by an academic panel. The external stakeholder will provide feedback to better inform the panel and its assessment. Students will receive feedback from the partner organisation and the academic supervisors at a dedicated event following the presentations.

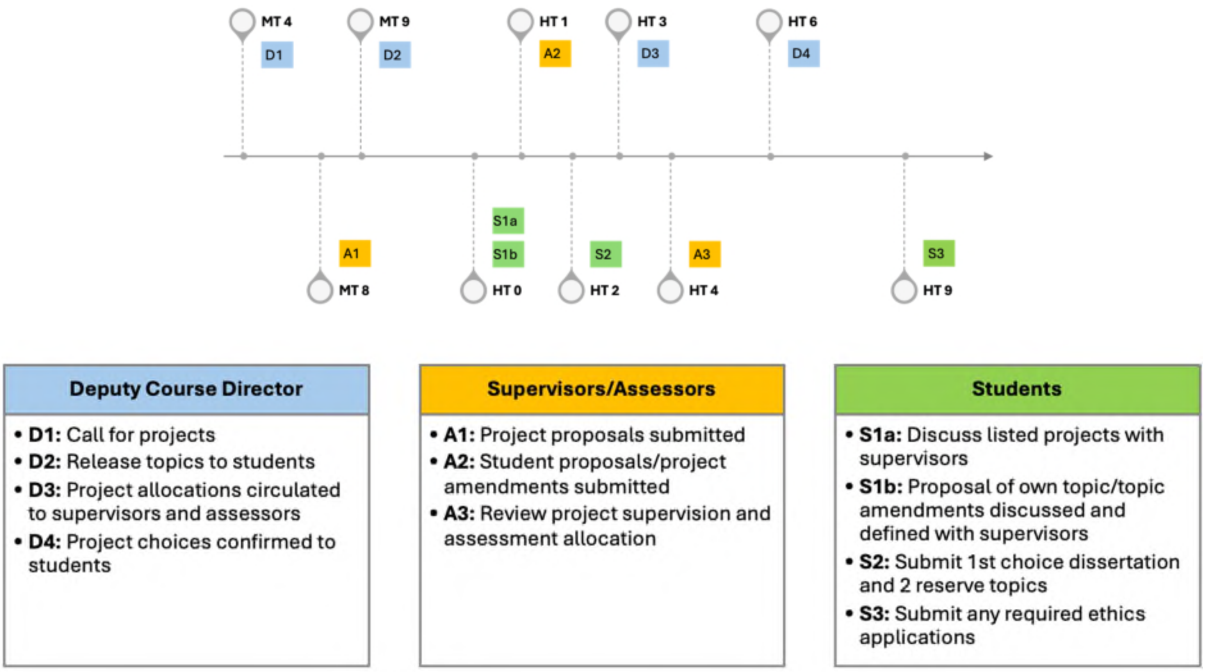
5. Dissertation

5.1 Scope, topic selection and approval

Each student’s dissertation topic must relate to energy systems as defined by the topics covered in the taught modules.

A list of potential dissertation projects and supervisors will be published at the end of Michaelmas term (Week 9). Alternatively, students can propose their own topic, provided it aligns with the headings presented in the taught modules or refine existing topics. To do this, students must identify an appropriate supervisor and work with them to define the topic. The supervisor will then submit new/amended dissertation proposals no later than Hilary Term Week 2 denoting the student the topic was developed with. All topics are subject to approval by the Course Director and Deputy Course Director. Students considering pursuing a topic of their own devising are strongly advised to begin preparation as early as possible.

A dissertation briefing will be provided in Week 0 of Hilary term. Students will have the opportunity to meet potential supervisors during the term. Once a student has discussed topics with potential supervisors, they must ensure the supervisor submits any amendments by Hilary Term Week 1. Details of the dissertation proposal form are given in Appendix 4 of this handbook. Students must submit their 1st choice dissertation topics along with two reserve topics by Hilary Term week 2. Student choices are collected via the webform circulated by the Deputy Course Director . The Course Director and Deputy Course Director will review and allocate topics based on student choices and supervisor load. Except in exceptional circumstances, supervisors are limited to three dissertation topics per year. Project allocations will be circulated to supervisors and assessors in Hilary Term week 3 for review before students are notified in Hilary Term Week 6. A summary of the timeline is given below.



Part-time students will begin their dissertation preparation in the final year of their course.

Notes

Where supervision is provided by a researcher at the Oxford Institute for Energy Studies (OIES), students will need to arrange a co-supervisor who is a member of the University of Oxford.

If a dissertation is likely to require approval by a university ethics panel, this should be identified as soon as possible. To allow sufficient time for approval to be sought, students should work with their supervisor to submit the required forms by Week 9 of Hilary term at the latest.

5.2 IP and Ownership of Data

If a student intends to base their dissertation on data collected by a company or other institution, it may be necessary to set up an agreement establishing intellectual property and ownership of data and results. This must be discussed with the dissertation supervisor. In such circumstances, students will be required to sign a non-disclosure agreement; additionally, dissertations will be marked as confidential and not disclosed. Where external examiners request to see these reports, a non-disclosure agreement can be signed if considered necessary. Reports will be reviewed very carefully by the supervisor from the institution concerned to identify any sensitive material.

5.3 Supervisor support

During the period designated for the dissertation, supervisors will provide a face-to-face or video conferencing meeting lasting one hour, every two weeks. It is the student's responsibility to arrange and agree the dates for these meetings. Students may also request advice by contacting their supervisor by email.

Supervisors will read and provide written feedback on one full draft of students' dissertations, provided it is sent to the supervisor by the Monday of 16th Week of Trinity term.

5.4 Report design

The dissertation must be no more than 15,000 words. Footnotes and endnotes are included in the word count. Bibliographies, tables, appendices and references are **not** included in the word count. Reports should be in the normal format for academic publications, including the following sections: abstract, introduction, methods, results, discussion, conclusions, references, and appendices.

Further guidance on the structure and production of the dissertation is given in Appendix 5.

5.5 Submission

Dissertations must be electronically submitted by the deadline. Submissions are made via Inspera in the normal way.

5.6 Dissertation assessment

The dissertation will account for 25% of the overall degree mark. It will be assessed according to the marking scheme shown in Appendix 6. Candidates who fail to achieve an overall mark of 50% or over in the dissertation may resubmit the failed assessment on one occasion only.

6. Good academic practice and avoiding plagiarism

Plagiarism is presenting someone else's work or ideas as your own, with or without their consent, by incorporating it into your work without full acknowledgement. All published and unpublished material, whether in manuscript, printed or electronic form, is covered under this definition. Plagiarism may be intentional or reckless, or unintentional. Under the regulations for examinations, intentional or reckless plagiarism is a disciplinary offence. Please review the Oxford Student's website guidance on plagiarism: www.ox.ac.uk/students/academic/guidance/skills/plagiarism.

Each student is **required** to complete the Avoiding Plagiarism course and gain the associated certificate. Once completed, students should send proof of their certification to the course administrator.

All dissertations will be screened by Turnitin software which will assess submissions against published and unpublished sources and the work of other students. Assignments from the taught modules may also be screened in the same way. Examiners will be notified of the extent of any textual matches discovered by Turnitin and will consider whether any text has been properly identified and referenced.

The Examination Conventions set out the academic penalties for (a) intentional or reckless plagiarism, and (b) poor academic practice.

Study skills

Guidance on time management, note-taking, referencing, research and library skills and information is available at www.ox.ac.uk/students/academic/guidance/skills.

7. Course feedback

At the end of each taught module, students will be asked to provide feedback via an anonymous survey. It is very important that students complete this survey to help us monitor teaching quality and to make necessary adjustments or improvements.

In December, all students at Oxford will also be asked to complete the Student Barometer, which monitors the quality of all aspects of the student experience.

Concerns

Any student who experiences an issue with their teaching or supervision should contact the relevant person listed in Appendix 2.

Student representation

Oversight of the course is managed by a Standing Committee, which meets three times a year. These meetings are attended by two student representatives, selected by the cohort for each year (one male and one female). One representative will also attend the termly departmental Graduate Joint Consultative Committee (GJCC).

8. Buildings and facilities

8.1 Engineering Science

All teaching will take place in the MSc Teaching Room at Holywell House, Osney Mead, Oxford, OX2 0FA.

The room will be open from 8.30 am to 5.30 pm, Monday to Friday.

Independent study space is also available in the Student Study Area on the 8th floor of Engineering Science's Thom Building on Parks Road. The Study Area is open from 8.30 am to 7.00 pm, Monday to Friday.

Students are expected to provide their own laptops. We recommend the following specification:

- CPU: 2.3GHz processor minimum (preferably multicore)
- Memory: 8Gb minimum
- Disk size: 256Gb minimum
- Operating System: Windows (Windows 8 or later), Linux (CentOS or similar distribution), Mac (OSX 10.13 or later)

8.2 University Libraries

Radcliffe Science library

The Radcliffe Science Library (RSL) (www.bodleian.ox.ac.uk/science) is the main science research library at the university. The library holds copies of the course's reading list items, and most research will be undertaken using this library's resources. The RSL is located a short walk away from the Engineering Science department on South Parks Road.

The Subject Librarian responsible for Engineering Science is Alessandra Vetrugno (alessandra.vetrugno@bodleian.ox.ac.uk), who is based at the RSL.

Social Sciences Library

The Social Science Library (SSL) (www.bodleian.ox.ac.uk/ssl) is the main social science research library at the university and holds resources relevant to some of the course modules. The library is located less than 15 minutes away from the Engineering Science department, on Manor Road, just off South Parks Road opposite St Catherine's College.

The Subject Librarian responsible for relevant areas within the library is John Southall (john.southall@bodleian.ox.ac.uk, who is based at the SSL.

Appendix 1: Detailed Syllabus

1. Resources Theme

How is energy produced, converted and traded? What energy technologies are available, what energy differences are there between different parts of the world? And how have we arrived where we are with global energy systems?

R1. Energy Sources (Michaelmas Term Weeks 1-2)*

Professor David Wallom (Department of Engineering Science)

Course Context

The production, transformation and consumption of energy are one of the key enablers for our current lifestyle, and will undergo a huge transformation as we move towards a low carbon future. As such it is essential that we understand energy itself from a theoretical and foundational basis, the primary sources of energy now and in the near past. This module is a foundational module and as such will describe the fundamentals of energy, including the different forms of energy when going beyond the fundamental of kinetic and potential towards those types of energy that can be exploited by society. We will discuss and understand the fundamental background of thermodynamics, conservation of energy and transformation of energy. We will discuss how we use energy at a high level to enable preparation for other modules within the course though topics such as energy for transport, energy for life and future energy sources for the masses. We will then consider the current global energy mix. We will also teach and discuss the underpinning climate change situation including carbon budgets. The module will use lectures, group work, presentations, debates and project based learning to cover this broad and foundational topic to the whole course.

Lecturers

Professor David Wallom
Professor Nick Eyre
Professor Sarah Sparrow
Professor Felix Leech
Professor Ben Williams

Course Content and Structure

The course will cover the following content in thirty 90-minute sessions:

1. **Introduction to the Energy System**
   Discussion about the system and where there are key strengths and weaknesses laying the groundwork for how we describe the Energy System within the course.

2. **Forms of Energy**

a. What is energy?
b. What is Work?
c. What is Power?
d. Units and Measurement

3. **Embodied or Embedded Energy**
    a. What is it and how important is it in current arguments about energy utilisation?
    b. Types of embodied energy
    c. Constraints
    d. Why?
    e. Definition
    f. Tracing the process
        i. Raw materials [extraction, transport, processing]
        ii. Construction [transport, assembly, waste]
        iii. Utilisation [operating]
        iv. Disposal [transport, waste]
    g. Example - buildings

4. **Energy System Behavioural Transition exercise**
There are many energy transitions that are suggested as ways to reduce our environmental impact. We should think critically about these. Are the published studies credible? We should ensure they haven't made unfortunate assumptions.

5. **History of Energy and Global Energy usage**
From the earliest times of almost prehistory to now energy has been a constant requirement of society, whether they realised it or not.

6. **Transformation and Transfer**
As we must operate under the principle of conservation of energy, we must understand the usable transformations between different types of energy.

7. **The Climate Change Challenge**
Climate change is the single biggest challenge for society as it moves forward. First and foremost it is an energy problem, and as such we must understand climate change's mechanisms. We must do this whilst also realising that we do not have uniform availability of energy on the planet so we must understand the current limitations of energy availability around the world.

8. **Thermodynamics**
It will be necessary to have an understanding of the theoretical underpinnings of how we calculate energy within a system, in transformations and how energy may be distributed within a system and change during action or changes within that system.

9. **The System**
    a. **Current Energy sources and interconnection**
    What are the energy sources used in society now? What are the mechanisms used to

transform their energy and make it usable? Resource location & distribution (local vs distributed)? Discussion on efficiency including full chain analysis.

b. **Future Energy**
   What are the restrictions on current energy sources and what new sources are available? What are the future roles for current energy sources and how will new sources become widely adopted?

Course Texts

- Energy Science 4th edition, Andrews and Jelley (OUP)
- Sustainable Energy –without the hot air, David J.C. MacKay
- Thermodynamics, A complete undergraduate course, Andrew M. Steane
- National Grid Future Energy Scenarios, National Grid PLC.
- Otto, F.E., 2017. Attribution of weather and climate events. *Annual Review of Environment and Resources*, *42*, pp.627-646.
- IPCC Special report on 1.5, https://www.ipcc.ch/sr15/
- Energy Systems: A Very Short Introduction, Nick Jenkins (OUP)
- BP Statistical review of world energy, BP.
- Applied Thermodynamics for Engineering Technologists, Eastop T.D. & McConkey A., Longman, 1993, Chaps 1-3, 6, 7-9, 13, 16
- Fundamentals of Engineering Thermodynamics , Moran M.J. & Shapiro H.N., Wiley, 2006, Chaps 1-4, 8-9, 11, 13
- Engineering Thermodynamics Work & Heat Transfer , Rogers G.F.C., Mayhew Y.R. Longman, 1993, Chaps 1-4, 7-12, 14-15, 17
- Basic Engineering Thermodynamics, Whalley, OUP, Chaps 1-7, 12-15, 17
- Four laws that drive the universe, Atkins, P. W. , Oxford University Press, 2007

Last reviewed: 09/24

R2. Energy Conversion 1 (Michaelmas Term Week 8)

Dr Anupama Sen (Smith School for Enterprise and the Environment)

Non renewable energy: growth, infrastructure and markets

Course Context

Non-renewable energy (oil, gas, coal and nuclear) accounts for just over 80 per cent of total global energy consumption. The current global energy system that we have today has been built around non-renewable energy sources, raising the question: *how did we get to where we are today?* This question can be considered in three connected parts.

The first part is the science of energy conversion, and the role of technology and technological advancements in facilitating newer and more efficient forms of non-renewable energy generation to meet society's needs. Technological advancement on its own is, however, insufficient in explaining the evolution of non-renewable energy systems and a deeper understanding requires going beyond the singular issue of technology to consider it in relation to wider socioeconomic factors.

The second part is the role of economic growth and human development and their contribution to non-renewable energy use. As societies grow richer and incomes increase, energy use among consumers typically evolves from lower value-added fuels to higher-value added and 'cleaner' fuels (e.g. from wood, through to coal, oil and gas). As energy consumers around the world moved up the 'energy ladder' in this way, it also catalysed the construction and development of capital-intensive infrastructure and markets for different fossil fuels, that was necessary to support the use of these non-renewable fuels, in a centralised way.

The third part is the dynamic nature of the process and the different speeds at which the non-renewable energy system has evolved in different countries around the world. Factors underpinning this 'differential development' of non-renewable energy systems include the speed of technology transfer, resource endowment, comparative advantage, and policies promoting inter-fuel substitution. For instance, many hydrocarbon-producing countries rely on the enormous rents generated by oil and gas production and export to support their societies and on cheap non-renewable energy to support their economies. These dynamics are rapidly changing.

This module will explore the evolution and development of the main non-renewable energy sources within the current energy system against the context of the three parts above. It will draw from the experiences of different countries to show how differences in contexts have shaped the evolution of non-renewable energy alongside the 'locking in' of infrastructure created to support them. Using specific examples, it will look at the path dependencies created by incumbent non-renewable energy systems, and the role of policies in disrupting them and shaping the transition to decarbonised energy systems.

The course will draw on a mix of academic and industry expertise, giving students the opportunity to engage with guest lecturers as well as tackle practical exercises and thought experiments.

Course Content and Structure

The course will cover most of the following topics through lectures and/or readings:

Global overview of non-renewable energy systems
Looks at the global energy scene and sets out the main trends in non-renewable energy use in different world regions. Connects this with the historical evolution of these systems and questions why economies moved from renewables to fossil fuels in the first place, with the process still happening today e.g. developing economies moving from traditional biomass to fossil fuels. Discusses the characteristics of past non-renewable energy transitions. Stresses that the drivers have been different in different countries. Covers key concepts including: resource extraction and the Hotelling Rule, comparative advantage, scarcity rents, interfuel substitution, path dependency, environmental Kuznets curve.

Energy Conversion and the Conventional Power Generation System
Principles of energy conversion in conventional non-renewable energy systems. The laws of thermodynamics and heat-to-work conversion in different thermodynamic cycles. The efficiencies of power plants and heating devices. State-of-the-art and future developments of different technologies: Steam power plant; Open Gas Turbine (GT) plants; Combined Cycle Gas Turbine Plants (CCGT)s. Future flexible operation of conventional power generation systems (improved operating flexibility, biofuels) with increasing presence of renewable power. Hybrid conventional and renewable energy systems (CCGT and Concentrated Solar Power (CSP). Fuel cells. Combined Heat and Power (CHP) – Cogeneration plants. Types of CHP plants. Performance parameters for a CHP plant. Power plants for transport: The reciprocating internal combustion engine and its performance. Turbojet engines.

Natural gas in the energy system
Gas's evolution from a by-product of oil to a high value-added fuel; the development of capital intensive infrastructure to support its use; the gas supply chain; how gas is valued and traded globally; the drivers of gas demand in different regions; the future of gas in a decarbonising energy system.

Decarbonisation technologies for fossil fuels
Carbon footprint of different power generation technologies. Carbon sequestration and storage (CCS). Although there are several recommended / researched techniques, it has not yet been implemented on a large scale. Carbon capture methods: Pre- and post-combustion, Oxy-Combustion systems. Coal gasification through Integrated Gasification Combined Cycle (IGCC) plants. Geological CO2 storage options and enhanced oil recovery. Reducing carbon emissions through further efficiency improvements: Ultra-high-efficiency Hybrid Combined Cycle Gas Turbine (CCGT) and Renewable Energy. The feasibility of implementation of different CCSs technologies depends on many factors, including economics (scale) and government policy. Clean coal initiatives – China and India cases. Thinking big – Climate Engineering: Direct CO2 Removal (DCR) and Solar Radiation Management. Why the energy shift towards renewables in Germany fails to cut the carbon emission?

Oil markets
Key drivers for the emergence and widespread use of oil across the world, including factors such as higher value-add, ease of transportation, and storage; the oil supply chain; the operation of world oil markets; the valuation of oil reserves and their contribution to path dependency; the

macroeconomics of oil in major exporting countries/OPEC; oil and the energy transition; adaptation strategies of oil producers.

Nuclear Energy
Fission and fusion technologies – the nature of energy release, and the challenges associated with controlling nuclear reactions. Energy density and fuel tolerance – the need for a nuclear fuel cycle – proliferation and security of supply. The role of nuclear energy in current power generation – national norms and historical perspectives. Possibilities for future development. Small Modular Reactors.

The energy transition and fossil fuels
Is technological change the only factor in transitioning from a predominantly non-renewable carbon emitting energy system to a decarbonised system; are there 'rigidities' or other characteristics of non-renewable energy systems that are unsuited (or suited) to a decarbonised future; how can the path dependency of non-renewable energy systems be disrupted or reshaped, and how can we begin thinking about this – i.e. which parts of the system need to be changed first; what are some of the difficult trade-offs involved and some of the uncertainties surrounding them; will we see increasing diversity or homogeneity between regions; what is the role of government policies vis-à-vis market instruments in catalysing change.

LECTURER BIOS

The main topics are covered by the following lecturers. Additional guest speakers may be added.

Dr Anupama Sen, Head of Policy Engagement, Smith School of Enterprise and the Environment, University of Oxford

Anupama Sen is Head of Policy Engagement for the Smith School of Enterprise and the Environment. Prior to the Smith School she spent over 10 years at the Oxford Institute for Energy Studies, where she was senior research fellow, executive director of the electricity research programme and deputy director of the energy transition initiative, and where she published and communicated policy-oriented research on energy and decarbonization targeted at audiences across academia, government and industry. Anupama holds a BA (Hons) in Economics from St Xavier's College at the University of Mumbai, MSc from the London School of Economics and Political Science and PhD from Cambridge University. She is an Official Fellow in Environmental Change at Reuben College, Oxford, a Fellow of the Cambridge Commonwealth Society, and a Research Affiliate of the Copenhagen School of Energy Infrastructure, Copenhagen Business School.

Professor Budimir Rosic, Associate Professor of Engineering Science, Department of Engineering Science, University of Oxford

Before joining Oxford, Professor Budimir Rosic was a Mitsubishi Heavy Industries (MHI) senior research fellow and college lecturer in engineering at the University of Cambridge. He received his undergraduate degree from the University of Belgrade, Serbia, where he also worked as a researcher in the turbomachinery and power plants group (faculty of mechanical engineering). During that time he was involved in research and consultancy of steam turbine related problems, and power plant monitoring and performance tests. Budimir undertook his Ph.D. research at the University of Cambridge's Whittle Laboratory in collaboration with Siemens Power Generation under the supervision of Dr. John Douglas Denton. He investigated, experimentally and numerically, the aerodynamics of low aspect ratio turbines and leakage flows, and earned his Ph.D. in 2005. He has been an ASME member since 2002 and has served on IGTI's Turbomachinery Committee since 2004. He was a recipient of ASME's 2006 Gas Turbine Award and again in 2011, he was recognized for the co-authored paper titled "Controlling Tip Leakage Flow Over a Shrouded Turbine Rotor Using an Air-Curtain." He received ASME's Gas Turbine Award, which recognizes outstanding contributions to the literature of combustion gas turbines or gas turbines thermally combined with nuclear or steam power plants. It was presented to Budimir in Vancouver, British Columbia.

Mr Howard Rogers, Distinguished Research Fellow, Oxford Institute for Energy Studies

Howard Rogers joined the Institute in January 2009 and became Director of the Natural Gas Programme in October 2011. He was appointed Chairman and Senior Research Fellow of the Programme in October 2016 and Distinguished Fellow in November 2019. Prior to joining the Institute Howard was with BP for 29 years, mostly in business development, strategy, planning, mergers and acquisitions and negotiation roles in upstream oil and gas in European, North American, Middle East and FSU locations. In 1999 Howard joined BP's Gas and Power division and in 2003 he became Head of Global Gas Fundamental Analysis. He has a degree in Chemical Engineering and is a Fellow of the Institution of Chemical Engineers.

Howard has published research papers and authored book chapters on LNG price arbitrage between the regional markets of Asia, Europe and North America, shale gas in the US and UK, The interaction between wind power generation and gas in the UK and the outlook for gas with CCS. As well as on the transition to hub-based pricing in Europe and the changing roles and risks of key players and also on the challenges to JCC pricing in Asian LNG markets. Howard's areas of expertise include global natural gas supply/demand/price structures and competing fuels, the LNG value chain, market dynamics, price arbitrage, and regional knowledge on markets and gas supply.

Dr Adi Imsirovic, Guest Lecturer, Department of Engineering Science, University of Oxford, Senior Visiting Research Fellow, Centre for Strategic and International Studies (CSIS)

Adi Imsirovic has 35 years of experience in oil trading. He has held a number of senior trading positions, including global head of oil at Gazprom Marketing & Trading and regional manager of Texaco oil trading for Asia. Dr. Imsirovic was a Fulbright scholar and studied at the Graduate School of Arts and Sciences, Harvard University. There, he was also an adjunct research fellow at the Kennedy School of Government. Adi taught economics at Surrey University for several years, including energy economics and resource and environmental economics. For a number of years, he was a senior research fellow at the Oxford Institute for Energy Studies. He has a PhD in economics and a master's degree in energy economics. Dr. Imsirovic has written a number of papers and articles on the topic of oil and gas prices, benchmarks, and energy security. He is the author of the *Trading and Price Discovery for Crude Oils: Growth and Development of International Oil Markets* (Palgrave, 2021). Adi also edited *Brent Crude Oil: Genesis and Development of the World's Most Important Oil Benchmark* (Palgrave, 2023).

Dr Sumiu Uchida, former Head of Research and Innovation, Mitsubishi Heavy Industries

Dr Uchida is the Chief Engineer and former Head of Research and Innovation Technical Headquarters of Mitsubishi Heavy Industries (MHI) and the Vice Chairman of Japan Turbomachinery Association. Dr

Uchida is responsible and oversees all R&D activities for almost seven hundred different engineering products at MHI - from power generation, energy, aerospace, environment, material handling, industrial machinery, transportation, etc. His experience ranges from development, operations, product design and company strategy. In the last twenty years, Dr Uchida helped to establish and promoted collaborations between MHI and leading British universities (Oxford, Cambridge, Imperial). He is also a Visiting Professor at the Department of Engineering Science in Oxford. Dr Uchida was an active researcher and has been awarded two ASME IGTI best paper awards and one ASME Gas Turbine Award, the most prestigious international award in the field of turbomachinery.

Mr Daniel Robertson is Senior Advanced Concepts Engineer and Modularisation Research and Technology Lead at Rolls Royce Plc. He has been with the company since 2006.

Last reviewed: 09/24

R3. Energy Conversion 2 (Hilary Term Week 4)

Professor Moritz Riede (Department of Physics)

Course Context

This module expands on the energy sources available to use in the form of renewables but is then extended into the different additional infrastructure that is necessary when considering renewable energy to cope with its intermittent nature. This will include Wind, Solar, Marine (Wave and Tidal), Geothermal and Bioenergy as well as a specific strength of the university in batteries and energy storage technologies. Alongside studies on the different methods of converting energy into heat and electricity using the renewable technologies the module will discuss implications of different energy mixes available and how they could affect a final energy balance. The module will use both lectures and project based learning to ensure there is a full understanding of the implications.

Course Content and Structure

1. The current capabilities of renewable energy
What are the overall contributions that renewables make to the energy mix currently and what are the restrictions on current expansion? Comparison to RE1 energy conversion technologies.

2. Solar energy **conversion**
What are the current designs of electricity generating solar panels and what are the current leading edge areas of research? What are alternative ways of using the sun's energy to generate electricity and heat. How the sun can be used for solar cooling?

3. Harnessing the power of the wind
Where can Wind power (onshore and offshore) contribute, what are the limitations and what specific infrastructure is necessary for wind to provide input to the grid? What unconventional concepts are explored?

4. Power from biomass
Traditional biomass has been used for heating and cooking for millennia. How can this form of energy be used today, and what implications are there for land use and food supply?

5. Geothermal energy
What ways are there to convert the heat the earth produces (both surface and deep) into other usable forms.

6. Power from water
How will running water sources and developments continue to contribute to the available renewable energy mix? How will Marine energy sources and developments contribute to the available renewable energy mix and what are leading edge areas of wave and tidal energy capture?

7. Energy Storage technologies and keeping the lights on
Due to the intermittent nature of renewables, it will be necessary to provide mechanisms for storing energy provided in times of plenty but required in times of famine. What technologies are available

at the moment and how can we use those currently available without environmental damage or external dependency?

8. Energy Transport
In addition to temporal intermittency, renewable energy resources are – just as e.g., fossil ones – unequally distributed across the Earth. How can energy, and in what form, be transported over short and large distances in an effective and safe way?

Course Texts

- Energy Science, J. Andrews and N. Jelley; OUP (3rd ed), 2017
- Renewable Energy: Power for a Sustainable Future, G. Boyle; OUP (3rd ed), 2012
- Renewable Energy Resources, J. Twidell and T. Weir; Routledge (3rd ed), 2015
- Elementary Climate Physics, F. W. Taylor; OUP, 2005
- Beyond Smoke and Mirrors, B. Richter; CUP, 2010
- IEA World Energy Outlook(s) (http://www.worldenergyoutlook.org/)
- Sustainable Energy- without hot air, David MacKay; UIT, 2009, (http://www.withouthotair.com/)

Last reviewed: 09/23

2. Systems Theme

How is energy distributed so that it is usable? What are the considerations that need to be made for bridging between the producers and consumers?

Sy1. Energy Infrastructure (Michaelmas Term Weeks 3 & 5)*

Professor Malcolm McCulloch (Department of Engineering Science)

Course Context

Useful energy is often not available to the end user at the time or place that it is required. Therefore the right type of energy – the energy vector – needs to be brought through space and time, from the source of production to the point of consumption. This module considers the former challenge – that of distributing the energy to the end user, often over long distances (transmission) and over wide areas (distribution). However, there is often an overlap with moving energy through time – storage – and this will be developed when considered as part of the design of the spatial distribution system.

This module develops some key principles, and then applies them to case studies – that highlight the common themes and challenges for distributing many forms of energy. This module is designed to enable the student to deeply understand the following principles:

1. The implications of the choice of energy vector.
2. The underlying physics and technical models.
3. Operational methods to manage losses and faults.
4. The drivers of capital expenditure.
5. Identification of key risks, including obsolesce, social acceptability and financial viability.

By the end of the module, you will be able to:

1. Critically assess an existing distribution system.
2. Develop a scoping study to develop an enhanced distribution system, considering multiple vectors.
3. Develop a scoping study for a new distribution system.

Course Content and Structure

1. **Understanding the problem today and tomorrow.**
    - Basics.
    - Energy density and timing of production and generation.
    - Diversity.
    - Moving energy through time and space: Storage, distribution and transmission.

2. **Types, principles and characteristics of energy vectors.**
    - Types of energy vectors: Mechanical, Thermal, Chemical, Electrical

- Energy, power and ramping.
- Losses: Conversion, spatial, temporal
- Costs, capex and opex: Conversion, spatial, temporal
- Reliability and fault management. (Degradation and failure mechanisms, Identification and mitigation)

3. Low fidelity modelling

- First principles model
- Sankey diagram
- LCOE for energy vector
- Exercise 1 - Enhance an existing system

4. Detailed analysis of power grids

- Power, Reactive Power and Apparent power.
- DC and AC Single and Three phase analysis.
- Power through a resistor (DC) and an inductor (AC).
- Simple power flow analysis in Python
- Parameters: Transmission lines and transformers.
- Costings for different technologies (overhead lines, cables, transformers, switchgear)
- Exercise 2 - Analyse an existing system

5. Spatial analysis

- GIS systems: QGIS
- Analysis of existing transmission grids: UK and Africa
- Coupled with power flow analysis.
- Analysis of existing distribution grids.
- Spatial optimisation in Python.

6. Emerging grid topologies

- Fractal like grids.
- Space-time grids.

7. Module synthesis

Course Texts

https://open-power-system-data.org

https://www.elexon.co.uk/wp-content/uploads/2017/06/bmrs_api_data_push_user_guide_v1.1.pdf

https://www.qgis.org

Last reviewed: 09/23

Sy2. Energy for Development (Hilary Term Week 1)

Professor Malcolm McCulloch (Department of Engineering Science)

Course Context

Modern energy is a necessary condition for development. This importance is recognised as it is a core Sustainable Development Goal: SDG7. Providing the energy needed at an acceptable cost to deliver appropriate services efficiently, while protecting the environment, is a significant challenge. New technologies are being developed and there is a growing appreciation that they need to be appropriately targeted. Furthermore, the system has to be able to grow with the customer, possibly changing technologies and providers. This transition is complicated by the institutional and economic local, regional and in-country capacities.

This module develops some key principles, and then applies them to case studies – that highlight the common themes and challenges for developing appropriate energy systems. This module is designed to enable the student to deeply understand the following principles:

- The end user is key in defining the service requirements and the finances available.
- The choice of distribution of energy is dependent on population density, effective load density and generation type.
- Key risks include social acceptability, obsolesce and financial viability.

By the end of the module, you will be able to:

1. Deploy different methods to understand end user requirements and capabilities.
2. Critically assess an existing distribution system.
3. Develop a scoping study for a new distribution system, including costings.

Lecturers

Professor Malcolm McCulloch (Department of Engineering Science)
Dr John Rhys (Environmental Change Institute, School of Geography and the Environment)
Dr Stephi Hirmer (Department of Engineering Science)

Course Content and Structure

1. **Understanding the end user**

   Energy Cultures as a framework of understanding the interplay of end-users and technology.
   Understanding norms and perceived value
   Social and productive uses: Information, motion, thermal
   Determining important energy services:
   Indicative load profiles and diversity.
   Willingness/ ability to pay
   Ethics
   Exercise 1: End users of West Ngosini

2. **Spatial density**

   Data sets
   Determining spatial density from discrete locations
   Nearest Neighbours
   Kernal methods
   Clustering techniques
   Exercise 2: Spatial analysis of West Ngosini

3. **Grid topologies**

   Spatial, temporal and energy resource as determinants.
   SHS, battery grid, Micro grid, Mini grid, grid, Fractal
   Exercise 3: Grid plan for Machakos County

4. **Institutions**

   Weberian vs Northian States
   Power sector organisation
   Vertically integrated
   Unbundling
   Private sector
   Synergistic frameworks
   Exercise 4: Institutions

Module synthesis

Course Texts

Topic 1
https://doi.org/10.1016/j.enpol.2010.05.069
https://doi.org/10.1016/j.rser.2014.03.005

Topic 2
https://www.qgis.org

Topic 3
https://open-power-system-data.org

Topic 4
https://www.beloit.edu/upton/assets/North.pgs.vol.I.pdf

Last reviewed: 09/23

Sy3. Digitisation, Smart Energy and Communication (Hilary Term: Week 5)

Module Leader: Professor David Wallom (Department of Engineering Science)

Course Context

It is clear that as we approach an era where we are no longer living in energy abundance that we must increase the efficiency with which we use energy. As such it is important that we consider how we will make use of advanced communications tools and technologies. These will primarily be concerned with the mechanisms by which we improve the distribution and consumption of energy and as such this is where this module will concentrate. Outside of regular smart systems for electricity we will also look at other activities in this area including local heat networks, smart homes and their interfaces to energy, etc. As part of the critical national infrastructure, we will also consider the cybersecurity aspects of smart systems.

Lecturers
Professor David Wallom (Department of Engineering Science)
Professor Alex Rogers (Department of Computer Science)
Ramon Granell (Department of Engineering Science)
Dr Scot Wheeler (Department of Engineering Science)
Dr Weiqi Hua (University of Birmingham)

We will also be completing a field trip within this module and have a number of industry presentation during the week.

Course Content and Structure

The course will cover the following content:

1. **Why do we need to smarten the energy grid?**

2. **What is a smart grid?**
    a. International Definitions
    b. Generalised characteristics exercise to pull out key points from definitions

3. **Smart grid concept and Reference model**
    a. NIST Smart Grid
    b. Smart Grid Architecture Model (SGAM)

4. **Smart Meters and smart homes**
    a. Current situation (SMETS 1)
    b. Current Smart home solutions

    c. The national smart meter rollout, (SMETS 2) including the full system design as currently proposed.
    d. The DCC and access models
    The advantages and disadvantages of smart meters

5. **Creating tools and services to inform smart energy systems roll outs**

6. **Local energy market examples**

7. **Creating insights from big data**
   Utilising Machine Learning and AI to understand better the relationship between energy consumption and the physical activities that are drivers. Using these to also enable the provision of behavioural changes to reduce consumption.
    a. Energy theft
    b. Cross domain insights

8. **The use of Forecasting within the energy system**

9. **Beyond just smart meters to an integrated communications and energy home, transport and lifestyle system**
    a. Integrating micro generation, home storage, transport infrastructure and the smart home. Include talking about market makers, new markets etc.
    b. Smart homes

10. **Cyber and physical security implications of energy systems**
    How as part of the critical national infrastructure should we be securing the communication channels, equipment and keeping data private in a new energy system where everything is 'smart'?

11. **Summary, Synthetisation and conclusions**

Course Text

https://ec.europa.eu/energy/sites/ener/files/documents/xpert_group1_reference_architecture.pdf

Last reviewed: 09/24

Sy4. Energy Systems; Economics and Markets (Hilary Term: Week 7)

Module Leader: Professor Steve Smith (Smith School of Enterprise and the Environment)

Course Context

Four of the six largest companies in the world by revenue are in the energy sector, which is at the start of a remarkable, once-in-a-civilisation transition. Coal is under severe pressure, and the oil and gas majors are rethinking their long-term strategies, driven by a combination of climate action, development goals and new technologies. After a brief background into the energy system, this course examines the shifts underway in technology, government policies for climate and energy, and economic and political issues across the energy supply chain. We introduce the basics of economics and finance, examin the potential for value creation as the transition to zero-carbon energy occurs around the world, and explore the social scientific dimensions of integrating those technologies into energy systems.

Lecturer

Associate Professor Steve Smith, Smith School of Enterprise and the Environment (stephen.smith@smithschool.ox.ac.uk)

Course Structure and Content

The course will cover the following content in eight, three-hour sessions:

1. Introduction, history and the present energy transition. Concepts and definitions. Brief overview of energy system history. Recent issues in energy markets. Introduction to the drivers of the present transition (new technologies and climate change).

   Economics. Fundamentals of demand, supply and markets. Price elasticity of demand and supply in the context of electricity. Welfare optimisation. Use of Python to model realistic electricity day-ahead wholesale market. Determination of electricity pricing using economic dispatch based on merit order considering network constraints. Introduction to nodal pricing.

2. Power markets. Challenge to power markets of very low marginal cost technologies. Balancing supply and demand. Functioning of wholesale power markets, balancing markets, capacity markets. Main approaches to regulation. Missing money problem. European day-ahead market orders. Uniform pricing vs pay-as-bid. Pool markets vs continuous trading.

3. Market liberalisation. Principles and objectives of market liberalisation. Experiences of liberalising OECD and non-OECD electricity markets. Interactions between liberalisation and decarbonisation. Current policy challenges. Case study and discussion.

4. Nexus! Challenge. The Nexus! board game - a playful exploration of resilience across the energy-water-food nexus.

5. Energy finance. Scale of the financing challenge for the energy transition. Financing of the energy supply chain. Finance in the context of political risk. Bankability of different energy revenue streams. Group finance exercise on financing offshore wind in the UK.

6. Energy access. Sustainable Development Goal 7. Energy use and energy markets in developing countries. The role of business in providing electricity for the 1 billion people without it. Grids vs distributed power generation.

7. Carbon markets. Compliance and voluntary markets. Interaction of energy firms with carbon markets. The problem of additionality. Carbon pricing and carbon offsetting in a net-zero world.

Each of the eight session has 1-2 essential readings and several additional readings. Useful references and sources of data include the annual publications of the International Energy Agency (IEA) World Energy Outlook, BP Energy Outlook, and the United States Energy Information Agency (EIA) Annual Energy Outlook, although you should not necessarily take numbers and certainly forecasts at face value.

Two very readable books on energy are:

- Helm, D. (2017) Burn Out: The Endgame for Fossil Fuels
- Yergin, D. (2012) The Quest: Energy, Security, and the Remaking of the Modern World.

Those wanting a more academic input can peruse journals such as Nature Energy, Applied Energy, or the Oxford Review of Economic Policy. Essential facts and figures can be found at Our World in Data.

Almost every 3-hour session has an external speaker for at least some part of the session. Speakers tend to be distinguished leaders in the energy industry, engaging communicators chosen for their experience in the application and limitations of concepts taught in this course. The sessions also include a multi-player game.

About the Lecturer

The course is taught by Professor Steve Smith, Associate Professor of Greenhouse Gas Removal at the Smith School. He is Executive Director of two programmes, both focussed on stabilising the climate both rapidly and sustainably: Oxford Net Zero and CO_2RE.

Steve's research interests lie at the intersection of climate science and policy. He has published on a range of topics including metrics for comparing the emissions of different greenhouse gases, and the governance of climate change mitigation. He is co-developer of a major global stocktake of net zero pledges. He joined the Smith School from the UK Department for Business, Energy and Industrial Strategy (BEIS) where he co-led the Climate Science Team and played a role in the legislation of the UK's net zero target. Before that he was Head of Science at the Committee on Climate Change. He has a PhD in atmospheric physics from Imperial College London and is a Fellow of the Royal Meteorological Society.

Course Structure

Timing

Please note morning sessions run ***0915-1215*** and afternoon sessions run ***1345-1645***. Wednesday and Friday contain morning sessions only (you have those afternoons free!)

Session 1: Introduction, history and the present energy transition

Session Content

Concepts and definitions. Brief overview of energy system history. Recent issues in energy markets. Introduction to the drivers of the present transition (new technologies and climate change).

Essential reading

- Energy Transition Commission (2017) Better Energy, Greater Prosperity, Executive Summary.
- International Energy Agency (2023) World Energy Outlook, Executive Summary.

Additional reading

- Fouquet, R. (2014). Long-run demand for energy services: Income and price elasticities over two hundred years. *Review of Environmental Economics and Policy*, 8(2): 186-207.
- Aurora Energy Research (2013) Predictable Surprises: Lessons from 30 Years of Energy Sector Forecasts, November.
- Segal, P. (2011). Oil price shocks and the macroeconomy, *Oxford Review of Economic Policy*, 27(1): 169-185.

Session 2: Economics

Session content

Fundamentals of demand, supply and markets. Price elasticity of demand and supply in the context of electricity. Welfare optimisation. Use of Python to model realistic electricity day-ahead wholesale market. Determination of electricity pricing using economic dispatch based on merit order considering network constraints. Introduction to nodal pricing.

Essential reading

- Pyomo Documentation

Additional reading

- Fundamentals of Power System Economics, Daniel Kirschen, Goran Strbac, 2nd Edition, 2018
- Biggar, D. R., & Hesamzadeh, M. R. (2014). The economics of electricity markets. John Wiley & Sons

Session 3: Power Markets

Session content

Challenge to power markets of very low marginal cost technologies. Balancing supply and demand. Functioning of wholesale power markets, balancing markets, capacity markets. Missing money problem. European day-ahead market orders. Uniform pricing vs pay-as-bid. Pool markets vs continuous trading.

Essential reading

- Green, R. (2005) Electricity and markets, *Oxford Review of Economic Policy*, 21(1): 67-87.

Additional reading

- Fundamentals of Power System Economics, D. Kirschen, G. Strbac, 2nd Edition, 2018
- Litvinov, E. (2010). Design and operation of the locational marginal prices-based electricity markets. IET generation, transmission & distribution, 4(2), 315-323.
- Joskow, P. L. (2008). Capacity payments in imperfect electricity markets: Need and design. *Utilities Policy*, 16(3), 159-170.
- Imran, K. and Kockar, I. (2014) A technical comparison of wholesale electricity markets in North America and Europe. *Electric Power Systems Research*, 108, pp.59-67.
- Farrell, N. et al (2017) Is this the end of conventional wholesale electricity markets?

Session 4: Market Liberalisation

Session content

Principles and objectives of market liberalisation. Experiences of liberalising OECD and non-OECD electricity markets. Interactions between liberalisation and decarbonisation. Current policy challenges. Case study and discussion.

Essential reading

- World Bank (2019) Rethinking Power Sector Reform in the Developing World.

Additional reading

- Sen et al. (2018) Have model, will reform: assessing the outcomes of electricity reforms in non-OECD Asia. *The Energy Journal*, 39(4) pp.181-209.
  Poudineh et al. (2018) Advancing renewable energy in resource-rich economies of the MENA. *Renewable Energy*, 123, pp.135-149.

Session 5: Nexus! Challenge

Session content

The Nexus! board game - a playful exploration of resilience across the energy-water-food nexus.

Session 6: Energy Finance

Session content

Scale of the financing challenge for the energy transition. Financing of the energy supply chain. Finance in the context of political risk. Bankability of different energy revenue streams. Group finance exercise on financing offshore wind in the UK.

Essential reading

- International Energy Agency (2024) World Energy Investment, Executive Summary.
- Kern et al (2014) From laggard to leader: Explaining offshore wind developments in the UK. Energy Policy, 69, 635-646.

Additional reading

- Covington et al. (2016) Global warming: Shareholders must vote for climate-change mitigation. *Nature*, 530(7589), 156.
- Milken Institute (2015) Innovative Financing Models for Energy Infrastructure in Africa.

Session 7: Energy Access

Session content

Sustainable Development Goal 7. Energy use and energy markets in developing countries. The role of business in providing electricity for the 1 billion people without it. Grids vs distributed power generation.

Essential reading

- Se4All (2023) Tracking SDG7: The Energy Progress Report.
- Shen, W. and Power, M (2017) Africa and the export of China's clean energy revolution, *Third World Quarterly*, 38:3, 678-697.

Additional reading

- M-KOPA (2015) Affordable, clean energy: A pathway to new consumer choices.
- World Bank Programme: http://www.scalingsolar.org
- Mulugetta et al. (2022) Africa needs context-relevant evidence to shape its clean energy future. *Nature Energy*, 7(1015-1022).
- Gies, E. (2016) Can wind and solar fuel Africa's future? *Nature*, 539: 20-22.
- Quansah et al (2016) Solar PV in Sub-Saharan Africa – Addressing Barriers, Unlocking Potential, *Energy Procedia*, 106: 97-110.

Session 8: Carbon Markets

Session content

Compliance and voluntary markets. Interaction of energy firms with carbon markets. The problem of additionality. Carbon pricing and carbon offsetting in a net-zero world.

Essential reading

- World Bank (2023) State and Trends of Carbon Pricing.
- Axelsson et al. (2024) The Oxford Principles for Net Zero Aligned Carbon Offsetting.

Additional reading

- Calel et al. (2021) Do Carbon Offsets Offset Carbon? *Grantham Research Institute on Climate Change and the Environment* Working Paper 371.
  Akerlof (1970) The Market for Lemons: Quality, Uncertainty and the Market Mechanism. *Quarterly Journal of Economics* 84(3) 488-500.

Review date: 09/24

3. Services Theme

What is energy for? Why and how is energy provided to society and how can the energy system change – or be changed by – demand for services? How might social and economic goals be met in future? This theme concentrates on the interface between people (individuals and organisations) and energy, considering the role of demand for energy and energy services in the broader energy system.

Se1. Energy Demand (Michaelmas Term: Weeks 6-7)*

Module Leader: Dr Sam Hampton (Environmental Change Institute, School of Geography and the Environment)

Course Context

The Energy Demand module introduces students to the end uses of energy, how they differ between and within societies (>Sy 4) and geographies. We will explore demand as a socio-technical evolutionary process driven by progress in technology (>Se 2), development (>Sy 2) and society (Se4/Sy4).

Students will gain a foundation and understanding of world energy demand, and the challenges and opportunities for changing demand through efficiency, behaviour change, and flexibility. Key concepts include socio-technical systems, energy services, energy efficiency, demand reduction, flexibility, and links beyond the energy system. Students will also be introduced to social scientific approaches to the study of energy, including different theories and methods. Key skills developed include critical evaluation and analysis, synthesis and presentation of data from diverse sources, reflexivity about studying complex systems using imperfect and incomplete data.

Assumptions: EVs and electrified heating are covered in Se2. Demand side policies are covered in Se4/Sy4.

Lecturers

Oxford based:
Dr Sam Hampton (Environmental Change Institute, School of Geography and the Environment)
Professor Nick Eyre (Environmental Change Institute, School of Geography and the Environment)
Dr Tina Fawcett (Environmental Change Institute, School of Geography and the Environment)
Dr Phil Grunewald (Engineering Science)
Dr Jesus Lizana (Engineering Science)
Dr JP Orjuela (Transport Studies Unit, School of Geography and the Environment)
Dr Marina Topouzi (Environmental Change Institute, School of Geography and the Environment)

Guest speakers
Professor Keith Hyams (Warwick University)
Wendy Stone (Global Academy)

Other speakers to be confirmed.

Course Content and Structure

The course will cover the following content in 30 ***1.5***-hour session*s:*

1. Energy and energy services. People and organisations use energy for a wide variety of purposes, but rarely ever consume energy for its own sake. The difference between the services we seek and the ways in which we achieve them have far-reaching implications for what we mean by energy demand and possible energy futures.

2. Energy in relation to other Sustainable Development Goals. Affordable and clean energy is one of 17 SDGs adopted by world leaders in 2015. The SDGs provide a framework for thinking about complexity, diversity, equity and human well-being in relation to environmental impacts.

3. Energy demand as a socio-technical system. Human activity, energy demand and energy services do not arise independently of technology. Instead, social processes and technological change can be considered as inter-dependent parts of a system which is therefore 'socio-technical' in nature.

4. Energy demand in buildings. Buildings account for a large and diverse share of energy demand worldwide. Innovations in technologies, processes and practices can all have an effect on energy demand. In theory, the demand reduction potential is large, but it remains difficult to achieve in practice.

5. Energy demand in transport. Transport energy demand is also large and varied. Mobility has links to different fuels and technologies, but also to patterns of social and economic activity, and to land-use and land-use planning.

6. Energy demand in industry. Goods and services provided by different kinds of industry account for a large share of energy use worldwide. This energy use can be analysed 'upstream' at the point of production but also 'downstream' at the point of consumption.

7. Energy efficiency and demand reduction. Energy efficiency has historically contributed to energy policy goals, and has the potential to continue to do so. Other routes to energy demand reduction (e.g., sufficiency) are also possible.

8. Understanding and comparing data for energy demand. Energy demand typically occurs in a highly distributed way, being made up of countless routine and strategic decisions by billions of people worldwide. This highly fragmented picture leads to numerous metrics and uses of energy data, which need to be analysed carefully if misleading conclusions are to be avoided.

9. Timing and flexibility of energy demand. With the rise of variable renewable energy supply and internet-enabled technologies, there is more potential than ever before to pay attention to the timing and flexibility of energy demand, which has the potential to contribute benefits to the wider energy system.

10. Thinking about future energy demand. Models and scenarios are widely used in strategic and policy debates about the future. Socio-technical systems thinking is useful when evaluating scenarios and the underlying assumptions about energy demand in relation to technology deployment

Course Texts

- Cooper, A.C.G., 2017. Building physics into the social: Enhancing the policy impact of energy studies and energy social science research. Energy Research & Social Science 26, 80–86. https://doi.org/10.1016/j.erss.2017.01.013
- Creutzig, F., et al., 2018. Towards demand-side solutions for mitigating climate change. Nature Clim Change 8, 260–263. https://doi.org/10.1038/s41558-018-0121-1
- Creutzig, F., et al, 2022. Demand, services and social aspects of mitigation. Cambridge University Press.
- IEA, 2022. Energy Efficiency 2022. Paris, France. https://www.iea.org/reports/energy-efficiency-2022
- Shove, E., 2003. Converging conventions of comfort, cleanliness and convenience. Journal of Consumer Policy 26, 395–418. https://doi.org/10.1023/A:1026362829781
- Shove, E., 2010. Beyond the ABC: Climate Change Policy and Theories of Social Change. Environment and Planning A 42, 1273–1285. https://doi.org/10.1068/a42282
- Shove, E., 2017. What is wrong with energy efficiency? Building Research & Information 1–11. https://doi.org/10.1080/09613218.2017.1361746

Last reviewed: 09/24

Se2. Energy and Society (Hilary Term: Week 2)

Module Leaders: Dr Nick Banks and Dr Jake Barnes (Environmental Change Institute, School of Geography and the Environment)

Course overview

Energy systems exist to provide energy services to people, and they are designed, operated, developed and (occasionally) sabotaged by people. It is reasonable to describe and analyse them as socio-technical systems, but the social dimension of energy systems is often missed or treated as an optional extra consideration.

This module aims to develop students' understanding of how energy systems are the outcome of interactions between technologies, infrastructures and people. It examines how energy systems evolve in response to technological development and innovation, changes in human activities and expectations, socio-political events, the economic context and governance arrangements.

Some of the talks will take a case study approach, showing how a technology and society dance together, evolving new ways of living and new technologies as they go – with attendant implications for energy demand and energy supply. Talks in the past taking this approach have focussed on:

- Place based approaches to roll out of heat pumps
- Social history of the motor car
- The impact of digital technologies and apps in shaping energy demand
- Interaction of heating practices with clothing styles and building design
- Evolution of vernacular architecture in Pakistan and associated changes in energy demand

Other talks will take a step back and explore the wider cross cutting issues. In the past we have had talks on:

- Energy equity and fuel poverty
- Geopolitics of energy transitions (the shift from fossil fuel powered economies to renewably powered economies)
- Energy system legislation at different scales
- Issues of race and ethnicity in the energy transition
- City scale governance for the energy transition

Learning outcomes

Students will learn how to analyse energy transitions in terms of:

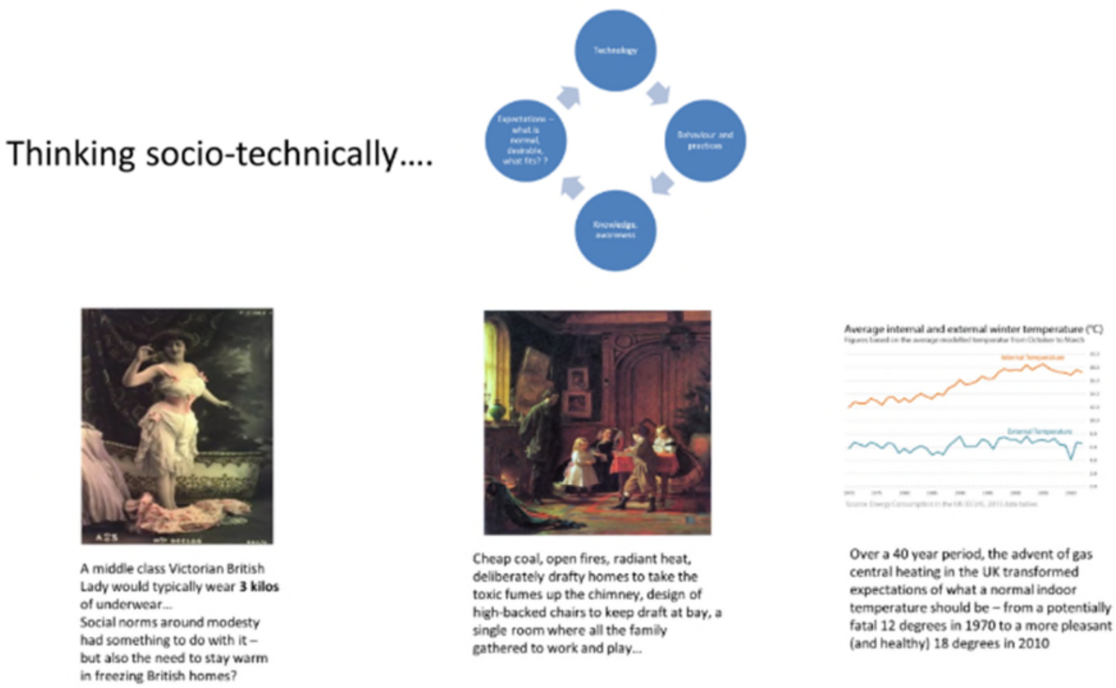
- The social history of technology
- The technical, social, economic and institutional attributes of people and communities and the interaction of these attributes to create a socio-technical context where some ways of living dominate whilst others are confined to the margins
- Socio-economic and geographical distribution of resources and the means to convert those resources into energy services and desirable outcomes
- Justice and fairness in the energy transition
- Technology adoption and adaptation in real-life conditions.

The teaching will build on teaching in the Energy Demand Module (SE 1) and the Energy Policy Module (SE 3).

Assessment

Each year we have chosen different assessment methods. However, the aim will always be to get the student thinking socio-technically and to give an opportunity to demonstrate what they have learned by exploring the interplay of the provision of an energy service (mobility, heating, refrigeration, cooking) or technology (the passenger car, central heating systems, refrigerators, the microwave oven) and the embedding societal context – drawing out implications for energy systems, energy policy, equity and societal change.

As an example of the approach we'd like student to take, consider the evolution of domestic heating in the UK where the convergence of availability of cheap coal, a newly prosperous middle class, a temperate climate, architectural styles, clothing styles (influenced by cheap cotton from the empire), the design of furniture which keeps the drafts at bay etc, all come together to sustain the practice of heating a living room with an open fire.



We aim to make the assessment exercise as interesting and enjoyable as possible. In the past we have asked the students to:

- Produce a research poster
- Write a 2000 word policy brief
- Record a 15 minute presentation

In the final session on Friday we will go through the assessment exercise in detail. The students will have lots of opportunity to ask questions and to understand how to do well in the assessment exercise.

Course staff

Dr Nick Banks and Dr Jake Barnes will lead the module with contributions from colleagues at the Environmental Change Institute and beyond. The details of guest speakers may vary, depending on their availability.

Dr Nick Banks

Nick is a senior researcher with the Energy Group at the Environmental Change Institute with over 25 years of experience in the sustainable energy field, specialising in behavioural research and the social dimensions of energy consumption and sustainability. In his current role as a researcher in Local Energy Systems he has a particular focus on low carbon technology adoption, energy equity, community engagement and methodologies for understanding the capability of a place to transition to low carbon living. Recent projects include “Project LEO” which explored governance, technical, market and social arrangements required to facilitate Smart Local Energy Systems and “Clean Heat Streets” which takes a place based approach to the challenge of installing dozens of heat pumps into a high diverse neighbourhood in Oxford.

nicholas.banks@ouce.ox.ac.uk

Dr Jake Barnes

Dr Jake Barnes is a researcher in the Energy group of the Environmental Change Institute, of the University of Oxford. Jake's research interests include the politics and sociology of innovation and change at community through city-regional scales to national systems. He has worked with local governments, community groups and social enterprises to reflect, learn and pursue societal transformations. His research is interdisciplinary and problem orientated, often combining different theoretical approaches to investigate how progress towards low carbon energy systems and sustainability transformations more broadly can be achieved. His work be split into two broad areas of interest: (1) Actors and their agency to pursue societal change, and (2) governing socio-technical change.

jake.barnes@ouce.ox.ac.uk

Course Content and Structure

The course will cover the content set out below. We will have two sessions in the morning and one in the afternoon, with time in the second half of the afternoon for further discussion and one-to-one guidance. However, there may be alterations depending on teaching conditions at the time.

Most of the talks will be given by invited speakers. We always emphasize that the talk should have plenty of time for interaction with and between the students by including micro-group exercises, lots of Q and A etc.

The precise scheduling of the speakers and their topics changes each year but we try to organise them into a theme for each day of the week.

Finalised details will be published on Canvas at least 1 week before the course is delivered. The general structure of the module and themes for each day are set out below:

Monday: Introduction to the Energy and Society module and then 2 sessions on “History and path dependency”
Introduction session

- Aims of the week
- Headline description of the various speakers
- Overlaps with Energy Policy Module and Energy Demand Module
- Discursive workshop type exercise led by Jake Barnes to warm the students up to the socio-technical perspective

History and path dependency sessions
- Energy systems as social systems, and vice versa.
- Energy services
- Infrastructures of demand and supply and how we engage with them.
- Energy transition – the global challenge.
- Actors in energy systems.

Tuesday: Geography, Space and Scale
- Place based approaches to system transition
- The Capability Approach, understanding place and design of interventions
- Engaging communities
- Transport, mobility and infrastructures
- Geopolitics of systems of energy provision
- Communicating energy – practical exercise.

Wednesday: Energy System transitions
- Transitions and practice theory – the nexus of society and technology
- Business models for local energy transition
- Digitisation
- Relationship between design of buildings, cultural norms for heating and clothing

Thursday: Energy equity
- Fuel poverty
- Inequities in the energy transition
- Race and ethnicity
- Legal structures and human rights

Friday: Synthesis day
- What are the main takeaways and how are they relevant to the rest of the course?
- Any unresolved issues?
- Fun, discursive session. Energy Quiz. Prizes may be awarded!
- Preparation for assignment.

Course Texts

Eyre, N., Darby, S.J., Grünewald, P., McKenna, E. and Ford, R., (2018) Reaching a 1.5C target: Socio-technical challenges for a rapid transition to low carbon electricity systems. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences* 376:20160462

Stephenson, J., Hopkins, J. and Doering, A. (2014) Conceptualizing transport transitions: Energy Cultures as an organizing framework. *Energy and Environment* 4 (4), 354-364

Wilhite, H. (2008) New thinking on the agentive relationship between end-use technologies and energy-using practices. *Energy Efficiency* 1, 121-130. Personal energy use in relation to system development

Khalid, R., Sunikka-Blank, M. (2018) Evolving houses, demanding practices: A case of rising electricity consumption of the middle class in Pakistan. *Building and Environment* 143, 293-305

Darby, S.J. and McKenna, E. (2012) Social implications of residential demand response in cool temperate climates. *Energy Policy*, 49: 759-769

Grunewald, P. and Diakonova, M. (2018) Flexibility, dynamism and diversity in energy supply and demand: A critical review. *Energy Research and Social Science*, 38: 58-66

Hargreaves, T., Wilson, C. and Hauxwell-Baldwin, R. (2017) Learning to live in a smart home. *Building Research and Information* 46 (1), pp.127-139

Energy system change as a social process. Boamah, F. and Rothfuss, E. (2018) From technical innovations towards social practices and socio-technical transition? Re-thinking the transition to decentralised solar PV electrification in Africa. *Energy Research & Social Science* 42, 1-10

BSECC: Bristol Smart Energy City Collaboration. Taking action to realise the benefits of smart energy data. https://www.cse.org.uk/projects/view/1296

Executive Summary of Darby, S.J., Liddell, C., Hills, D. and Drabble, D. (2015) Smart Metering Early Learning Project: synthesis report. For the Department of Energy and Climate Change, London https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/407568/8_Synthesis_FINAL_25feb15.pdf

Nolden, C., Barnes, J. and Nicholls, J. (2020) Community energy business model evolution: A review of solar photovoltaic developments in England. Renewable and Sustainable Energy Reviews 122, 109772. https://www.sciencedirect.com/science/article/pii/S1364032120300198

Parag, Y. and Janda, K.B. (2014) More than filler: Middle actors and socio-technical change in the energy system from the “middle-out”. *Energy Research & Social Science* 3, 102-112

Last reviewed: 09/24

Se3. Energy Policy and Governance (Hilary Term: Week 8)

Dr Tina Fawcett (Environmental Change Institute, School of Geography and the Environment)

Course Context

This module will provide an understanding of the social, economic, technical and political contexts in which policies are formed and implemented. Theories of policy making will be introduced. Students will learn about the different policy instruments and policy mixes used in various countries and contexts. Most focus will be on policies related to the energy transition – policy on energy efficiency / energy demand reduction and renewable energy. Throughout the module there will be examples of successful and unsuccessful policies from across the world. By the end of the module, students will understand how to critically analyse current and proposed policies against a range of criteria.

The teaching will build on the introductory material on policy covered in Se1, and rely on the strong socio-technical understanding of the energy system delivered by previous modules.

Lecturers

Dr Tina Fawcett will lead the module, with contributions from colleagues at the Environmental Change Institute and elsewhere.

Course Content and Structure

Elements of the course content may be delivered on different days from the description below, depending on the availability of external speakers.

Monday: Policy goals overview, case studies of policy making

A brief history of energy policy and why it matters. Discussion of the energy trilemma. Contrasts in policy for people / organisations / technologies / markets. Policy making from practitioners' perspectives – how does policy really get made?

Tuesday: Policy types and theories of policy making

Outline of different types of policy and policy combinations. Investigating theories of policy making and reflecting on how these match with real world case studies. How does change happen? Developing and promoting new policy ideas – examples from current ECI research.

Wednesday: International policy, politics & policy transfer

Contributions from a range of international policy practitioners, Q&A with students. The politics of energy policy, overview and examples from around the world. The Overton window of public and political acceptability. Theories of international policy transfer, illustrated with case studies.

Thursday: Governance, communities & public involvement

What do we mean by governance and who, if anyone, is in charge of the energy system? Exploring international, national and local energy governance. Focus on governance for energy system transformation. More democracy, not less: the role of democratic participation for climate action.

Friday: Policy into the future, new perspectives

What new policies, governance arrangements and ideas do we need for a just energy transition? Improving equity and sustainability in the energy sector. Focus on global North / South justice issues, particularly in relation to GHG emissions and climate impacts. A re-cap of the week. Introduction to the assignment.

Course Texts

Some of these papers / information sources would fit under more than one heading. It is not necessary to read them all, but worthwhile looking at one source from each category.

Energy policy: overview and aims of policy
World Energy Trilemma Index – this ranks countries on their ability to provide sustainable energy through 3 dimensions: Energy security, Energy equity (accessibility and affordability), Environmental sustainability. Use the 'Trilemma Tool' to explore different countries:
https://www.worldenergy.org/publications/entry/world-energy-trilemma-report-2024

Sterner, B. et al (2019) Policy design for the Anthropocene. *Nature Sustainability* 2:14-21 (Goes beyond energy – broad overview of policy options and key considerations in design.)

Current policy
Rosenow, J., Cowart, R., Thomas, S. (2019): Market-based instruments for energy efficiency: a global review. Energy Efficiency 12(5), pp. 1379–1398

Databases for policy measures:
MURE (Mesures d'Utilisation Rationnelle de l'Energie) provides information on energy efficiency policies and measures that have been carried out in the Member States of the European Union.
http://www.measures-odyssee-mure.eu/
International Energy Agency database: https://www.iea.org/policies - for global coverage

Policy making processes and evaluation
Obeng-Darko, N.A. (2018) Why Ghana will not achieve its renewable energy target for electricity. Policy, legal and regulatory implications. *Energy Policy* 128:75-83

EPATEE European project on evaluation – includes case studies from EU and USA:
https://epatee.eu/case-studies

Politics and policy
Cairney, Paul (2015) 12 Things to know about studying public policy.
https://paulcairney.wordpress.com/2015/10/29/12-things-to-know-about-studying-public-policy/

Mallaburn, P. and Eyre, N. (2014) Lessons from energy efficiency policy and programmes in the UK from 1973 to 2013. *Energy Efficiency* **7:** 23–41

Lamb, W., Mattioli, G., Levi, S., Roberts, J., Capstick, S., Creutzig, F., . . . Steinberger, J. (2020). Discourses of climate delay. *Global Sustainability, 3*, E17. doi:10.1017/sus.2020.13

Policies for a better future

ECEEE, AEEE, ACEEE (2019) 12 strategies to step up global energy efficiency: Advice from three expert NGOs to IEA's High Level Commission on Energy Efficiency: https://www.eceee.org/all-news/news/12-strategies-to-step-up-global-energy-efficiency/

Oxford Martin School (2024) Cooling the world without heating the planet: https://www.oxfordmartin.ox.ac.uk/long-read/cooling-the-world-without-heating-the-planet

Executive summary of: IRENA (2018) Renewable energy policies in a time of transition. https://www.irena.org/publications/2018/Apr/Renewable-energy-policies-in-a-time-of-transition

Bruun, E. and Givoni, M. (2015) Sustainable mobility: Six research routes to steer transport policy. *Nature* 523:29-31Green Alliance and CREDS (2020) Balancing the energy equation: Three steps to cutting UK demand https://www.green-alliance.org.uk/Balancing_the_energy_equation.php

Last reviewed: 09/24

Appendix 2: Complaints and Appeals

The University, MPLS Division and the Department of Engineering Science hope that provision made for students at all stages of their course of study will make the need for complaints (about that provision) or appeals (against the outcomes of any form of assessment) infrequent.

Nothing in the University's complaints procedure precludes an informal discussion with the person immediately responsible for the issue that you wish to complain about (and who may not be one of the individuals identified below). This is often the simplest way to achieve a satisfactory resolution.

Many sources of advice are available within colleges, within faculties/departments and from bodies such as the Student Advice Service provided by OUSU or the Counselling Service, which have extensive experience in advising students. You may wish to take advice from one of these sources before pursuing a complaint.

General areas of concern about provision affecting students should be raised through Joint Consultative Committees or via student representation on the faculty/department's committees.

Complaints

Concerns or complaints relating to teaching or other provision made by the faculty/department should be raised with the Course Director (Professor David Wallom), Deputy Course Director (Dr Sarah Sparrow) or Director of Graduate Studies (Professor Daniel Eakins) as appropriate. Within the faculty/department, the officer concerned will attempt to resolve the concern/complaint informally.

Student concerns can be taken further by making a formal complaint to the University Proctors. The procedures adopted by the Proctors for the consideration of complaints and appeals are described on the Proctors' webpage (Academic appeals, complaints and conduct) and the Student Handbook.

If a concern or complaint relates to teaching or other provision of a college, it should be raised either with the college tutor or with one of the college officers, a Senior Tutor, or Tutor for Graduates (as appropriate). The college will also be able to explain how to take a complaint further if a student is dissatisfied with the outcome of its consideration.

Academic appeals

An academic appeal is defined as a formal questioning of a decision on an academic matter made by the responsible academic body.

A concern which might lead to an appeal should be raised with the college authorities and the individual responsible for overseeing a student's work. It must not be raised directly with examiners or assessors. If it is not possible to resolve a concern in this way, it may be put in writing and submitted to the Proctors via the Senior Tutor of the relevant college.

As noted above, the procedures adopted by the Proctors in relation to complaints and appeals can be found via the following:

- Proctors’ webpage (https://www.ox.ac.uk/students/academic/complaints)
- Student Handbook (https://www.ox.ac.uk/students/academic/student-handbook?wssl=1)

In relation to academic appeals, please note that:

- The Proctors are not empowered to challenge the academic judgement of examiners or academic bodies.
- The Proctors can consider whether the procedures for reaching an academic decision were properly followed; i.e., whether there was a significant procedural administrative error; whether there is evidence of bias or inadequate assessment; whether the examiners failed to take into account special factors affecting a candidate’s performance.
- On no account should a student attempt to contact examiners or assessors directly.

Harassment

The University condemns harassment as an unacceptable form of behaviour and has an advisory system to help people who think they are being harassed. Harassment includes any unwarranted behaviour directed towards another person which disrupts that person’s work or reduces their quality of life. Further information and guidance are available at:

- www.admin.ox.ac.uk/eop/harassmentadvice
- http://www.admin.ox.ac.uk/eop/harassmentadvice/policyandprocedure/

The Engineering Science department has two advisors on harassment who can provide confidential support and guidance to students:

- Christine Mitchell, Head of Student Administration: christine.mitchell@eng.ox.ac.uk
- Helen Burton, HR Manager: helen.burton@eng.ox.ac.uk

Appendix 3: Small Group Case Study Guidance

You are a small but innovative energy consultancy that has been engaged by the Ministry for Energy of your assigned country to develop a national energy transition strategy. The country has made commitments to NetZero by 2050 and signed up to the 2015 Paris Agreement. It must also aim to at least maintain GDP per head and economic growth (i.e., the transition should be economically positive).

You are asked to deliver a 35-page report[*] and an additional 2-page executive summary, along with a video presentation on your strategy. The video should be no shorter than 30 minutes and no longer than 45 minutes. The minimum requirement is for a slide presentation with voice over, though improvements in presentation style are encouraged.

The report should be structured in the normal way that a consultancy report would be presented to a government. There should be a clear breakdown of the contributions made by each member of the group towards both the report and the presentation.

[*] Not including references and appendices though the total submitted report should not exceed 50 pages.

Appendix 4: Dissertation Proposal Form

Project Description

- Title
- Description (Max 15 lines)

Objectives:

- Easily Attainable
- Attainable
- Advanced

Supervision and assessment:

- Name of student (if topic has been student-led/amended)
- Supervisor name
- Co-supervisor
- Suggested 2nd assessor

Collaborators:

- External collaborators (name and contribution)
- Requirement of formal agreement

Practical considerations:

- External resources required (e.g. consumables, travel, technical workshops, IT support etc.)
- Health and Safety considerations:
    - Computer use: Y/N
    - Using hazardous substances: Y/N
    - Using nanomaterials: Y/N
    - Using biological substances: Y/N
    - Using lasers or high power LEDs: Y/N
    - Using components or systems pressurized with gases or compressed air: Y/N
    - Using liquefied gases e.g. liquid nitrogen: Y/N
    - Other hazard

Appendix 5: Dissertation Report Guidance

Planning

Examination Regulations require each MSc candidate to submit a dissertation of not more than 15,000 words on a topic selected by the candidate in consultation with the supervisor and approved by the Standing Committee.

The report must not exceed 75 pages (including all diagrams, photographs, references and appendices). All pages should be numbered, include margins of not less than 20 mm on all sides and use a font size not less than 11 points, with line spacing of no less than 8 mm.

Before starting to write, be clear what is the purpose of the report and who will read it. The principal readers will be one or more examiners or assessors. However, subsequent readers may include students, technical staff and academics.

Structure

A report should include the following:

- Cover and Title Page: the project title, the author and their college affiliation should be prominently displayed, both on the front cover and on the first page. Your candidate number **must not** be included.
- Acknowledgements should be made of sources of help and finance.
- Abstract: a summary of the project, not longer than one page in length. This is best written last.
- Contents page giving page numbers of the main sections and sub-sections of the report.
- Sectional structure – for example:

  1. Introduction
  1.1 What the project is about
  1.2 How the report is organised
  2. Literature Review
  3. Methodology
  4. Results
  4.1 Presentation of collected data or input
  5. Discussion
  5.1 Analysis of results
  5.2 Presentation of findings from analysis
  6. Conclusions
  6.1 Summary, recapitulating what was achieved
  7 Recommendations for future work

  n+1. References Appendices

  All projects should include a review of appropriate research literature.

  The two Sections 'Introduction' and 'Conclusions' should make sense if read together without the intervening sections.

- References are an essential part of any technical report because credibility depends not only on a clear explanation of what has been done, but also on showing how it relates to, or builds on, prior knowledge. References to other work, whenever it is used, should be included in a way that clearly distinguishes between the work of the report and the work of others. Refer also to the source of any quoted text or diagrams or other graphics. (See section 3 on the style of references.)

- Appendices should record information that is likely to be of use to the reader who seeks detailed information, but which is not essential to an understanding of the report. For example: tables of numerical data, computer source-code, details of electronic circuits (if incidental to the main body of the text). Appendices are included in the page count.

Style

- Authors should concentrate on communicating with readers. For engineering projects, readers may be assumed to understand engineering language but not to know anything about the subject of the project. A report suitable for a reasonably competent contemporary engineering student would be at about the right level.

- For formal reports, such as these are, use the third person passive. For example, 'In Section 2 it is shown that . .' rather than 'I found that . .'

- Avoid jargon. Define any unusual terms or acronyms wherever they first appear.

- Spelling and grammar are important.

- Reports should be presented to give a good impression.

- Guidance can also be found in the books listed in the bibliography below.

Figures, Tables and Equations

Every figure and table should have a caption and should be explicitly referred to in the text, using a numbering system that identifies the object within its section of the report. For example, Figure 3.4 would be the fourth figure in Section 3. Place the figure or table near the text that refers to it, but not necessarily embedded within word-processed text.

Diagrams in the main text of a report should be simple and clear. Detailed material, such as engineering drawing or computer source code, is often better placed in an appendix. Tabulated data can sometimes be represented in graphical form in the main text. Large sets of numbers, if they must be included, should be placed in an appendix.

Equations should in general be numbered either sequentially or using a numbering system as for figures.

References

There are two main styles for references:

- A numerical system with a number in square brackets in the text after each reference, the numbers running in sequence starting at the beginning of the report, with a numbered list of references in the same order at the end of the report.

- Reference by author name(s) and date of publication in the text with the list of references at the end of the report arranged in alphabetical order according to the surname of the first author. This second method is recommended because it more easily accommodates changes during composition.

Examples of referencing systems can be found in most periodicals in the departmental Library, and in some of the books mentioned in Section 5. Where quoting web pages the full description of the document (including its electronic source data) must be given using the following format: Creator's surname, creator's first name. Title. Date of publication. Name of Institution associated with site. View date. <http://address/filename>.

Practical advice

- Writing a report is not a trivial task, so allow plenty of time (i.e., weeks, not days).

- Plan the structure as early as possible. In consultation with your supervisor, decide what will be the main technical sections of the report. The structure is not developed to show the chronology of the work, but rather to help communicate the nature of the work done (hindsight is very useful!).

- Agree with the supervisor a schedule which exploits the full time available and allows time to receive sufficient guidance on writing your report. Note that supervisors are expected to:

- Discuss in detail the student's outline for the report.

- Look carefully at the early drafts of chapters, making reasonably detailed comments and constructive suggestions on both the content and style (including grammar).

- Give a quick overview of later drafts, but not the finished report, and point out any major problems.

- Before submitting a final version, ask a friend to read the report and comment on it. Or have it read aloud. Failing these, re-read the report a few days after completing it. Residual errors can be detected by this procedure.

Bibliography

Strunk W & White E B, 'The Elements of Style', MacMillan 1995 Gowers E, 'The Complete Plain Words', Penguin 1987

Fowler H W, 'The new Fowler's modern English usage', Clarendon, 1996 Davies J W, 'Communication for Engineering Students', Longman, 1996 Turk C and Kirkman J, 'Effective Writing', Chapman and Hall 1989

Sharp J A & Howard K, 'The Management of a Student Research Project', Gower 1996

Appendix 6: Dissertation Marking Scheme

Introduction (/10)

- Has the topic of study been introduced, stating clearly its relevance using a set of well described aims and objectives?
- Does the introduction make clear for the reader how the candidate has approached the problem?

Literature Review (/15)

- Is the review well-ordered showing a clear logical structure displaying an understanding of relevant literature that is used to form the basis for the investigation?
- Are the sources used timely and academically qualified to provide justification in their usage?
- Are sources correctly referenced in a consistent/appropriate manner?

Methodology (/25)

- Is the research methodology appropriate to the objectives of the study being conducted? Are there clear rationales for the methods chosen that are well described?
- Has the methodology been evaluated against other possible methods or structures to show that there is justification for that chosen?

Results & Discussion (/25)

- Is the data collected during the study relevant to the objectives and aims of the study?
- Are appropriate data visualisation tools and techniques utilised where insights are presented or claimed to be shown by the data?
- Are appropriate considerations of uncertainty, errors and or omissions made by the student wrt the data collected, i.e., are there improvements they could make with hindsight?
- Are the results discussed appropriately such that they are compared to available research elsewhere?

Conclusion (/20)

- [Note: Students are given the option of using their conclusion section as a draft publication to showcase their results. Therefore, alongside this will be a brief Summary conclusions section.]
- Have the research aims and objectives, the research question, been evaluated in light of the results and discussion?
- Does the study show that by building on results and discussion that appropriate conclusions can be made?
- Can the conclusions have been made more generally applicable beyond any specific use cases or examples?
- Has the student outlined possible future work that could be conducted in light of their research outputs?

Report Structure and presentation (/5)

- Is the report correctly structured, following guidelines originally given to the students?

- Is there correct labelling of figures/tables in a manner such that it is consistent throughout and able to be followed?
- Is the text free of grammatical errors to a level that would be expected of a professional document?
- Are all external sources correctly cited within the text with references recorded in a consistent manner?

Appendix 7: Guidance in the event of an attack by an armed person or persons

1. Be prepared and stay calm

The purpose of this guidance is to alert and not to alarm – it is not being provided in response to any specific information. Although students are asked to be mindful and alert, please do not be overly concerned. You are asked to carry on with your day-to-day life as normal.

In the event of an incident, quickly determine the best way to protect yourself.

2. Evacuate

- If it is possible to do so safely, exit the building or area immediately
- Have an escape route in mind (Fire Exit signs are a good point of reference)
- Evacuate regardless of whether others agree to follow
- Help others, if possible
- Prevent others from entering the area of danger
- Do not attempt to move wounded people
- When you are safe, call 999 and ask for the police

3. Hide

- If evacuation is not possible, find a place to hide where the offender is less likely to find you
- If you are in a room/office, stay there
- If you are in a corridor, get into a room/office
- Lock the door and blockade it with furniture
- Silence your mobile phone and remain quiet
- Turn off the lights and draw any blinds
- Hide out of view and behind something solid (desk or cabinet)
- If it is possible to do so safely, call 999 and ask for the police

4. Inform

If you contact the police, provide the following information:

- Location of and the number of offenders
- Any physical descriptions of the offenders
- Number and type of weapons used by the offenders
- Number and potential victims at the location
- Your location

Stay Safe

Further information and advice are available from Oxford University Security Services (telephone 01865 (2)72944 or email: security.control@admin.ox.ac.uk).

This handbook applies to students starting the MSc Energy Systems in October 2024.

The Examination Regulations relating to this course are available at:
https://examregs.admin.ox.ac.uk/Contents

MSc in Energy Systems (full-time):
https://examregs.admin.ox.ac.uk/Regulation?code=mosbcinenersyst&srchYear=2024&srchTerm=1&year=2024&term=1

MSc in Energy Systems (part-time):
https://examregs.admin.ox.ac.uk/Regulation?code=mosbcienersyst-p-t&srchYear=2024&srchTerm=1&year=2024&term=1

If there is a conflict between information in this handbook and the Examination Regulations, then you should follow the Examination Regulations. If you have any queries, please contact mscprogrammes@eng.ox.ac.uk.

The information in this handbook is accurate as of 9 October 2024 however, it may be necessary to make changes in course provision. For more information, please visit https://www.ox.ac.uk/admissions/graduate/courses/changes-to-courses.

MSc Energy Systems
2024: version 1.0

For the latest version of this handbook, please see https://www.eng.ox.ac.uk/mscenergy/.

Contents

1. Introduction

We are delighted to welcome you to the MSc in Energy Systems course.

The transition of worldwide energy systems towards cleaner sources is one of the biggest challenges of the twenty-first century. We aim to equip you with the best possible appreciation of the complex issues facing the development of energy systems, to ensure that industry and government policies can address these challenges most effectively.

The University of Oxford is recognised as a leader in interdisciplinary energy research, nationally and globally. The creation of the Oxford Energy Network (www.energy.ox.ac.uk) has brought together some 200 energy researchers from 19 departments and institutions from across the university.

In this multi-disciplinary course, you will be taught by energy researchers from across the University of Oxford, including academics in the departments of Engineering Science (the admitting department for the course), Physics, Materials Science, Chemistry, Economics, International Development, and the School of Geography and the Environment. Together the research carried out by these departments addresses the major technical, social, economic and policy challenges of providing secure, affordable and sustainable energy for all. We additionally engage with small and large energy companies, government agencies and NGOs around the world. Major industrial collaborators include BBOXX, Bosch, BP, British Gas, EDF, E.ON, Jaguar Land Rover, Johnson Matthey, KETEP, Mitsubishi Heavy Industries, National Grid, Nissan, Rolls-Royce, Samsung, Shell, Siemens, SSE, Statoil, and UK Power Networks.

We hope that you will be very happy at the University of Oxford, and that you will flourish academically and personally during your time here. The collegiate University provides a diverse range of opportunities to learn new skills, and we encourage you to make the most of what we offer. I trust that you will become active participants and engage with the many events and activities that we host.

Professor David Wallom
Course Director

Professor Sarah Sparrow
Deputy Course Director

1.1 Important dates

2024-2025 Academic Year

Monday 7 October 2024	Departmental Induction
Sunday 13 October	Start of Michaelmas Term
Friday 29 November	R1. Energy Sources assignment deadline
Saturday 7 December	End of Michaelmas Term
Friday 20 December	Sy1. Energy Infrastructure assignment deadline
Friday 3 January 2025	Se1. Energy Demand assignment deadline
Friday 10 January	R2. Energy Conversion 1 assignment deadline
Sunday 19 January	Start of Hilary Term
Friday 28 February	Sy2. Energy for Development assignment deadline
Friday 7 March	Se2. Energy and Society assignment deadline
Saturday 15 March	End of Hilary Term
Friday 21 March	R3. Energy Conversion 2 assignment deadline
Friday 28 March	Sy3. Digitization, Smart Energy and Communication assignment deadline
Friday 11 April	Sy4. Energy Systems: Economics and Markets assignment deadline
Friday 18 April	Se3. Energy Policy and Governance assignment deadline
Sunday 27 April	Start of Trinity Term
Friday 2 May	Whole Cohort Exercise presentation and event
Friday 16 May	Small Group Case Study video presentation and report deadline
Saturday 21 June	End of Trinity Term
Monday 1 September	Dissertation deadline

1.2 Key Contacts

Professor David Wallom, Course Director (director-energyms@eng.ox.ac.uk)

Professor Sarah Sparrow, Deputy Course Director (sarah.sparrow@oerc.ox.ac.uk)

Dr Erin Nyborg, Course Administrator (mscprogrammes@eng.ox.ac.uk)

Engineering Science IT Helpdesk: https://thehub.eng.ox.ac.uk

1.3 Disability

If you have any form of disability, we strongly encourage you to disclose this to the Head of Student Administration in Engineering Science, Christine Mitchell (christine.mitchell@eng.ox.ac.uk), so that we can make provision for you. Your college will advise you of your Disability Contact, who will be pleased to talk to you in the strictest confidence.

Students with a disability may also find useful advice and guidance on the University of Oxford Disability Office web page: www.ox.ac.uk/students/welfare/disability.

1.4 Virtual Learning Environment

This course uses Canvas, a web-based Virtual Learning Environment (VLE), to deliver information on the course's modules.

- Induction materials
- Reading lists for each module
- Hand-outs and presentations from modules
- Links to resources on academic good practice and study skills
- Forums - for tutor-student and student-student interaction

You can log onto Canvas using your Single Sign-On (SSO) at https://canvas.ox.ac.uk/. If you are unable to access Canvas, please email the course administrator with details of your SSO.

1.7 Online Presence, Virtual Meetings and Video Conferencing

Students are expected to attend all teaching sessions in person. Where necessary, we will use MS Teams to enable speakers to present remotely.

1.8 Sources of information

The University Student Handbook provides general information and guidance on making the most of the opportunities on offer at the University of Oxford. It also explains the University's codes, regulations, policies and procedures.

The Oxford Students website provides a single point of access to information, services and resources for students.

The Student Self Service portal enables you to register, view and update your personal and academic information throughout your studies at Oxford. You must complete your annual registration at the start of your course and each successive year.

The Graduate Supervision Reporting system allows you and your supervisor to record and review your progress. You can access the GSR system via the Student Self Service portal.

2. Course content and structure

2.1 Course aims and learning outcomes

The course is designed to be accessible to those who have a first degree in engineering, the physical sciences or geography. By the end of the course, you will have acquired:

- A fundamental understanding of the interdependencies in energy systems;
- A substantial base of knowledge in the processes involved from energy conversion to delivery;
- A broad knowledge of technical and societal options that could contribute towards future systems and an understanding of where more detail may be obtained;
- Economic, legal and scientific tools to weigh up and compare the relative merits and limitations of system options;
- Knowledge of key authoritative sources of information to inform decision making and the ability to question these;
- Methods to critically assess the validity and merit of energy policies and strategies;
- An ability to communicate complex energy issues across disciplines and publics;
- Experience of professionally presenting possible solutions to complex problems within energy.

2.2 Course structure

The MSc in Energy Systems can be studied full time, or part time over two or three years.

Candidates will complete and be assessed on the following parts:

1. Submission of written assignments in each of the following foundation modules:
    a. Energy Sources
    b. Energy Demand
    c. Energy Infrastructure
2. Submission of written assignments corresponding to a minimum of six and a maximum of seven further taught modules chosen from those listed in the Course Handbook
3. A group case study project
4. The whole cohort industrial case study
5. A dissertation of not more than 15,000 words and/or 75 pages on a topic selected by the candidate in consultation with the supervisor and approved by the Standing Committee.

The programme is at level 7 in the Framework for Higher Education Qualifications (England, Wales and Northern Ireland)[1], which means it is equivalent to Masters Level. It meets the subject benchmark statement for Engineering at Masters Level, published by the Quality Assurance agency.[2]

[1] https://www.qaa.ac.uk/docs/qaa/quality-code/uk-quality-code-for-higher-education-2024.pdf
[2] https://www.qaa.ac.uk/docs/qaa/sbs/sbs-engineering-23.pdf

3. Taught modules

3.1 Teaching and Learning

The course is split into three core themes:

- Resources – How is energy produced, converted, and traded? What energy technologies are available, what energy differences are there between different parts of the world?
- Systems – How is energy distributed so that it is usable and what are the considerations that need to be made for bridging between producers and consumers?
- Services – What, why and how is energy provided or made available to society and how may it change or be changed by society? This theme concentrates on the interface between people and energy, and considers the consumptive end of the energy chain.

Each theme includes a set of taught modules. The three mandatory foundation modules (starred below) are each two weeks long, and the remaining seven modules are one week long. Modules are delivered using a mixture of lectures, tutorials, classroom discussion and external speaker seminars. Energy Infrastructure is taught wholly in a tutorial style and therefore it is not possible to supply notes beforehand. An example completed set of notes will be made available at the end of the module.

Students on the full-time course will take all taught and non-taught elements over the course of one year.

In Year 1, students on the 24-month part-time course, must complete the Resources theme modules (indicated in **red**). They are also free to choose to complete either, or neither, of the Systems (elements indicated in **blue**) or Services (elements indicated in yellow) theme modules in that year. In Year 2, students on the 24-month programme will complete all modules in those themes (either Systems and/or Services) that they did not complete in Year 1, and the dissertation (indicated in green). The Small Group Case Study and Whole Cohort Exercise can be taken in either year. Students can complete one group exercise in each year or complete both group assessments in the same year. The two skills training weeks are not assessed, but are to be completed at the prescribed time due to dependencies of taught elements on the skills given.

Students on the 36-month part-time course will complete the Resources theme modules during their first year (indicated in **red**). In the second year, part-time students (36 months) may take either the Systems (indicated in **blue**) or Services (indicated in **yellow**) theme modules. In the final year, part-time students (36 months) will complete modules from the theme that they did not complete in Year 2, and the dissertation (indicated in **green**). The Small Group Case Study and Whole Cohort Exercise can be taken during any year of the course. We would recommend completing one group assessment during each of the first two years of the course. The two skills training weeks are not assessed but are to be completed at the prescribed time due to dependencies of taught elements on the skills given.

Term	Week 0	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
Michaelmas	Induction and Research Challenge	Resources 1: Energy Sources (CORE)		Skills 1	Systems 1: Energy Infrastructure (CORE)		Services 1: Energy Demand (CORE)		Resources 2: Energy conversion 1, Fixed generation sources
Hillary	Dissertation Planning 1 Small group case study preparation	Systems 2: Energy for Development	Services 2: Energy and Society	Skills 2	Resources 3: Energy conversion 2, distributed and renewable generation	Systems 3: Energy digitiisation, smart energy and communication	Whole Cohort Exercise Planning	Systems 4: Energy Systems: Economics and Markets	Services 3: Energy policy and governance
Trinity	Whole Cohort Exercise Preparation, presentations and event (Weeks -1 to 1) Dissertation Planning 2		Small group case study, including report presentation		Dissertation (Weeks 4 to 16)				

	Full time	2 year part time	3 year part time
Red	Year 1	Year 1	Year 1
Blue	Year 1	Year 1 or Year 2	Year 2 or Year 3
Yellow	Year 1	Year 1 or Year 2	Year 3 or Year 2
Grey	Year 1	Year 1 or Year 2	Year 1, 2 or 3
Green	Year 1	Year 2	Year 3

2-Year PT students may choose the year in which to complete Systems & Services themes. The course must be notified of the choice of order by MT WK2 in year 2

3-Year Part-time students may choose the order of studying the Systems or Services themes in years 2 & 3. The course must be notified of the choice of order by MT WK2 in year 2.

Part-time students may begin the development of their dissertation projects at any point up until wk1 TT of their final year.

[Hatched weeks are not assessed]

All modules of an individual theme must be taken in the same academic year unless special dispensation is applied for which will only be given in very limited circumstances.

Module descriptions can be found in Appendix 1.

All teaching will be held in the ground floor Teaching Room at Holywell House, Osney Mead. Space for independent study and collaborative working in groups will be available within the Department of Engineering Science.

During the induction week, students will be placed into small groups and asked to address a specific research challenge which covers the disciplinary breadth of the course. Each group will contain at least one student with a particular strength in each of the subject areas, who will be able to explain concepts to fellow students where needed. This exercise is not assessed but encourages a better appreciation of the subject and helps to develop successful working relationships among students.

3.2 Assessment of taught modules

The taught module assessments combined contribute 50% of the overall marks for the degree.

Students must attend and submit assessments for **all** taught modules. Of these, the three foundation modules and the best six results from the remaining modules will be taken by the Board of Examiners to contribute towards your overall degree result.

Each taught module will be followed by an assessment. Assessments may take different forms: written essay-type questions, consultant style reports and worked problems, video presentations or poster designs. The form of the assignment being chosen by the module leader may not be consistent year by year. Students are expected to spend approximately twice the amount of time on their foundation module assessments as on the seven single-week modules. A rule of thumb is that for each week of taught program a student should spend approximately 20 hours completing a related assignment.

Each module assessment question paper will be distributed at 12.00 noon on Inspera on the penultimate teaching day of the module and will include the format of the assessment. Students have five weeks to complete the exercise and submit it electronically through Inspera, the University's secure submissions portal.

We have introduced a system of indicative deadlines to help students better plan their time and avoid becoming overwhelmed by successive deadlines. For each foundation module assignment, we recommend that you aim to spend no longer than 4 weeks. For all other single-week modules, you should aim to spend a maximum of 2 weeks.

Online submission

During the course you will be required to submit work through Inspera, a secure submissions portal, which you can access using your SSO at https://oxford.inspera.com/. **You must** submit your assignments online using Inspera by the date specified on the assessment question paper. You are required to submit a declaration of authorship, confirming that the work you are submitting is your own. You should keep copies of all submitted work.

All submitted written assignments must include a word count on the title page. Where applicable, students should also indicate their observance of other limitations and requirements (for example, the running time of a video presentation should be stated, along with the time limit stipulated in the assignment question paper).

There are penalties for work submitted late without prior agreement. Details are set out in Section 3.6 of the course's Examination Conventions.

If you submit your work late, or do not expect to be able to meet a forthcoming deadline, the University Students website provides a helpful guide that explains the steps to take: https://www.ox.ac.uk/students/academic/exams/problems-completing-your-assessment.

If you are unsure about any element of the procedure for submitting your work, or are encountering difficulty submitting your work, please contact the MSc Programmes Administrator.

Please refer to the course's Examination Conventions for procedures relating to assignment resubmission.

Provisional Marks and Feedback

Six weeks after the assignment deadline, you will receive a provisional mark and qualitative feedback from the assessors. Please note that these marks will remain provisional until approved by the final Board of Examiners meeting

Marks and feedback for each assignment will be uploaded to each student's private SharePoint folder. The MSc Programmes Administrator will send you an access link.

This taught module assignment feedback will take the form of statements describing the top 3 improvements that could be made to the submission in the opinion of the assessor.

It is intended that a more standard rubric of comments will be developed to simplify the feedback process.

No feedback will normally be given for the Small Group Case Study, Whole Cohort Exercise or Dissertations.

3.3 Programming and data skills

We hold skills training sessions in Week 3 of Michaelmas and Hilary terms. Although not assessed, these sessions provide important material relating to the taught modules and contribute to students' overall development. This year's topics are:

Michaelmas Term, Week 3	Topic
Day 1	Systems Thinking
Day 2	Scientific Programming in Python
Day 3	Scientific Programming in Python
Day 4	Scientific Programming in Python
Day 5	Essay Writing and Critical Thinking; Presentation Bootcamp

Hilary Term, Week 3	Topic
Day 1	Research Ethics
Day 2	Project Management
Day 3	Project Finance
Day 4	Data Management
Day 5	Scientific Visualisation

4. Group work

4.1 Small Group Case study

During Hilary term, students begin planning an energy transition case study in small groups. Topics will be made available at the start of the course. The content of lectures in the modules and skills training will provide important context for these case studies.

During Weeks 2 and 3 of Trinity term, each group will produce a video presentation and report. At the end of Week 3, each group will submit their video presentation and report, which will be assessed by the course director and assessors. The outputs each comprise 50% of the total mark and will constitute 15% of the overall degree mark. Full details of the guidance given are in Appendix 3.

4.2 Whole Cohort Exercise

During Hilary term, the cohort will partner with an external stakeholder to begin planning the shape and context of their agreed energy-related problem. The exercise will be overseen by the course director, with a team of academic supervisors contributing their expertise to the group where requested.

During Week -1 to Week 1 of Trinity term, the cohort will finalise a coherent series of presentations, posters and a multi-chapter report. Each cohort member is expected to submit contributions to the assigned author of each chapter.

The Whole Cohort Exercise constitutes 10% of students' overall degree mark. Students cannot pass the course without successfully completing it.

The entire cohort will receive the same mark, awarded by an academic panel. The external stakeholder will provide feedback to better inform the panel and its assessment. Students will receive feedback from the partner organisation and the academic supervisors at a dedicated event following the presentations.

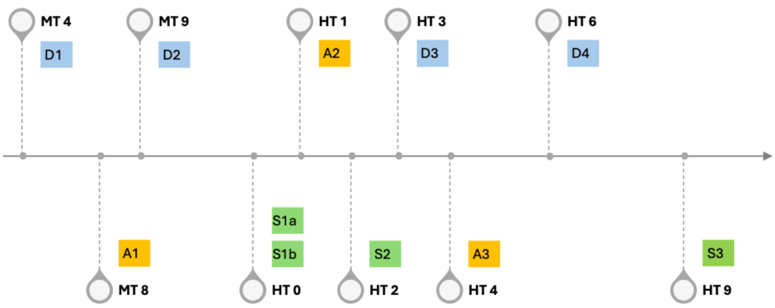
5. Dissertation

5.1 Scope, topic selection and approval

Each student's dissertation topic must relate to energy systems as defined by the topics covered in the taught modules.

A list of potential dissertation projects and supervisors will be published at the end of Michaelmas term (Week 9). Alternatively, students can propose their own topic, provided it aligns with the headings presented in the taught modules or refine existing topics. To do this, students must identify an appropriate supervisor and work with them to define the topic. The supervisor will then submit new/amended dissertation proposals no later than Hilary Term Week 2 denoting the student the topic was developed with. All topics are subject to approval by the Course Director and Deputy Course Director. Students considering pursuing a topic of their own devising are strongly advised to begin preparation as early as possible.

A dissertation briefing will be provided in Week 0 of Hilary term. Students will have the opportunity to meet potential supervisors during the term. Once a student has discussed topics with potential supervisors, they must ensure the supervisor submits any amendments by Hilary Term Week 1. Details of the dissertation proposal form are given in Appendix 4 of this handbook. Students must submit their 1st choice dissertation topics along with two reserve topics by Hilary Term week 2. Student choices are collected via the webform circulated by the Deputy Course Director . The Course Director and Deputy Course Director will review and allocate topics based on student choices and supervisor load. Except in exceptional circumstances, supervisors are limited to three dissertation topics per year. Project allocations will be circulated to supervisors and assessors in Hilary Term week 3 for review before students are notified in Hilary Term Week 6. A summary of the timeline is given below.



Deputy Course Director	Supervisors/Assessors	Students
• **D1:** Call for projects • **D2:** Release topics to students • **D3:** Project allocations circulated to supervisors and assessors • **D4:** Project choices confirmed to students	• **A1:** Project proposals submitted • **A2:** Student proposals/project amendments submitted • **A3:** Review project supervision and assessment allocation	• **S1a:** Discuss listed projects with supervisors • **S1b:** Proposal of own topic/topic amendments discussed and defined with supervisors • **S2:** Submit 1st choice dissertation and 2 reserve topics • **S3:** Submit any required ethics applications

Part-time students will begin their dissertation preparation in the final year of their course.

Notes

Where supervision is provided by a researcher at the Oxford Institute for Energy Studies (OIES), students will need to arrange a co-supervisor who is a member of the University of Oxford.

If a dissertation is likely to require approval by a university ethics panel, this should be identified as soon as possible. To allow sufficient time for approval to be sought, students should work with their supervisor to submit the required forms by Week 9 of Hilary term at the latest.

5.2 IP and Ownership of Data

If a student intends to base their dissertation on data collected by a company or other institution, it may be necessary to set up an agreement establishing intellectual property and ownership of data and results. This must be discussed with the dissertation supervisor. In such circumstances, students will be required to sign a non-disclosure agreement; additionally, dissertations will be marked as confidential and not disclosed. Where external examiners request to see these reports, a non-disclosure agreement can be signed if considered necessary. Reports will be reviewed very carefully by the supervisor from the institution concerned to identify any sensitive material.

5.3 Supervisor support

During the period designated for the dissertation, supervisors will provide a face-to-face or video conferencing meeting lasting one hour, every two weeks. It is the student's responsibility to arrange and agree the dates for these meetings. Students may also request advice by contacting their supervisor by email.

Supervisors will read and provide written feedback on one full draft of students' dissertations, provided it is sent to the supervisor by the Monday of 16th Week of Trinity term.

5.4 Report design

The dissertation must be no more than 15,000 words. Footnotes and endnotes are included in the word count. Bibliographies, tables, appendices and references are **not** included in the word count. Reports should be in the normal format for academic publications, including the following sections: abstract, introduction, methods, results, discussion, conclusions, references, and appendices.

Further guidance on the structure and production of the dissertation is given in Appendix 5.

5.5 Submission

Dissertations must be electronically submitted by the deadline. Submissions are made via Inspera in the normal way.

5.6 Dissertation assessment

The dissertation will account for 25% of the overall degree mark. It will be assessed according to the marking scheme shown in Appendix 6. Candidates who fail to achieve an overall mark of 50% or over in the dissertation may resubmit the failed assessment on one occasion only.

6. Good academic practice and avoiding plagiarism

Plagiarism is presenting someone else's work or ideas as your own, with or without their consent, by incorporating it into your work without full acknowledgement. All published and unpublished material, whether in manuscript, printed or electronic form, is covered under this definition. Plagiarism may be intentional or reckless, or unintentional. Under the regulations for examinations, intentional or reckless plagiarism is a disciplinary offence. Please review the Oxford Student's website guidance on plagiarism: www.ox.ac.uk/students/academic/guidance/skills/plagiarism.

Each student is **required** to complete the Avoiding Plagiarism course and gain the associated certificate. Once completed, students should send proof of their certification to the course administrator.

All dissertations will be screened by Turnitin software which will assess submissions against published and unpublished sources and the work of other students. Assignments from the taught modules may also be screened in the same way. Examiners will be notified of the extent of any textual matches discovered by Turnitin and will consider whether any text has been properly identified and referenced.

The Examination Conventions set out the academic penalties for (a) intentional or reckless plagiarism, and (b) poor academic practice.

Study skills

Guidance on time management, note-taking, referencing, research and library skills and information is available at www.ox.ac.uk/students/academic/guidance/skills.

7. Course feedback

At the end of each taught module, students will be asked to provide feedback via an anonymous survey. It is very important that students complete this survey to help us monitor teaching quality and to make necessary adjustments or improvements.

In December, all students at Oxford will also be asked to complete the Student Barometer, which monitors the quality of all aspects of the student experience.

Concerns

Any student who experiences an issue with their teaching or supervision should contact the relevant person listed in Appendix 2.

Student representation

Oversight of the course is managed by a Standing Committee, which meets three times a year. These meetings are attended by two student representatives, selected by the cohort for each year (one male and one female). One representative will also attend the termly departmental Graduate Joint Consultative Committee (GJCC).

8. Buildings and facilities

8.1 Engineering Science

All teaching will take place in the MSc Teaching Room at Holywell House, Osney Mead, Oxford, OX2 0FA.

The room will be open from 8.30 am to 5.30 pm, Monday to Friday.

Independent study space is also available in the Student Study Area on the 8th floor of Engineering Science's Thom Building on Parks Road. The Study Area is open from 8.30 am to 7.00 pm, Monday to Friday.

Students are expected to provide their own laptops. We recommend the following specification:

- CPU: 2.3GHz processor minimum (preferably multicore)
- Memory: 8Gb minimum
- Disk size: 256Gb minimum
- Operating System: Windows (Windows 8 or later), Linux (CentOS or similar distribution), Mac (OSX 10.13 or later)

8.2 University Libraries

Radcliffe Science library

The Radcliffe Science Library (RSL) (www.bodleian.ox.ac.uk/science) is the main science research library at the university. The library holds copies of the course's reading list items, and most research will be undertaken using this library's resources. The RSL is located a short walk away from the Engineering Science department on South Parks Road.

The Subject Librarian responsible for Engineering Science is Alessandra Vetrugno (alessandra.vetrugno@bodleian.ox.ac.uk), who is based at the RSL.

Social Sciences Library

The Social Science Library (SSL) (www.bodleian.ox.ac.uk/ssl) is the main social science research library at the university and holds resources relevant to some of the course modules. The library is located less than 15 minutes away from the Engineering Science department, on Manor Road, just off South Parks Road opposite St Catherine's College.

The Subject Librarian responsible for relevant areas within the library is John Southall (john.southall@bodleian.ox.ac.uk, who is based at the SSL.

Appendix 1: Detailed Syllabus

1. Resources Theme

How is energy produced, converted and traded? What energy technologies are available, what energy differences are there between different parts of the world? And how have we arrived where we are with global energy systems?

R1. Energy Sources (Michaelmas Term Weeks 1-2)*

Professor David Wallom (Department of Engineering Science)

Course Context

The production, transformation and consumption of energy are one of the key enablers for our current lifestyle, and will undergo a huge transformation as we move towards a low carbon future. As such it is essential that we understand energy itself from a theoretical and foundational basis, the primary sources of energy now and in the near past. This module is a foundational module and as such will describe the fundamentals of energy, including the different forms of energy when going beyond the fundamental of kinetic and potential towards those types of energy that can be exploited by society. We will discuss and understand the fundamental background of thermodynamics, conservation of energy and transformation of energy. We will discuss how we use energy at a high level to enable preparation for other modules within the course though topics such as energy for transport, energy for life and future energy sources for the masses. We will then consider the current global energy mix. We will also teach and discuss the underpinning climate change situation including carbon budgets. The module will use lectures, group work, presentations, debates and project based learning to cover this broad and foundational topic to the whole course.

Lecturers

Professor David Wallom
Professor Nick Eyre
Professor Sarah Sparrow
Professor Felix Leech
Professor Ben Williams

Course Content and Structure

The course will cover the following content in thirty 90-minute sessions:

1. **Introduction to the Energy System**
   Discussion about the system and where there are key strengths and weaknesses laying the groundwork for how we describe the Energy System within the course.

2. **Forms of Energy**

a. What is energy?

b. What is Work?
c. What is Power?
d. Units and Measurement

3. Embodied or Embedded Energy

a. What is it and how important is it in current arguments about energy utilisation?
b. Types of embodied energy
c. Constraints
d. Why?
e. Definition
f. Tracing the process
    i. Raw materials [extraction, transport, processing]
    ii. Construction [transport, assembly, waste]
    iii. Utilisation [operating]
    iv. Disposal [transport, waste]
g. Example - buildings

4. Energy System Behavioural Transition exercise

There are many energy transitions that are suggested as ways to reduce our environmental impact. We should think critically about these. Are the published studies credible? We should ensure they haven't made unfortunate assumptions.

5. History of Energy and Global Energy usage

From the earliest times of almost prehistory to now energy has been a constant requirement of society, whether they realised it or not.

6. Transformation and Transfer

As we must operate under the principle of conservation of energy, we must understand the usable transformations between different types of energy.

7. The Climate Change Challenge

Climate change is the single biggest challenge for society as it moves forward. First and foremost it is an energy problem, and as such we must understand climate change's mechanisms. We must do this whilst also realising that we do not have uniform availability of energy on the planet so we must understand the current limitations of energy availability around the world.

8. Thermodynamics

It will be necessary to have an understanding of the theoretical underpinnings of how we calculate energy within a system, in transformations and how energy may be distributed within a system and change during action or changes within that system.

9. The System

a. **Current Energy sources and interconnection**
What are the energy sources used in society now? What are the mechanisms used to

transform their energy and make it usable? Resource location & distribution (local vs distributed)? Discussion on efficiency including full chain analysis.

b. **Future Energy**
What are the restrictions on current energy sources and what new sources are available? What are the future roles for current energy sources and how will new sources become widely adopted?

Course Texts

- Energy Science 4th edition, Andrews and Jelley (OUP)
- Sustainable Energy –without the hot air, David J.C. MacKay
- Thermodynamics, A complete undergraduate course, Andrew M. Steane
- National Grid Future Energy Scenarios, National Grid PLC.
- Otto, F.E., 2017. Attribution of weather and climate events. *Annual Review of Environment and Resources*, *42*, pp.627-646.
- IPCC Special report on 1.5, https://www.ipcc.ch/sr15/
- Energy Systems: A Very Short Introduction, Nick Jenkins (OUP)
- BP Statistical review of world energy, BP.
- Applied Thermodynamics for Engineering Technologists, Eastop T.D. & McConkey A., Longman, 1993, Chaps 1-3, 6, 7-9, 13, 16
- Fundamentals of Engineering Thermodynamics , Moran M.J. & Shapiro H.N., Wiley, 2006, Chaps 1-4, 8-9, 11, 13
- Engineering Thermodynamics Work & Heat Transfer , Rogers G.F.C., Mayhew Y.R. Longman, 1993, Chaps 1-4, 7-12, 14-15, 17
- Basic Engineering Thermodynamics, Whalley, OUP, Chaps 1-7, 12-15, 17
- Four laws that drive the universe, Atkins, P. W. , Oxford University Press, 2007

Last reviewed: 09/24

R2. Energy Conversion 1 (Michaelmas Term Week 8)

Dr Anupama Sen (Smith School for Enterprise and the Environment)

Non renewable energy: growth, infrastructure and markets

Course Context

Non-renewable energy (oil, gas, coal and nuclear) accounts for just over 80 per cent of total global energy consumption. The current global energy system that we have today has been built around non-renewable energy sources, raising the question: *how did we get to where we are today?* This question can be considered in three connected parts.

The first part is the science of energy conversion, and the role of technology and technological advancements in facilitating newer and more efficient forms of non-renewable energy generation to meet society's needs. Technological advancement on its own is, however, insufficient in explaining the evolution of non-renewable energy systems and a deeper understanding requires going beyond the singular issue of technology to consider it in relation to wider socioeconomic factors.

The second part is the role of economic growth and human development and their contribution to non-renewable energy use. As societies grow richer and incomes increase, energy use among consumers typically evolves from lower value-added fuels to higher-value added and 'cleaner' fuels (e.g. from wood, through to coal, oil and gas). As energy consumers around the world moved up the 'energy ladder' in this way, it also catalysed the construction and development of capital-intensive infrastructure and markets for different fossil fuels, that was necessary to support the use of these non-renewable fuels, in a centralised way.

The third part is the dynamic nature of the process and the different speeds at which the non-renewable energy system has evolved in different countries around the world. Factors underpinning this 'differential development' of non-renewable energy systems include the speed of technology transfer, resource endowment, comparative advantage, and policies promoting inter-fuel substitution. For instance, many hydrocarbon-producing countries rely on the enormous rents generated by oil and gas production and export to support their societies and on cheap non-renewable energy to support their economies. These dynamics are rapidly changing.

This module will explore the evolution and development of the main non-renewable energy sources within the current energy system against the context of the three parts above. It will draw from the experiences of different countries to show how differences in contexts have shaped the evolution of non-renewable energy alongside the 'locking in' of infrastructure created to support them. Using specific examples, it will look at the path dependencies created by incumbent non-renewable energy systems, and the role of policies in disrupting them and shaping the transition to decarbonised energy systems.

The course will draw on a mix of academic and industry expertise, giving students the opportunity to engage with guest lecturers as well as tackle practical exercises and thought experiments.

Course Content and Structure

The course will cover most of the following topics through lectures and/or readings:

Global overview of non-renewable energy systems
Looks at the global energy scene and sets out the main trends in non-renewable energy use in different world regions. Connects this with the historical evolution of these systems and questions why economies moved from renewables to fossil fuels in the first place, with the process still happening today e.g. developing economies moving from traditional biomass to fossil fuels. Discusses the characteristics of past non-renewable energy transitions. Stresses that the drivers have been different in different countries. Covers key concepts including: resource extraction and the Hotelling Rule, comparative advantage, scarcity rents, interfuel substitution, path dependency, environmental Kuznets curve.

Energy Conversion and the Conventional Power Generation System
Principles of energy conversion in conventional non-renewable energy systems. The laws of thermodynamics and heat-to-work conversion in different thermodynamic cycles. The efficiencies of power plants and heating devices. State-of-the-art and future developments of different technologies: Steam power plant; Open Gas Turbine (GT) plants; Combined Cycle Gas Turbine Plants (CCGT)s. Future flexible operation of conventional power generation systems (improved operating flexibility, biofuels) with increasing presence of renewable power. Hybrid conventional and renewable energy systems (CCGT and Concentrated Solar Power (CSP). Fuel cells. Combined Heat and Power (CHP) – Cogeneration plants. Types of CHP plants. Performance parameters for a CHP plant. Power plants for transport: The reciprocating internal combustion engine and its performance. Turbojet engines.

Natural gas in the energy system
Gas's evolution from a by-product of oil to a high value-added fuel; the development of capital intensive infrastructure to support its use; the gas supply chain; how gas is valued and traded globally; the drivers of gas demand in different regions; the future of gas in a decarbonising energy system.

Decarbonisation technologies for fossil fuels
Carbon footprint of different power generation technologies. Carbon sequestration and storage (CCS). Although there are several recommended / researched techniques, it has not yet been implemented on a large scale. Carbon capture methods: Pre- and post-combustion, Oxy-Combustion systems. Coal gasification through Integrated Gasification Combined Cycle (IGCC) plants. Geological CO2 storage options and enhanced oil recovery. Reducing carbon emissions through further efficiency improvements: Ultra-high-efficiency Hybrid Combined Cycle Gas Turbine (CCGT) and Renewable Energy. The feasibility of implementation of different CCSs technologies depends on many factors, including economics (scale) and government policy. Clean coal initiatives – China and India cases. Thinking big – Climate Engineering: Direct CO2 Removal (DCR) and Solar Radiation Management. Why the energy shift towards renewables in Germany fails to cut the carbon emission?

Oil markets
Key drivers for the emergence and widespread use of oil across the world, including factors such as higher value-add, ease of transportation, and storage; the oil supply chain; the operation of world oil markets; the valuation of oil reserves and their contribution to path dependency; the macroeconomics of oil in major exporting countries/OPEC; oil and the energy transition; adaptation strategies of oil producers.

Nuclear Energy
Fission and fusion technologies – the nature of energy release, and the challenges associated with controlling nuclear reactions. Energy density and fuel tolerance – the need for a nuclear fuel cycle – proliferation and security of supply. The role of nuclear energy in current power generation – national norms and historical perspectives. Possibilities for future development. Small Modular Reactors.

The energy transition and fossil fuels
Is technological change the only factor in transitioning from a predominantly non-renewable carbon emitting energy system to a decarbonised system; are there 'rigidities' or other characteristics of non-renewable energy systems that are unsuited (or suited) to a decarbonised future; how can the path dependency of non-renewable energy systems be disrupted or reshaped, and how can we begin thinking about this – i.e. which parts of the system need to be changed first; what are some of the difficult trade-offs involved and some of the uncertainties surrounding them; will we see increasing diversity or homogeneity between regions; what is the role of government policies vis-à-vis market instruments in catalysing change.

LECTURER BIOS

The main topics are covered by the following lecturers. Additional guest speakers may be added.

Dr Anupama Sen, Head of Policy Engagement, Smith School of Enterprise and the Environment, University of Oxford

Anupama Sen is Head of Policy Engagement for the Smith School of Enterprise and the Environment. Prior to the Smith School she spent over 10 years at the Oxford Institute for Energy Studies, where she was senior research fellow, executive director of the electricity research programme and deputy director of the energy transition initiative, and where she published and communicated policy-oriented research on energy and decarbonization targeted at audiences across academia, government and industry. Anupama holds a BA (Hons) in Economics from St Xavier's College at the University of Mumbai, MSc from the London School of Economics and Political Science and PhD from Cambridge University. She is an Official Fellow in Environmental Change at Reuben College, Oxford, a Fellow of the Cambridge Commonwealth Society, and a Research Affiliate of the Copenhagen School of Energy Infrastructure, Copenhagen Business School.

Professor Budimir Rosic, Associate Professor of Engineering Science, Department of Engineering Science, University of Oxford

Before joining Oxford, Professor Budimir Rosic was a Mitsubishi Heavy Industries (MHI) senior research fellow and college lecturer in engineering at the University of Cambridge. He received his undergraduate degree from the University of Belgrade, Serbia, where he also worked as a researcher in the turbomachinery and power plants group (faculty of mechanical engineering). During that time he was involved in research and consultancy of steam turbine related problems, and power plant monitoring and performance tests. Budimir undertook his Ph.D. research at the University of Cambridge's Whittle Laboratory in collaboration with Siemens Power Generation under the supervision of Dr. John Douglas Denton. He investigated, experimentally and numerically, the aerodynamics of low aspect ratio turbines and leakage flows, and earned his Ph.D. in 2005. He has been an ASME member since 2002 and has served on IGTI's Turbomachinery Committee since 2004. He was a recipient of ASME's 2006 Gas Turbine Award and again in 2011, he was recognized for the co-authored paper titled "Controlling Tip Leakage Flow Over a Shrouded Turbine Rotor Using an Air-Curtain." He received ASME's Gas Turbine Award, which recognizes outstanding contributions to the literature of combustion gas turbines or gas turbines thermally combined with nuclear or steam power plants. It was presented to Budimir in Vancouver, British Columbia.

Mr Howard Rogers, Distinguished Research Fellow, Oxford Institute for Energy Studies

Howard Rogers joined the Institute in January 2009 and became Director of the Natural Gas Programme in October 2011. He was appointed Chairman and Senior Research Fellow of the Programme in October 2016 and Distinguished Fellow in November 2019. Prior to joining the Institute Howard was with BP for 29 years, mostly in business development, strategy, planning, mergers and acquisitions and negotiation roles in upstream oil and gas in European, North American, Middle East and FSU locations. In 1999 Howard joined BP's Gas and Power division and in 2003 he became Head of Global Gas Fundamental Analysis. He has a degree in Chemical Engineering and is a Fellow of the Institution of Chemical Engineers.

Howard has published research papers and authored book chapters on LNG price arbitrage between the regional markets of Asia, Europe and North America, shale gas in the US and UK, The interaction between wind power generation and gas in the UK and the outlook for gas with CCS. As well as on the transition to hub-based pricing in Europe and the changing roles and risks of key players and also on the challenges to JCC pricing in Asian LNG markets. Howard's areas of expertise include global natural gas supply/demand/price structures and competing fuels, the LNG value chain, market dynamics, price arbitrage, and regional knowledge on markets and gas supply.

Dr Adi Imsirovic, Guest Lecturer, Department of Engineering Science, University of Oxford, Senior Visiting Research Fellow, Centre for Strategic and International Studies (CSIS)

Adi Imsirovic has 35 years of experience in oil trading. He has held a number of senior trading positions, including global head of oil at Gazprom Marketing & Trading and regional manager of Texaco oil trading for Asia. Dr. Imsirovic was a Fulbright scholar and studied at the Graduate School of Arts and Sciences, Harvard University. There, he was also an adjunct research fellow at the Kennedy School of Government. Adi taught economics at Surrey University for several years, including energy economics and resource and environmental economics. For a number of years, he was a senior research fellow at the Oxford Institute for Energy Studies. He has a PhD in economics and a master's degree in energy economics. Dr. Imsirovic has written a number of papers and articles on the topic of oil and gas prices, benchmarks, and energy security. He is the author of the *Trading and Price Discovery for Crude Oils: Growth and Development of International Oil Markets* (Palgrave, 2021). Adi also edited *Brent Crude Oil: Genesis and Development of the World's Most Important Oil Benchmark* (Palgrave, 2023).

Dr Sumiu Uchida, former Head of Research and Innovation, Mitsubishi Heavy Industries

Dr Uchida is the Chief Engineer and former Head of Research and Innovation Technical Headquarters of Mitsubishi Heavy Industries (MHI) and the Vice Chairman of Japan Turbomachinery Association. Dr Uchida is responsible and oversees all R&D activities for almost seven hundred different engineering products at MHI - from power generation, energy, aerospace, environment, material handling, industrial machinery, transportation, etc. His experience ranges from development, operations, product design and company strategy. In the last twenty years, Dr Uchida helped to establish and promoted collaborations between MHI and leading British universities (Oxford, Cambridge, Imperial). He is also a Visiting Professor at the Department of Engineering Science in Oxford. Dr Uchida was an active researcher and has been awarded two ASME IGTI best paper awards and one ASME Gas Turbine Award, the most prestigious international award in the field of turbomachinery.

Mr Daniel Robertson is Senior Advanced Concepts Engineer and Modularisation Research and Technology Lead at Rolls Royce Plc. He has been with the company since 2006.

Last reviewed: 09/24

R3. Energy Conversion 2 (Hilary Term Week 4)

Professor Moritz Riede (Department of Physics)

Course Context

This module expands on the energy sources available to use in the form of renewables but is then extended into the different additional infrastructure that is necessary when considering renewable energy to cope with its intermittent nature. This will include Wind, Solar, Marine (Wave and Tidal), Geothermal and Bioenergy as well as a specific strength of the university in batteries and energy storage technologies. Alongside studies on the different methods of converting energy into heat and electricity using the renewable technologies the module will discuss implications of different energy mixes available and how they could affect a final energy balance. The module will use both lectures and project based learning to ensure there is a full understanding of the implications.

Course Content and Structure

1. The current capabilities of renewable energy
What are the overall contributions that renewables make to the energy mix currently and what are the restrictions on current expansion? Comparison to RE1 energy conversion technologies.

2. Solar energy **conversion**
What are the current designs of electricity generating solar panels and what are the current leading edge areas of research? What are alternative ways of using the sun's energy to generate electricity and heat. How the sun can be used for solar cooling?

3. Harnessing the power of the wind
Where can Wind power (onshore and offshore) contribute, what are the limitations and what specific infrastructure is necessary for wind to provide input to the grid? What unconventional concepts are explored?

4. Power from biomass
Traditional biomass has been used for heating and cooking for millennia. How can this form of energy be used today, and what implications are there for land use and food supply?

5. Geothermal energy
What ways are there to convert the heat the earth produces (both surface and deep) into other usable forms.

6. Power from water
How will running water sources and developments continue to contribute to the available renewable energy mix? How will Marine energy sources and developments contribute to the available renewable energy mix and what are leading edge areas of wave and tidal energy capture?

7. Energy Storage technologies and keeping the lights on
Due to the intermittent nature of renewables, it will be necessary to provide mechanisms for storing energy provided in times of plenty but required in times of famine. What technologies are available

at the moment and how can we use those currently available without environmental damage or external dependency?

8. Energy Transport

In addition to temporal intermittency, renewable energy resources are – just as e.g., fossil ones – unequally distributed across the Earth. How can energy, and in what form, be transported over short and large distances in an effective and safe way?

Course Texts

- Energy Science, J. Andrews and N. Jelley; OUP (3rd ed), 2017
- Renewable Energy: Power for a Sustainable Future, G. Boyle; OUP (3rd ed), 2012
- Renewable Energy Resources, J. Twidell and T. Weir; Routledge (3rd ed), 2015
- Elementary Climate Physics, F. W. Taylor; OUP, 2005
- Beyond Smoke and Mirrors, B. Richter; CUP, 2010
- IEA World Energy Outlook(s) (http://www.worldenergyoutlook.org/)
- Sustainable Energy- without hot air, David MacKay; UIT, 2009, (http://www.withouthotair.com/)

Last reviewed: 09/23

2. Systems Theme

How is energy distributed so that it is usable? What are the considerations that need to be made for bridging between the producers and consumers?

Sy1. Energy Infrastructure (Michaelmas Term Weeks 3 & 5)*

Professor Malcolm McCulloch (Department of Engineering Science)

Course Context

Useful energy is often not available to the end user at the time or place that it is required. Therefore the right type of energy – the energy vector – needs to be brought through space and time, from the source of production to the point of consumption. This module considers the former challenge – that of distributing the energy to the end user, often over long distances (transmission) and over wide areas (distribution). However, there is often an overlap with moving energy through time – storage – and this will be developed when considered as part of the design of the spatial distribution system.

This module develops some key principles, and then applies them to case studies – that highlight the common themes and challenges for distributing many forms of energy. This module is designed to enable the student to deeply understand the following principles:

1. The implications of the choice of energy vector.
2. The underlying physics and technical models.
3. Operational methods to manage losses and faults.
4. The drivers of capital expenditure.
5. Identification of key risks, including obsolesce, social acceptability and financial viability.

By the end of the module, you will be able to:

1. Critically assess an existing distribution system.
2. Develop a scoping study to develop an enhanced distribution system, considering multiple vectors.
3. Develop a scoping study for a new distribution system.

Course Content and Structure

1. **Understanding the problem today and tomorrow.**
    - Basics.
    - Energy density and timing of production and generation.
    - Diversity.
    - Moving energy through time and space: Storage, distribution and transmission.

2. **Types, principles and characteristics of energy vectors.**
    - Types of energy vectors: Mechanical, Thermal, Chemical, Electrical

- Energy, power and ramping.
- Losses: Conversion, spatial, temporal
- Costs, capex and opex: Conversion, spatial, temporal
- Reliability and fault management. (Degradation and failure mechanisms, Identification and mitigation)

3. Low fidelity modelling

- First principles model
- Sankey diagram
- LCOE for energy vector
- Exercise 1 - Enhance an existing system

4. Detailed analysis of power grids

- Power, Reactive Power and Apparent power.
- DC and AC Single and Three phase analysis.
- Power through a resistor (DC) and an inductor (AC).
- Simple power flow analysis in Python
- Parameters: Transmission lines and transformers.
- Costings for different technologies (overhead lines, cables, transformers, switchgear)
- Exercise 2 - Analyse an existing system

5. Spatial analysis

- GIS systems: QGIS
- Analysis of existing transmission grids: UK and Africa
- Coupled with power flow analysis.
- Analysis of existing distribution grids.
- Spatial optimisation in Python.

6. Emerging grid topologies

- Fractal like grids.
- Space-time grids.

7. Module synthesis

Course Texts

https://open-power-system-data.org

https://www.elexon.co.uk/wp-content/uploads/2017/06/bmrs_api_data_push_user_guide_v1.1.pdf

https://www.qgis.org

Last reviewed: 09/23

Sy2. Energy for Development (Hilary Term Week 1)

Professor Malcolm McCulloch (Department of Engineering Science)

Course Context

Modern energy is a necessary condition for development. This importance is recognised as it is a core Sustainable Development Goal: SDG7. Providing the energy needed at an acceptable cost to deliver appropriate services efficiently, while protecting the environment, is a significant challenge. New technologies are being developed and there is a growing appreciation that they need to be appropriately targeted. Furthermore, the system has to be able to grow with the customer, possibly changing technologies and providers. This transition is complicated by the institutional and economic local, regional and in-country capacities.

This module develops some key principles, and then applies them to case studies – that highlight the common themes and challenges for developing appropriate energy systems. This module is designed to enable the student to deeply understand the following principles:

- The end user is key in defining the service requirements and the finances available.
- The choice of distribution of energy is dependent on population density, effective load density and generation type.
- Key risks include social acceptability, obsolesce and financial viability.

By the end of the module, you will be able to:

1. Deploy different methods to understand end user requirements and capabilities.
2. Critically assess an existing distribution system.
3. Develop a scoping study for a new distribution system, including costings.

Lecturers

Professor Malcolm McCulloch (Department of Engineering Science)
Dr John Rhys (Environmental Change Institute, School of Geography and the Environment)
Dr Stephi Hirmer (Department of Engineering Science)

Course Content and Structure

1. **Understanding the end user**

   Energy Cultures as a framework of understanding the interplay of end-users and technology.
   Understanding norms and perceived value
   Social and productive uses: Information, motion, thermal
   Determining important energy services:
   Indicative load profiles and diversity.
   Willingness/ ability to pay
   Ethics
   Exercise 1: End users of West Ngosini

2. **Spatial density**

    Data sets
    Determining spatial density from discrete locations
    Nearest Neighbours
    Kernal methods
    Clustering techniques
    Exercise 2: Spatial analysis of West Ngosini

3. **Grid topologies**

    Spatial, temporal and energy resource as determinants.
    SHS, battery grid, Micro grid, Mini grid, grid, Fractal
    Exercise 3: Grid plan for Machakos County

4. **Institutions**

    Weberian vs Northian States
    Power sector organisation
    Vertically integrated
    Unbundling
    Private sector
    Synergistic frameworks
    Exercise 4: Institutions

Module synthesis

Course Texts

Topic 1
https://doi.org/10.1016/j.enpol.2010.05.069
https://doi.org/10.1016/j.rser.2014.03.005

Topic 2
https://www.qgis.org

Topic 3
https://open-power-system-data.org

Topic 4
https://www.beloit.edu/upton/assets/North.pgs.vol.I.pdf

Sy3. Digitisation, Smart Energy and Communication (Hilary Term: Week 5)

Module Leader: Professor David Wallom (Department of Engineering Science)

Course Context

It is clear that as we approach an era where we are no longer living in energy abundance that we must increase the efficiency with which we use energy. As such it is important that we consider how we will make use of advanced communications tools and technologies. These will primarily be concerned with the mechanisms by which we improve the distribution and consumption of energy and as such this is where this module will concentrate. Outside of regular smart systems for electricity we will also look at other activities in this area including local heat networks, smart homes and their interfaces to energy, etc. As part of the critical national infrastructure, we will also consider the cybersecurity aspects of smart systems.

Lecturers
Professor David Wallom (Department of Engineering Science)
Professor Alex Rogers (Department of Computer Science)
Ramon Granell (Department of Engineering Science)
Dr Scot Wheeler (Department of Engineering Science)
Dr Weiqi Hua (University of Birmingham)

We will also be completing a field trip within this module and have a number of industry presentation during the week.

Course Content and Structure

The course will cover the following content:

1. **Why do we need to smarten the energy grid?**

2. **What is a smart grid?**
    a. International Definitions
    b. Generalised characteristics exercise to pull out key points from definitions

3. **Smart grid concept and Reference model**
    a. NIST Smart Grid
    b. Smart Grid Architecture Model (SGAM)

4. **Smart Meters and smart homes**
    a. Current situation (SMETS 1)
    b. Current Smart home solutions

c. The national smart meter rollout, (SMETS 2) including the full system design as currently proposed.
d. The DCC and access models
The advantages and disadvantages of smart meters

5. **Creating tools and services to inform smart energy systems roll outs**

6. **Local energy market examples**

7. **Creating insights from big data**
   Utilising Machine Learning and AI to understand better the relationship between energy consumption and the physical activities that are drivers. Using these to also enable the provision of behavioural changes to reduce consumption.
   a. Energy theft
   b. Cross domain insights

8. **The use of Forecasting within the energy system**

9. **Beyond just smart meters to an integrated communications and energy home, transport and lifestyle system**
   a. Integrating micro generation, home storage, transport infrastructure and the smart home. Include talking about market makers, new markets etc.
   b. Smart homes

10. **Cyber and physical security implications of energy systems**
    How as part of the critical national infrastructure should we be securing the communication channels, equipment and keeping data private in a new energy system where everything is 'smart'?

11. **Summary, Synthetisation and conclusions**

Course Text

https://ec.europa.eu/energy/sites/ener/files/documents/xpert_group1_reference_architecture.pdf

Last reviewed: 09/24

Sy4. Energy Systems; Economics and Markets (Hilary Term: Week 7)

Module Leader: Professor Steve Smith (Smith School of Enterprise and the Environment)

Course Context

Four of the six largest companies in the world by revenue are in the energy sector, which is at the start of a remarkable, once-in-a-civilisation transition. Coal is under severe pressure, and the oil and gas majors are rethinking their long-term strategies, driven by a combination of climate action, development goals and new technologies. After a brief background into the energy system, this course examines the shifts underway in technology, government policies for climate and energy, and economic and political issues across the energy supply chain. We introduce the basics of economics and finance, examin the potential for value creation as the transition to zero-carbon energy occurs around the world, and explore the social scientific dimensions of integrating those technologies into energy systems.

Lecturer

Associate Professor Steve Smith, Smith School of Enterprise and the Environment (stephen.smith@smithschool.ox.ac.uk)

Course Structure and Content

The course will cover the following content in eight, three-hour sessions:

1. Introduction, history and the present energy transition. Concepts and definitions. Brief overview of energy system history. Recent issues in energy markets. Introduction to the drivers of the present transition (new technologies and climate change).

   Economics. Fundamentals of demand, supply and markets. Price elasticity of demand and supply in the context of electricity. Welfare optimisation. Use of Python to model realistic electricity day-ahead wholesale market. Determination of electricity pricing using economic dispatch based on merit order considering network constraints. Introduction to nodal pricing.

2. Power markets. Challenge to power markets of very low marginal cost technologies. Balancing supply and demand. Functioning of wholesale power markets, balancing markets, capacity markets. Main approaches to regulation. Missing money problem. European day-ahead market orders. Uniform pricing vs pay-as-bid. Pool markets vs continuous trading.

3. Market liberalisation. Principles and objectives of market liberalisation. Experiences of liberalising OECD and non-OECD electricity markets. Interactions between liberalisation and decarbonisation. Current policy challenges. Case study and discussion.

4. Nexus! Challenge. The Nexus! board game - a playful exploration of resilience across the energy-water-food nexus.

5. Energy finance. Scale of the financing challenge for the energy transition. Financing of the energy supply chain. Finance in the context of political risk. Bankability of different energy revenue streams. Group finance exercise on financing offshore wind in the UK.

6. Energy access. Sustainable Development Goal 7. Energy use and energy markets in developing countries. The role of business in providing electricity for the 1 billion people without it. Grids vs distributed power generation.

7. Carbon markets. Compliance and voluntary markets. Interaction of energy firms with carbon markets. The problem of additionality. Carbon pricing and carbon offsetting in a net-zero world.

Each of the eight session has 1-2 essential readings and several additional readings. Useful references and sources of data include the annual publications of the International Energy Agency (IEA) World Energy Outlook, BP Energy Outlook, and the United States Energy Information Agency (EIA) Annual Energy Outlook, although you should not necessarily take numbers and certainly forecasts at face value.

Two very readable books on energy are:

- Helm, D. (2017) Burn Out: The Endgame for Fossil Fuels
- Yergin, D. (2012) The Quest: Energy, Security, and the Remaking of the Modern World.

Those wanting a more academic input can peruse journals such as Nature Energy, Applied Energy, or the Oxford Review of Economic Policy. Essential facts and figures can be found at Our World in Data.

Almost every 3-hour session has an external speaker for at least some part of the session. Speakers tend to be distinguished leaders in the energy industry, engaging communicators chosen for their experience in the application and limitations of concepts taught in this course. The sessions also include a multi-player game.

About the Lecturer

The course is taught by Professor Steve Smith, Associate Professor of Greenhouse Gas Removal at the Smith School. He is Executive Director of two programmes, both focussed on stabilising the climate both rapidly and sustainably: Oxford Net Zero and CO_2RE.

Steve's research interests lie at the intersection of climate science and policy. He has published on a range of topics including metrics for comparing the emissions of different greenhouse gases, and the governance of climate change mitigation. He is co-developer of a major global stocktake of net zero pledges. He joined the Smith School from the UK Department for Business, Energy and Industrial Strategy (BEIS) where he co-led the Climate Science Team and played a role in the legislation of the UK's net zero target. Before that he was Head of Science at the Committee on Climate Change. He has a PhD in atmospheric physics from Imperial College London and is a Fellow of the Royal Meteorological Society.

Course Structure

Timing
Please note morning sessions run ***0915-1215*** and afternoon sessions run ***1345-1645***. Wednesday and Friday contain morning sessions only (you have those afternoons free!)

Session 1: Introduction, history and the present energy transition

Session Content
Concepts and definitions. Brief overview of energy system history. Recent issues in energy markets. Introduction to the drivers of the present transition (new technologies and climate change).

Essential reading

- Energy Transition Commission (2017) Better Energy, Greater Prosperity, Executive Summary.
- International Energy Agency (2023) World Energy Outlook, Executive Summary.

Additional reading

- Fouquet, R. (2014). Long-run demand for energy services: Income and price elasticities over two hundred years. *Review of Environmental Economics and Policy*, 8(2): 186-207.
- Aurora Energy Research (2013) Predictable Surprises: Lessons from 30 Years of Energy Sector Forecasts, November.
- Segal, P. (2011). Oil price shocks and the macroeconomy, *Oxford Review of Economic Policy*, 27(1): 169-185.

Session 2: Economics

Session content

Fundamentals of demand, supply and markets. Price elasticity of demand and supply in the context of electricity. Welfare optimisation. Use of Python to model realistic electricity day-ahead wholesale market. Determination of electricity pricing using economic dispatch based on merit order considering network constraints. Introduction to nodal pricing.

Essential reading

– Pyomo Documentation

Additional reading

- Fundamentals of Power System Economics, Daniel Kirschen, Goran Strbac, 2nd Edition, 2018
- Biggar, D. R., & Hesamzadeh, M. R. (2014). The economics of electricity markets. John Wiley & Sons

Session 3: Power Markets

Session content

Challenge to power markets of very low marginal cost technologies. Balancing supply and demand. Functioning of wholesale power markets, balancing markets, capacity markets. Missing money problem. European day-ahead market orders. Uniform pricing vs pay-as-bid. Pool markets vs continuous trading.

Essential reading

- Green, R. (2005) Electricity and markets, *Oxford Review of Economic Policy*, 21(1): 67-87.

Additional reading

- Fundamentals of Power System Economics, D. Kirschen, G. Strbac, 2nd Edition, 2018
- Litvinov, E. (2010). Design and operation of the locational marginal prices-based electricity markets. IET generation, transmission & distribution, 4(2), 315-323.
- Joskow, P. L. (2008). Capacity payments in imperfect electricity markets: Need and design. *Utilities Policy*, 16(3), 159-170.
- Imran, K. and Kockar, I. (2014) A technical comparison of wholesale electricity markets in North America and Europe. *Electric Power Systems Research*, 108, pp.59-67.
- Farrell, N. et al (2017) Is this the end of conventional wholesale electricity markets?

Session 4: Market Liberalisation

Session content

Principles and objectives of market liberalisation. Experiences of liberalising OECD and non-OECD electricity markets. Interactions between liberalisation and decarbonisation. Current policy challenges. Case study and discussion.

Essential reading

- World Bank (2019) Rethinking Power Sector Reform in the Developing World.

Additional reading

- Sen et al. (2018) Have model, will reform: assessing the outcomes of electricity reforms in non-OECD Asia. *The Energy Journal*, 39(4) pp.181-209.
  Poudineh et al. (2018) Advancing renewable energy in resource-rich economies of the MENA. *Renewable Energy*, 123, pp.135-149.

Session 5: Nexus! Challenge

Session content

The Nexus! board game - a playful exploration of resilience across the energy-water-food nexus.

Session 6: Energy Finance

Session content

Scale of the financing challenge for the energy transition. Financing of the energy supply chain. Finance in the context of political risk. Bankability of different energy revenue streams. Group finance exercise on financing offshore wind in the UK.

Essential reading

- International Energy Agency (2024) World Energy Investment, Executive Summary.
- Kern et al (2014) From laggard to leader: Explaining offshore wind developments in the UK. Energy Policy, 69, 635-646.

Additional reading

- Covington et al. (2016) Global warming: Shareholders must vote for climate-change mitigation. *Nature*, 530(7589), 156.
- Milken Institute (2015) Innovative Financing Models for Energy Infrastructure in Africa.

Session 7: Energy Access

Session content

Sustainable Development Goal 7. Energy use and energy markets in developing countries. The role of business in providing electricity for the 1 billion people without it. Grids vs distributed power generation.

Essential reading

- Se4All (2023) Tracking SDG7: The Energy Progress Report.
- Shen, W. and Power, M (2017) Africa and the export of China's clean energy revolution, *Third World Quarterly*, 38:3, 678-697.

Additional reading

- M-KOPA (2015) Affordable, clean energy: A pathway to new consumer choices.
- World Bank Programme: http://www.scalingsolar.org
- Mulugetta et al. (2022) Africa needs context-relevant evidence to shape its clean energy future. *Nature Energy*, 7(1015-1022).
- Gies, E. (2016) Can wind and solar fuel Africa's future? *Nature*, 539: 20-22.
- Quansah et al (2016) Solar PV in Sub-Saharan Africa – Addressing Barriers, Unlocking Potential, *Energy Procedia*, 106: 97-110.

Session 8: Carbon Markets

Session content

Compliance and voluntary markets. Interaction of energy firms with carbon markets. The problem of additionality. Carbon pricing and carbon offsetting in a net-zero world.

Essential reading

- World Bank (2023) State and Trends of Carbon Pricing.

- Axelsson et al. (2024) The Oxford Principles for Net Zero Aligned Carbon Offsetting.

Additional reading

- Calel et al. (2021) Do Carbon Offsets Offset Carbon? *Grantham Research Institute on Climate Change and the Environment* Working Paper 371.
  Akerlof (1970) The Market for Lemons: Quality, Uncertainty and the Market Mechanism. *Quarterly Journal of Economics* 84(3) 488-500.

Review date: 09/24

3. Services Theme

What is energy for? Why and how is energy provided to society and how can the energy system change – or be changed by – demand for services? How might social and economic goals be met in future? This theme concentrates on the interface between people (individuals and organisations) and energy, considering the role of demand for energy and energy services in the broader energy system.

Se1. Energy Demand (Michaelmas Term: Weeks 6-7)*

Module Leader: Dr Sam Hampton (Environmental Change Institute, School of Geography and the Environment)

Course Context

The Energy Demand module introduces students to the end uses of energy, how they differ between and within societies (>Sy 4) and geographies. We will explore demand as a socio-technical evolutionary process driven by progress in technology (>Se 2), development (>Sy 2) and society (Se4/Sy4).

Students will gain a foundation and understanding of world energy demand, and the challenges and opportunities for changing demand through efficiency, behaviour change, and flexibility. Key concepts include socio-technical systems, energy services, energy efficiency, demand reduction, flexibility, and links beyond the energy system. Students will also be introduced to social scientific approaches to the study of energy, including different theories and methods. Key skills developed include critical evaluation and analysis, synthesis and presentation of data from diverse sources, reflexivity about studying complex systems using imperfect and incomplete data.

Assumptions: EVs and electrified heating are covered in Se2. Demand side policies are covered in Se4/Sy4.

Lecturers

Oxford based:
Dr Sam Hampton (Environmental Change Institute, School of Geography and the Environment)
Professor Nick Eyre (Environmental Change Institute, School of Geography and the Environment)
Dr Tina Fawcett (Environmental Change Institute, School of Geography and the Environment)
Dr Phil Grunewald (Engineering Science)
Dr Jesus Lizana (Engineering Science)
Dr JP Orjuela (Transport Studies Unit, School of Geography and the Environment)
Dr Marina Topouzi (Environmental Change Institute, School of Geography and the Environment)

Guest speakers
Professor Keith Hyams (Warwick University)
Wendy Stone (Global Academy)

Other speakers to be confirmed.

Course Content and Structure

The course will cover the following content in 30 ***1.5***-hour session*s:*

1. Energy and energy services. People and organisations use energy for a wide variety of purposes, but rarely ever consume energy for its own sake. The difference between the services we seek and the ways in which we achieve them have far-reaching implications for what we mean by energy demand and possible energy futures.

2. Energy in relation to other Sustainable Development Goals. Affordable and clean energy is one of 17 SDGs adopted by world leaders in 2015. The SDGs provide a framework for thinking about complexity, diversity, equity and human well-being in relation to environmental impacts.

3. Energy demand as a socio-technical system. Human activity, energy demand and energy services do not arise independently of technology. Instead, social processes and technological change can be considered as inter-dependent parts of a system which is therefore 'socio-technical' in nature.

4. Energy demand in buildings. Buildings account for a large and diverse share of energy demand worldwide. Innovations in technologies, processes and practices can all have an effect on energy demand. In theory, the demand reduction potential is large, but it remains difficult to achieve in practice.

5. Energy demand in transport. Transport energy demand is also large and varied. Mobility has links to different fuels and technologies, but also to patterns of social and economic activity, and to land-use and land-use planning.

6. Energy demand in industry. Goods and services provided by different kinds of industry account for a large share of energy use worldwide. This energy use can be analysed 'upstream' at the point of production but also 'downstream' at the point of consumption.

7. Energy efficiency and demand reduction. Energy efficiency has historically contributed to energy policy goals, and has the potential to continue to do so. Other routes to energy demand reduction (e.g., sufficiency) are also possible.

8. Understanding and comparing data for energy demand. Energy demand typically occurs in a highly distributed way, being made up of countless routine and strategic decisions by billions of people worldwide. This highly fragmented picture leads to numerous metrics and uses of energy data, which need to be analysed carefully if misleading conclusions are to be avoided.

9. Timing and flexibility of energy demand. With the rise of variable renewable energy supply and internet-enabled technologies, there is more potential than ever before to pay attention to the timing and flexibility of energy demand, which has the potential to contribute benefits to the wider energy system.

10. Thinking about future energy demand. Models and scenarios are widely used in strategic and policy debates about the future. Socio-technical systems thinking is useful when evaluating scenarios and the underlying assumptions about energy demand in relation to technology deployment

Course Texts

- Cooper, A.C.G., 2017. Building physics into the social: Enhancing the policy impact of energy studies and energy social science research. Energy Research & Social Science 26, 80–86. https://doi.org/10.1016/j.erss.2017.01.013
- Creutzig, F., et al., 2018. Towards demand-side solutions for mitigating climate change. Nature Clim Change 8, 260–263. https://doi.org/10.1038/s41558-018-0121-1
- Creutzig, F., et al, 2022. Demand, services and social aspects of mitigation. Cambridge University Press.
- IEA, 2022. Energy Efficiency 2022. Paris, France. https://www.iea.org/reports/energy-efficiency-2022
- Shove, E., 2003. Converging conventions of comfort, cleanliness and convenience. Journal of Consumer Policy 26, 395–418. https://doi.org/10.1023/A:1026362829781
- Shove, E., 2010. Beyond the ABC: Climate Change Policy and Theories of Social Change. Environment and Planning A 42, 1273–1285. https://doi.org/10.1068/a42282
- Shove, E., 2017. What is wrong with energy efficiency? Building Research & Information 1–11. https://doi.org/10.1080/09613218.2017.1361746

Last reviewed: 09/24

Se2. Energy and Society (Hilary Term: Week 2)

Module Leaders: Dr Nick Banks and Dr Jake Barnes (Environmental Change Institute, School of Geography and the Environment)

Course overview

Energy systems exist to provide energy services to people, and they are designed, operated, developed and (occasionally) sabotaged by people. It is reasonable to describe and analyse them as socio-technical systems, but the social dimension of energy systems is often missed or treated as an optional extra consideration.

This module aims to develop students' understanding of how energy systems are the outcome of interactions between technologies, infrastructures and people. It examines how energy systems evolve in response to technological development and innovation, changes in human activities and expectations, socio-political events, the economic context and governance arrangements.

Some of the talks will take a case study approach, showing how a technology and society dance together, evolving new ways of living and new technologies as they go – with attendant implications for energy demand and energy supply. Talks in the past taking this approach have focussed on:

- Place based approaches to roll out of heat pumps
- Social history of the motor car
- The impact of digital technologies and apps in shaping energy demand

- Interaction of heating practices with clothing styles and building design
- Evolution of vernacular architecture in Pakistan and associated changes in energy demand

Other talks will take a step back and explore the wider cross cutting issues. In the past we have had talks on:

- Energy equity and fuel poverty
- Geopolitics of energy transitions (the shift from fossil fuel powered economies to renewably powered economies)
- Energy system legislation at different scales
- Issues of race and ethnicity in the energy transition
- City scale governance for the energy transition

Learning outcomes

Students will learn how to analyse energy transitions in terms of:

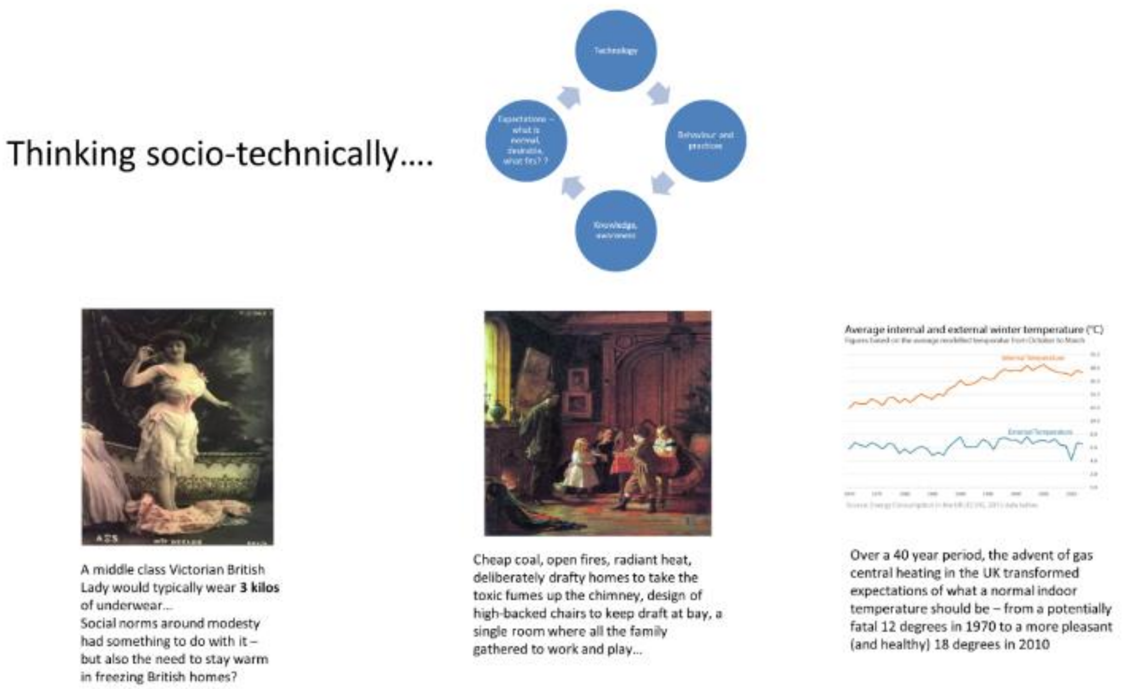
- The social history of technology
- The technical, social, economic and institutional attributes of people and communities and the interaction of these attributes to create a socio-technical context where some ways of living dominate whilst others are confined to the margins
- Socio-economic and geographical distribution of resources and the means to convert those resources into energy services and desirable outcomes
- Justice and fairness in the energy transition
- Technology adoption and adaptation in real-life conditions.

The teaching will build on teaching in the Energy Demand Module (SE 1) and the Energy Policy Module (SE 3).

Assessment

Each year we have chosen different assessment methods. However, the aim will always be to get the student thinking socio-technically and to give an opportunity to demonstrate what they have learned by exploring the interplay of the provision of an energy service (mobility, heating, refrigeration, cooking) or technology (the passenger car, central heating systems, refrigerators, the microwave oven) and the embedding societal context – drawing out implications for energy systems, energy policy, equity and societal change.

As an example of the approach we'd like student to take, consider the evolution of domestic heating in the UK where the convergence of availability of cheap coal, a newly prosperous middle class, a temperate climate, architectural styles, clothing styles (influenced by cheap cotton from the empire), the design of furniture which keeps the drafts at bay etc, all come together to sustain the practice of heating a living room with an open fire.



We aim to make the assessment exercise as interesting and enjoyable as possible. In the past we have asked the students to:

- Produce a research poster
- Write a 2000 word policy brief
- Record a 15 minute presentation

In the final session on Friday we will go through the assessment exercise in detail. The students will have lots of opportunity to ask questions and to understand how to do well in the assessment exercise.

Course staff

Dr Nick Banks and Dr Jake Barnes will lead the module with contributions from colleagues at the Environmental Change Institute and beyond. The details of guest speakers may vary, depending on their availability.

Dr Nick Banks

Nick is a senior researcher with the Energy Group at the Environmental Change Institute with over 25 years of experience in the sustainable energy field, specialising in behavioural research and the social dimensions of energy consumption and sustainability. In his current role as a researcher in Local Energy Systems he has a particular focus on low carbon technology adoption, energy equity, community engagement and methodologies for understanding the capability of a place to transition to low carbon living. Recent projects include “Project LEO” which explored governance, technical, market and social arrangements required to facilitate Smart Local Energy Systems and “Clean Heat Streets” which takes a place based approach to the challenge of installing dozens of heat pumps into a high diverse neighbourhood in Oxford.

nicholas.banks@ouce.ox.ac.uk

Dr Jake Barnes

Dr Jake Barnes is a researcher in the Energy group of the Environmental Change Institute, of the University of Oxford. Jake's research interests include the politics and sociology of innovation and change at community through city-regional scales to national systems. He has worked with local governments, community groups and social enterprises to reflect, learn and pursue societal transformations. His research is interdisciplinary and problem orientated, often combining different theoretical approaches to investigate how progress towards low carbon energy systems and sustainability transformations more broadly can be achieved. His work be split into two broad areas of interest: (1) Actors and their agency to pursue societal change, and (2) governing socio-technical change.

jake.barnes@ouce.ox.ac.uk

Course Content and Structure

The course will cover the content set out below. We will have two sessions in the morning and one in the afternoon, with time in the second half of the afternoon for further discussion and one-to-one guidance. However, there may be alterations depending on teaching conditions at the time.

Most of the talks will be given by invited speakers. We always emphasize that the talk should have plenty of time for interaction with and between the students by including micro-group exercises, lots of Q and A etc.

The precise scheduling of the speakers and their topics changes each year but we try to organise them into a theme for each day of the week.

Finalised details will be published on Canvas at least 1 week before the course is delivered. The general structure of the module and themes for each day are set out below:

Monday: Introduction to the Energy and Society module and then 2 sessions on “History and path dependency”

Introduction session
- Aims of the week
- Headline description of the various speakers
- Overlaps with Energy Policy Module and Energy Demand Module
- Discursive workshop type exercise led by Jake Barnes to warm the students up to the socio-technical perspective

History and path dependency sessions
- Energy systems as social systems, and vice versa.
- Energy services
- Infrastructures of demand and supply and how we engage with them.
- Energy transition – the global challenge.
- Actors in energy systems.

Tuesday: Geography, Space and Scale
- Place based approaches to system transition
- The Capability Approach, understanding place and design of interventions
- Engaging communities
- Transport, mobility and infrastructures
- Geopolitics of systems of energy provision
- Communicating energy – practical exercise.

Wednesday: Energy System transitions
- Transitions and practice theory – the nexus of society and technology
- Business models for local energy transition
- Digitisation
- Relationship between design of buildings, cultural norms for heating and clothing

Thursday: Energy equity
- Fuel poverty
- Inequities in the energy transition
- Race and ethnicity
- Legal structures and human rights

Friday: Synthesis day
- What are the main takeaways and how are they relevant to the rest of the course?
- Any unresolved issues?
- Fun, discursive session. Energy Quiz. Prizes may be awarded!
- Preparation for assignment.

Course Texts

Eyre, N., Darby, S.J., Grünewald, P., McKenna, E. and Ford, R., (2018) Reaching a 1.5C target: Socio-technical challenges for a rapid transition to low carbon electricity systems. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences* 376:20160462

Stephenson, J., Hopkins, J. and Doering, A. (2014) Conceptualizing transport transitions: Energy Cultures as an organizing framework. *Energy and Environment* 4 (4), 354-364

Wilhite, H. (2008) New thinking on the agentive relationship between end-use technologies and energy-using practices. *Energy Efficiency* 1, 121-130. Personal energy use in relation to system development

Khalid, R., Sunikka-Blank, M. (2018) Evolving houses, demanding practices: A case of rising electricity consumption of the middle class in Pakistan. *Building and Environment* 143, 293-305

Darby, S.J. and McKenna, E. (2012) Social implications of residential demand response in cool temperate climates. *Energy Policy*, 49: 759-769

Grunewald, P. and Diakonova, M. (2018) Flexibility, dynamism and diversity in energy supply and demand: A critical review. *Energy Research and Social Science*, 38: 58-66

Hargreaves, T., Wilson, C. and Hauxwell-Baldwin, R. (2017) Learning to live in a smart home. *Building Research and Information* 46 (1), pp.127-139

Energy system change as a social process. Boamah, F. and Rothfuss, E. (2018) From technical innovations towards social practices and socio-technical transition? Re-thinking the transition to decentralised solar PV electrification in Africa. *Energy Research & Social Science* 42, 1-10

BSECC: Bristol Smart Energy City Collaboration. Taking action to realise the benefits of smart energy data. https://www.cse.org.uk/projects/view/1296

Executive Summary of Darby, S.J., Liddell, C., Hills, D. and Drabble, D. (2015) Smart Metering Early Learning Project: synthesis report. For the Department of Energy and Climate Change, London https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/407568/8_Synthesis_FINAL_25feb15.pdf

Nolden, C., Barnes, J. and Nicholls, J. (2020) Community energy business model evolution: A review of solar photovoltaic developments in England. Renewable and Sustainable Energy Reviews 122, 109772. https://www.sciencedirect.com/science/article/pii/S1364032120300198

Parag, Y. and Janda, K.B. (2014) More than filler: Middle actors and socio-technical change in the energy system from the “middle-out”. *Energy Research & Social Science* 3, 102-112

Last reviewed: 09/24

Se3. Energy Policy and Governance (Hilary Term: Week 8)

Dr Tina Fawcett (Environmental Change Institute, School of Geography and the Environment)

Course Context

This module will provide an understanding of the social, economic, technical and political contexts in which policies are formed and implemented. Theories of policy making will be introduced. Students will learn about the different policy instruments and policy mixes used in various countries and contexts. Most focus will be on policies related to the energy transition – policy on energy efficiency / energy demand reduction and renewable energy. Throughout the module there will be examples of successful and unsuccessful policies from across the world. By the end of the module, students will understand how to critically analyse current and proposed policies against a range of criteria.

The teaching will build on the introductory material on policy covered in Se1, and rely on the strong socio-technical understanding of the energy system delivered by previous modules.

Lecturers

Dr Tina Fawcett will lead the module, with contributions from colleagues at the Environmental Change Institute and elsewhere.

Course Content and Structure

Elements of the course content may be delivered on different days from the description below, depending on the availability of external speakers.

Monday: Policy goals overview, case studies of policy making

A brief history of energy policy and why it matters. Discussion of the energy trilemma. Contrasts in policy for people / organisations / technologies / markets. Policy making from practitioners' perspectives – how does policy really get made?

Tuesday: Policy types and theories of policy making

Outline of different types of policy and policy combinations. Investigating theories of policy making and reflecting on how these match with real world case studies. How does change happen? Developing and promoting new policy ideas – examples from current ECI research.

Wednesday: International policy, politics & policy transfer

Contributions from a range of international policy practitioners, Q&A with students. The politics of energy policy, overview and examples from around the world. The Overton window of public and political acceptability. Theories of international policy transfer, illustrated with case studies.

Thursday: Governance, communities & public involvement

What do we mean by governance and who, if anyone, is in charge of the energy system? Exploring international, national and local energy governance. Focus on governance for energy system transformation. More democracy, not less: the role of democratic participation for climate action.

Friday: Policy into the future, new perspectives

What new policies, governance arrangements and ideas do we need for a just energy transition? Improving equity and sustainability in the energy sector. Focus on global North / South justice issues, particularly in relation to GHG emissions and climate impacts. A re-cap of the week. Introduction to the assignment.

Course Texts

Some of these papers / information sources would fit under more than one heading. It is not necessary to read them all, but worthwhile looking at one source from each category.

Energy policy: overview and aims of policy
World Energy Trilemma Index – this ranks countries on their ability to provide sustainable energy through 3 dimensions: Energy security, Energy equity (accessibility and affordability), Environmental sustainability. Use the 'Trilemma Tool' to explore different countries:
https://www.worldenergy.org/publications/entry/world-energy-trilemma-report-2024

Sterner, B. et al (2019) Policy design for the Anthropocene. *Nature Sustainability* 2:14-21 (Goes beyond energy – broad overview of policy options and key considerations in design.)

Current policy
Rosenow, J., Cowart, R., Thomas, S. (2019): Market-based instruments for energy efficiency: a global review. Energy Efficiency 12(5), pp. 1379–1398

Databases for policy measures:
MURE (Mesures d'Utilisation Rationnelle de l'Energie) provides information on energy efficiency policies and measures that have been carried out in the Member States of the European Union.
http://www.measures-odyssee-mure.eu/
International Energy Agency database: https://www.iea.org/policies - for global coverage

Policy making processes and evaluation
Obeng-Darko, N.A. (2018) Why Ghana will not achieve its renewable energy target for electricity. Policy, legal and regulatory implications. *Energy Policy* 128:75-83

EPATEE European project on evaluation – includes case studies from EU and USA:
https://epatee.eu/case-studies

Politics and policy
Cairney, Paul (2015) 12 Things to know about studying public policy.
https://paulcairney.wordpress.com/2015/10/29/12-things-to-know-about-studying-public-policy/

Mallaburn, P. and Eyre, N. (2014) Lessons from energy efficiency policy and programmes in the UK from 1973 to 2013. *Energy Efficiency* **7:** 23–41

Lamb, W., Mattioli, G., Levi, S., Roberts, J., Capstick, S., Creutzig, F., . . . Steinberger, J. (2020). Discourses of climate delay. *Global Sustainability, 3*, E17. doi:10.1017/sus.2020.13

Policies for a better future

ECEEE, AEEE, ACEEE (2019) 12 strategies to step up global energy efficiency: Advice from three expert NGOs to IEA's High Level Commission on Energy Efficiency: https://www.eceee.org/all-news/news/12-strategies-to-step-up-global-energy-efficiency/

Oxford Martin School (2024) Cooling the world without heating the planet: https://www.oxfordmartin.ox.ac.uk/long-read/cooling-the-world-without-heating-the-planet

Executive summary of: IRENA (2018) Renewable energy policies in a time of transition. https://www.irena.org/publications/2018/Apr/Renewable-energy-policies-in-a-time-of-transition

Bruun, E. and Givoni, M. (2015) Sustainable mobility: Six research routes to steer transport policy. *Nature* 523:29-31Green Alliance and CREDS (2020) Balancing the energy equation: Three steps to cutting UK demand https://www.green-alliance.org.uk/Balancing_the_energy_equation.php

Last reviewed: 09/24

Appendix 2: Complaints and Appeals

The University, MPLS Division and the Department of Engineering Science hope that provision made for students at all stages of their course of study will make the need for complaints (about that provision) or appeals (against the outcomes of any form of assessment) infrequent.

Nothing in the University's complaints procedure precludes an informal discussion with the person immediately responsible for the issue that you wish to complain about (and who may not be one of the individuals identified below). This is often the simplest way to achieve a satisfactory resolution.

Many sources of advice are available within colleges, within faculties/departments and from bodies such as the Student Advice Service provided by OUSU or the Counselling Service, which have extensive experience in advising students. You may wish to take advice from one of these sources before pursuing a complaint.

General areas of concern about provision affecting students should be raised through Joint Consultative Committees or via student representation on the faculty/department's committees.

Complaints

Concerns or complaints relating to teaching or other provision made by the faculty/department should be raised with the Course Director (Professor David Wallom), Deputy Course Director (Dr Sarah Sparrow) or Director of Graduate Studies (Professor Daniel Eakins) as appropriate. Within the faculty/department, the officer concerned will attempt to resolve the concern/complaint informally.

Student concerns can be taken further by making a formal complaint to the University Proctors. The procedures adopted by the Proctors for the consideration of complaints and appeals are described on the Proctors' webpage (Academic appeals, complaints and conduct) and the Student Handbook.

If a concern or complaint relates to teaching or other provision of a college, it should be raised either with the college tutor or with one of the college officers, a Senior Tutor, or Tutor for Graduates (as appropriate). The college will also be able to explain how to take a complaint further if a student is dissatisfied with the outcome of its consideration.

Academic appeals

An academic appeal is defined as a formal questioning of a decision on an academic matter made by the responsible academic body.

A concern which might lead to an appeal should be raised with the college authorities and the individual responsible for overseeing a student's work. It must not be raised directly with examiners or assessors. If it is not possible to resolve a concern in this way, it may be put in writing and submitted to the Proctors via the Senior Tutor of the relevant college.

As noted above, the procedures adopted by the Proctors in relation to complaints and appeals can be found via the following:

- Proctors' webpage (https://www.ox.ac.uk/students/academic/complaints)
- Student Handbook (https://www.ox.ac.uk/students/academic/student-handbook?wssl=1)

In relation to academic appeals, please note that:

- The Proctors are not empowered to challenge the academic judgement of examiners or academic bodies.
- The Proctors can consider whether the procedures for reaching an academic decision were properly followed; i.e., whether there was a significant procedural administrative error; whether there is evidence of bias or inadequate assessment; whether the examiners failed to take into account special factors affecting a candidate's performance.
- On no account should a student attempt to contact examiners or assessors directly.

Harassment

The University condemns harassment as an unacceptable form of behaviour and has an advisory system to help people who think they are being harassed. Harassment includes any unwarranted behaviour directed towards another person which disrupts that person's work or reduces their quality of life. Further information and guidance are available at:

- www.admin.ox.ac.uk/eop/harassmentadvice
- http://www.admin.ox.ac.uk/eop/harassmentadvice/policyandprocedure/

The Engineering Science department has two advisors on harassment who can provide confidential support and guidance to students:

- Christine Mitchell, Head of Student Administration: christine.mitchell@eng.ox.ac.uk
- Helen Burton, HR Manager: helen.burton@eng.ox.ac.uk

Appendix 3: Small Group Case Study Guidance

You are a small but innovative energy consultancy that has been engaged by the Ministry for Energy of your assigned country to develop a national energy transition strategy. The country has made commitments to NetZero by 2050 and signed up to the 2015 Paris Agreement. It must also aim to at least maintain GDP per head and economic growth (i.e., the transition should be economically positive).

You are asked to deliver a 35-page report[*] and an additional 2-page executive summary, along with a video presentation on your strategy. The video should be no shorter than 30 minutes and no longer than 45 minutes. The minimum requirement is for a slide presentation with voice over, though improvements in presentation style are encouraged.

The report should be structured in the normal way that a consultancy report would be presented to a government. There should be a clear breakdown of the contributions made by each member of the group towards both the report and the presentation.

[*] Not including references and appendices though the total submitted report should not exceed 50 pages.

Appendix 4: Dissertation Proposal Form

Project Description

- Title
- Description (Max 15 lines)

Objectives:

- Easily Attainable
- Attainable
- Advanced

Supervision and assessment:

- Name of student (if topic has been student-led/amended)
- Supervisor name
- Co-supervisor
- Suggested 2nd assessor

Collaborators:

- External collaborators (name and contribution)
- Requirement of formal agreement

Practical considerations:

- External resources required (e.g. consumables, travel, technical workshops, IT support etc.)
- Health and Safety considerations:
    - Computer use: Y/N
    - Using hazardous substances: Y/N
    - Using nanomaterials: Y/N
    - Using biological substances: Y/N
    - Using lasers or high power LEDs: Y/N
    - Using components or systems pressurized with gases or compressed air: Y/N
    - Using liquefied gases e.g. liquid nitrogen: Y/N
    - Other hazard

Appendix 5: Dissertation Report Guidance

Planning

Examination Regulations require each MSc candidate to submit a dissertation of not more than 15,000 words on a topic selected by the candidate in consultation with the supervisor and approved by the Standing Committee.

The report must not exceed 75 pages (including all diagrams, photographs, references and appendices). All pages should be numbered, include margins of not less than 20 mm on all sides and use a font size not less than 11 points, with line spacing of no less than 8 mm.

Before starting to write, be clear what is the purpose of the report and who will read it. The principal readers will be one or more examiners or assessors. However, subsequent readers may include students, technical staff and academics.

Structure

A report should include the following:

- Cover and Title Page: the project title, the author and their college affiliation should be prominently displayed, both on the front cover and on the first page. Your candidate number **must not** be included.
- Acknowledgements should be made of sources of help and finance.
- Abstract: a summary of the project, not longer than one page in length. This is best written last.
- Contents page giving page numbers of the main sections and sub-sections of the report.
- Sectional structure – for example:

  1. Introduction
  1.1 What the project is about
  1.2 How the report is organised
  2. Literature Review
  3. Methodology
  4. Results
  4.1 Presentation of collected data or input
  5. Discussion
  5.1 Analysis of results
  5.2 Presentation of findings from analysis
  6. Conclusions
  6.1 Summary, recapitulating what was achieved
  7 Recommendations for future work

  n+1. References Appendices

  All projects should include a review of appropriate research literature.

  The two Sections 'Introduction' and 'Conclusions' should make sense if read together without the intervening sections.

- References are an essential part of any technical report because credibility depends not only on a clear explanation of what has been done, but also on showing how it relates to, or builds on, prior knowledge. References to other work, whenever it is used, should be included in a way that clearly distinguishes between the work of the report and the work of others. Refer also to the source of any quoted text or diagrams or other graphics. (See section 3 on the style of references.)

- Appendices should record information that is likely to be of use to the reader who seeks detailed information, but which is not essential to an understanding of the report. For example: tables of numerical data, computer source-code, details of electronic circuits (if incidental to the main body of the text). Appendices are included in the page count.

Style

- Authors should concentrate on communicating with readers. For engineering projects, readers may be assumed to understand engineering language but not to know anything about the subject of the project. A report suitable for a reasonably competent contemporary engineering student would be at about the right level.

- For formal reports, such as these are, use the third person passive. For example, 'In Section 2 it is shown that . .' rather than 'I found that . .'

- Avoid jargon. Define any unusual terms or acronyms wherever they first appear.

- Spelling and grammar are important.

- Reports should be presented to give a good impression.

- Guidance can also be found in the books listed in the bibliography below.

Figures, Tables and Equations

Every figure and table should have a caption and should be explicitly referred to in the text, using a numbering system that identifies the object within its section of the report. For example, Figure 3.4 would be the fourth figure in Section 3. Place the figure or table near the text that refers to it, but not necessarily embedded within word-processed text.

Diagrams in the main text of a report should be simple and clear. Detailed material, such as engineering drawing or computer source code, is often better placed in an appendix. Tabulated data can sometimes be represented in graphical form in the main text. Large sets of numbers, if they must be included, should be placed in an appendix.

Equations should in general be numbered either sequentially or using a numbering system as for figures.

References

There are two main styles for references:

- A numerical system with a number in square brackets in the text after each reference, the numbers running in sequence starting at the beginning of the report, with a numbered list of references in the same order at the end of the report.

- Reference by author name(s) and date of publication in the text with the list of references at the end of the report arranged in alphabetical order according to the surname of the first author. This second method is recommended because it more easily accommodates changes during composition.

Examples of referencing systems can be found in most periodicals in the departmental Library, and in some of the books mentioned in Section 5. Where quoting web pages the full description of the document (including its electronic source data) must be given using the following format: Creator's surname, creator's first name. Title. Date of publication. Name of Institution associated with site. View date. <http://address/filename>.

Practical advice

- Writing a report is not a trivial task, so allow plenty of time (i.e., weeks, not days).

- Plan the structure as early as possible. In consultation with your supervisor, decide what will be the main technical sections of the report. The structure is not developed to show the chronology of the work, but rather to help communicate the nature of the work done (hindsight is very useful!).

- Agree with the supervisor a schedule which exploits the full time available and allows time to receive sufficient guidance on writing your report. Note that supervisors are expected to:

- Discuss in detail the student's outline for the report.

- Look carefully at the early drafts of chapters, making reasonably detailed comments and constructive suggestions on both the content and style (including grammar).

- Give a quick overview of later drafts, but not the finished report, and point out any major problems.

- Before submitting a final version, ask a friend to read the report and comment on it. Or have it read aloud. Failing these, re-read the report a few days after completing it. Residual errors can be detected by this procedure.

Bibliography

Strunk W & White E B, 'The Elements of Style', MacMillan 1995 Gowers E, 'The Complete Plain Words', Penguin 1987

Fowler H W, 'The new Fowler's modern English usage', Clarendon, 1996 Davies J W, 'Communication for Engineering Students', Longman, 1996 Turk C and Kirkman J, 'Effective Writing', Chapman and Hall 1989

Sharp J A & Howard K, 'The Management of a Student Research Project', Gower 1996

Appendix 6: Dissertation Marking Scheme

Introduction (/10)

- Has the topic of study been introduced, stating clearly its relevance using a set of well described aims and objectives?
- Does the introduction make clear for the reader how the candidate has approached the problem?

Literature Review (/15)

- Is the review well-ordered showing a clear logical structure displaying an understanding of relevant literature that is used to form the basis for the investigation?
- Are the sources used timely and academically qualified to provide justification in their usage?
- Are sources correctly referenced in a consistent/appropriate manner?

Methodology (/25)

- Is the research methodology appropriate to the objectives of the study being conducted? Are there clear rationales for the methods chosen that are well described?
- Has the methodology been evaluated against other possible methods or structures to show that there is justification for that chosen?

Results & Discussion (/25)

- Is the data collected during the study relevant to the objectives and aims of the study?
- Are appropriate data visualisation tools and techniques utilised where insights are presented or claimed to be shown by the data?
- Are appropriate considerations of uncertainty, errors and or omissions made by the student wrt the data collected, i.e., are there improvements they could make with hindsight?
- Are the results discussed appropriately such that they are compared to available research elsewhere?

Conclusion (/20)

- [Note: Students are given the option of using their conclusion section as a draft publication to showcase their results. Therefore, alongside this will be a brief Summary conclusions section.]
- Have the research aims and objectives, the research question, been evaluated in light of the results and discussion?
- Does the study show that by building on results and discussion that appropriate conclusions can be made?
- Can the conclusions have been made more generally applicable beyond any specific use cases or examples?
- Has the student outlined possible future work that could be conducted in light of their research outputs?

Report Structure and presentation (/5)

- Is the report correctly structured, following guidelines originally given to the students?

- Is there correct labelling of figures/tables in a manner such that it is consistent throughout and able to be followed?
- Is the text free of grammatical errors to a level that would be expected of a professional document?
- Are all external sources correctly cited within the text with references recorded in a consistent manner?

Appendix 7: Guidance in the event of an attack by an armed person or persons

1. Be prepared and stay calm

The purpose of this guidance is to alert and not to alarm – it is not being provided in response to any specific information. Although students are asked to be mindful and alert, please do not be overly concerned. You are asked to carry on with your day-to-day life as normal.

In the event of an incident, quickly determine the best way to protect yourself.

2. Evacuate

- If it is possible to do so safely, exit the building or area immediately
- Have an escape route in mind (Fire Exit signs are a good point of reference)
- Evacuate regardless of whether others agree to follow
- Help others, if possible
- Prevent others from entering the area of danger
- Do not attempt to move wounded people
- When you are safe, call 999 and ask for the police

3. Hide

- If evacuation is not possible, find a place to hide where the offender is less likely to find you
- If you are in a room/office, stay there
- If you are in a corridor, get into a room/office
- Lock the door and blockade it with furniture
- Silence your mobile phone and remain quiet
- Turn off the lights and draw any blinds
- Hide out of view and behind something solid (desk or cabinet)
- If it is possible to do so safely, call 999 and ask for the police

4. Inform

If you contact the police, provide the following information:

- Location of and the number of offenders
- Any physical descriptions of the offenders
- Number and type of weapons used by the offenders
- Number and potential victims at the location
- Your location

Stay Safe

Further information and advice are available from Oxford University Security Services (telephone 01865 (2)72944 or email: security.control@admin.ox.ac.uk).