COURSE HANDBOOK

2026/2027

MSc Energy Systems

This handbook applies to students starting the MSc Energy Systems in October 2026.

The Examination Regulations relating to this course are available here.

Course Specific Regulations:

- MSc in Energy Systems (full-time)
- MSc in Energy Systems (part-time)

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 msc-energy@eng.ox.ac.uk.

The information in this handbook is accurate as of 6 October 2026 however, it may be necessary to make changes in course provision. For more information, please visit this website.

MSc Energy Systems
2026: version 1.1

For the latest version of this handbook, please see this website

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

2026-2027 Academic Year

Monday 5 October 2026	Departmental Induction
Sunday 12 October 2026	Start of Michaelmas Term
Friday 27 November 2026	R1. Energy Fundamentals and Thermodynamics assignment deadline
Saturday 5 December 2026	End of Michaelmas Term
Friday 18 December 2026	Sy1. Energy Infrastructure: Power Systems assignment deadline
Friday 1 January 2027 tbc	Se1. Energy Demand assignment deadline
Friday 8 January 2027	R2. Energy Conversion 1: Large Fixed Generation assignment deadline
Sunday 17 January 2027	Start of Hilary Term
Friday 26 February 2027	Sy2. Energy for Development assignment deadline
Friday 5 March 2027	Se2. Energy and Society assignment deadline
Friday 12 March 2027	R3. Energy Conversion 2: Distributed and Renewable Generation and Storage assignment deadline
Saturday 13 March 2027	End of Hilary Term
Friday 2 April 2027	Se3. Energy Policy and Governance assignment deadline
Friday 9 April 2027	Sy4. Energy Systems: Economics and Markets assignment deadline
Friday 16 April 2027	Sy3. Digitization, Smart Energy and Communication assignment deadline
Sunday 25 April 2027	Start of Trinity Term
Friday 30 April 2027 tbc	Whole Cohort Exercise presentation and event
Friday 14 May 2027	Small Group Case Study video presentation and report deadline
Saturday 19 June 2027	End of Trinity Term
Monday 6 September 2027	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)

Course Administrator (msc-energy@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 Department's Disability Lead and Head of Student Administration in Engineering Science, Dr Philip Bolton (phil.bolton@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.

1.5 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.

1.6 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. Buildings and facilities

2.1 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)

2.2 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.

3. 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).

4. Course content and structure

4.1 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.

4.2 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 Fundamentals and Thermodynamics
    b. Energy Infrastructure: Power Systems
    c. Energy Demand
2. Submission of written assignments corresponding to a minimum of six and a maximum of seven further taught modules chosen from those listed below,
    a. Energy Conversion 1, Large Fixed Generation,
    b. Energy Conversion 2, Distributed and Renewable Generation & Storage,
    c. Energy for Development,
    d. Digitisation, Smart Energy and Communication,
    e. Energy Systems: Economics and Markets,
    f. Energy and Society,
    g. Energy Policy and Governance,
3. A group case study project
4. The whole cohort exercise
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]

5. Taught modules

5.1 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.

Module Structure for Part-Time Students

24-Month Programme

- **Year 1**:
  - Complete all **Resources** theme modules *(red)*.
  - Optionally begin **Systems** *(blue)* and/or **Services** *(yellow)* modules.
- **Year 2**:
  - Complete any remaining **Systems** and/or **Services** modules.
  - Submit the **Dissertation** *(green)*.
- **Group Exercises**:

[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

    - *Small Group Case Study* and *Whole Cohort Exercise* can be taken in either year.
    - Students may complete one per year or both in the same year.
- **Skills Training Weeks**:
    - Not assessed but must be completed at the scheduled time due to dependencies with taught content.

36-Month Programme

- **Year 1**:
    - Complete all **Resources** theme modules *(red)*.
- **Year 2**:
    - Choose to complete either **Systems** *(blue)* or **Services** *(yellow)* modules.
- **Year 3**:
    - Complete the remaining theme modules and submit the **Dissertation** *(green)*.
- **Group Exercises**:
    - Can be taken in any year.
    - Recommended: one group assessment in each of the first two years.
- **Skills Training Weeks**:
    - Not assessed but must be completed at the scheduled time due to dependencies with taught content.

<table>
<tr><th>Term</th><th>Week 0</th><th>Week 1</th><th>Week 2</th><th>Week 3</th><th>Week 4</th><th>Week 5</th><th>Week 6</th><th>Week 7</th><th>Week 8</th></tr>
<tr><td>Michaelmas</td><td>Induction and Research Challenge</td><td colspan="2">Resources 1: Energy Fundamentals and Thermodynamics (CORE)</td><td>Skills 1</td><td colspan="2">Systems 1: Energy Infrastructure: Power Systems (CORE)</td><td colspan="2">Services 1: Energy Demand (CORE)</td><td>Resources 2: Energy Conversion 1: Large Fixed Generation</td></tr>
<tr><td rowspan="2">Hillary</td><td>Dissertation Planning 1</td><td rowspan="2">Systems 2: Energy for Development</td><td rowspan="2">Services 2: Energy and Society</td><td rowspan="2">Resources 3: Energy Conversion 2: Distributed and Renewable Generation & Storage</td><td rowspan="2">Skills 2</td><td rowspan="2">Whole Cohort Exercise Planning</td><td rowspan="2">Services 3: Energy policy and governance</td><td rowspan="2">Systems 4: Energy Systems: Economics and Markets</td><td rowspan="2">Systems 3: Digitization, smart energy and communication</td></tr>
<tr><td>Small group case study preparation</td></tr>
<tr><td rowspan="2">Trinity</td><td colspan="2">Whole Cohort Exercise Preparation, presentations and event (Weeks -1 to 1)</td><td colspan="2" rowspan="2">Small group case study, including report presentation</td><td colspan="5" rowspan="2">Dissertation (Weeks 4 to 16)</td></tr>
<tr><td>Dissertation Planning 2</td><td></td></tr>
</table>

	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 2 or Year 1	Year 3 or Year 2
Grey	Year 1	Year 2	Year 2
Green	Year 1	Year 2	Year 3

Part-time students may choose the order of studying the Systems or Services themes. The course must be notified of the choice of order by MT WK2.
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.

Module descriptions can be found in Section 13.

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.

5.2 Assessment of taught modules

The taught module assessments combined contribute 65% of the overall marks for the degree.

Students must attend and submit assessments for **all** taught modules. All module marks are taken by the Board of Examiners to contribute towards your overall degree result with the foundation modules being worth twice the 7 further module marks. The lowest mark in the further modules is allowed to be a failure though the value is still used.

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 change each 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.

5.3 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. As part of your online submission, 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.

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 Programme Administrator (Energy Systems).

Please refer to the course's Examination Conventions [linked from the course Canvas page] for procedures relating to assignment resubmission.

5.4 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 will be published in the Gradebook on Canvas and feedback for each assignment will be circulated by email.

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.

5.5 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	Scientific Programming in Python
Day 2	Scientific Programming in Python
Day 3	Scientific Programming in Python
Day 4	Essay Writing
Day 5	Presentation Bootcamp & Data Management

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

6. Group work

6.1 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 assessments total mark and will constitute 5% of the overall degree mark.

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.

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

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.

6.2 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 5% 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.

7. 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:

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.

The course will be following guidelines on the use of Generative AI in assessment.

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.

8. Study skills

Guidance on time management, note-taking, referencing, research and library skills and information is available here.

9. 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.

10. 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).

11. Complaints and Appeals

The University's Mathematics, Physics and Life Sciences Division (MPLS) 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 Oxford University Student Union (Oxford SU) 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.

11.1 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.

11.2 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
- Student Handbook

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.

12. 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:

- Sexual Harassment and Violence Support Service | Oxford University

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

- Dr Phil Bolton, Head of Student Administration: phil.bolton@eng.ox.ac.uk
- Helen Burton, HR Manager: helen.burton@eng.ox.ac.uk

13.Detailed Syllabus

Accreditation: The Accreditation of Higher Education Programmes (AHEP) Learning Outcomes set out the required standard for an accredited Engineering degree programme.
The AHEP learning outcomes M1-5, M7, M16 are delivered throughout the course.
M17 is developed throughout the submitted work, and is explicitly assessed in some submissions, however your communication skills will be developed throughout all modules.
The remaining AHEP learning outcomes are achieved at the previous level of study.

13.1 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 Fundamentals and Thermodynamics (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
Dr Scot Wheeler
Professor Barabara Rossi
Professor Myles Allen
Prof Tim Woolings
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 *[AHEP 4.0 – M1]***
   a. What is energy?
   b. What is Work?
   c. What is Power?
   d. Units and Measurement
3. **Embodied or Embedded Energy *[AHEP 4.0 – M1, M2, M7]***
   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 *[AHEP 4.0 – M4, M7]***
   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 *[AHEP 4.0 – M7]***
   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 *[AHEP 4.0 – M1]***
   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 *[AHEP 4.0 – M1]***
   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 *[AHEP 4.0 – M2, M3, M4, M5, M7]***
   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: 09/26

R2. Energy Conversion 1: Large Fixed Generation (Michaelmas Term Week 8)

Module Leader: Dr Anupama Sen (Smith School of Enterprise and the Environment, University of Oxford)

Module 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 resource endowment, comparative advantage, the speed of technology transfer, and policies promoting inter-fuel substitution and circular economy. 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 (large, fixed generation) 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.

Module Structure

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

1. **Global overview of non-renewable energy systems based on large fixed generation** (Dr Anupama Sen)

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: sustainability, comparative advantage, scarcity rents, interfuel substitution, path dependency, environmental Kuznets curve, efficiency of energy use.

2. **Energy Conversion and the Conventional Power Generation System** (Professor Budimir Rosic)

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.

3. **Life Cycle Analysis of Energy Technologies** (Dr Amani Maalouf)

This session introduces Life Cycle Assessment (LCA) as an increasingly important tool for evaluating the environmental implications of energy technologies, an area now central to government strategies and policy discussions worldwide. The lecture begins by outlining why LCA has become essential for ensuring that the transition to clean energy does not unintentionally shift environmental burdens elsewhere. Students are then guided through the LCA methodology, including goal and scope definition, life cycle inventory, impact assessment, and interpretation, drawing on examples from current research and policy applications. The second part of the session follows the flow of a practical case study, presenting a cradle-to-gate LCA of emerging third-generation solar cell technology to illustrate how LCA identifies environmental hotspots across materials, energy use, and manufacturing processes. The session also concludes with a short exercise to familiarise students with interpreting LCA data and applying the method to real-world sustainability challenges.

4. **Decarbonisation technologies for fossil fuels** (Professor Budimir Rosic)

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 CO_2 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 CO_2 Removal (DCR) and Solar Radiation Management. Why the energy shift towards renewables in Germany fails to cut the carbon emission?

5. **Oil: history and market development** (Dr Adi Imsirovic)

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. Futures markets and other derivatives in oil, their role and impact on prices. Recent events in the Persian Gulf and future of OPEC and oil in general.

6. **Oil markets in transition** (Dr Adi Imsirovic)

What are markets anyway? Can they really help the energy transition and make the world a better place? 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.

7. **Natural gas in the energy system** (Mr Howard Rogers)

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.

8. **Nuclear energy generation** (Professor Budimir Rosic)

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. Modern fuel cycles from mining to reuse/ storage. Possibilities for future development.

Invited guest talks

Each year the module has a number of invited guests from industry on various topics including commodity trading, public finance, and SMR technologies, who interact with the course participants. These will be confirmed in the week before the module runs.

Useful Readings

Global overview of non-renewable energy systems based on large fixed generation

International Energy Agency, *World Energy Outlook 2026*, chapter 1. (Published online in November 2026).

Basu, P., Jamasb, T. and Sen, A., 'Trilemma or Trinity? The Nexus of Economic Growth, Circular Economy and Net Zero' (2024). *Energy Economics.* https://doi.org/10.1016/j.eneco.2024.107844

Sen A. and Jamasb T., 'The New Energy State: Offshore Governance Regimes for Renewables As Natural Resources' (2024) *The Energy Journal* 45 (6) https://doi.org/10.1177/01956574241281565

Poudineh, R. Sen, A. and Fattouh, B. (2020) "Electricity Markets in Resource-Rich Countries of the MENA: Adapting for the Transition Era", *Economics of Energy and Environmental Policy*. DOI: 10.5547/2160-5890.10.1.rpou

Keay, M. (2020) 'Energy Systems Thinking and Decarbonisation of Heat in the UK', OIES Paper EL39, Oxford Institute for Energy Studies. Available at https://www.oxfordenergy.org/wpcms/wp-content/uploads/2020/02/Energy-systems-thinking-and-the-decarbonization-of-heat-in-the-UK-EL-39.pdf

Sen A, Nepal R and Jamasb T, 'Have Model, Will Reform: Assessing the Outcomes of Electricity Reforms in Non-OECD Asia' (2018) 39 The Energy Journal 39(4). https://doi.org/10.5547/01956574.39.4.asen

Nepal, R., Jamasb, T. and Sen, A., 'Small Systems, Big Targets: Power Sector Reforms and Renewable Energy in Small Systems' (2018), *Energy Policy, Vol. 118*, pp. 19-29. https://doi.org/10.1016/j.enpol.2018.01.013

Poudineh, R, Sen., A and Fattouh, B., 'Advancing Renewable Energy in Resource-Rich Economies of the MENA' (2018), *Renewable Energy*, Volume 123, pp.135-49. https://doi.org/10.1016/j.renene.2018.02.015

Sen, A. and Segal, P. (2011) "Oil revenues and economic development: the case of Rajasthan, India", *Oxford Institute for Energy Studies* https://www.oxfordenergy.org/wpcms/wp-content/uploads/2011/08/WPM-43.pdf?v=79cba1185463

Bhattacharya, S. C. *Energy Economics: Concepts, Issues, Markets and Governance,* Springer, ISBN 978-0-85729-267-4.

Helm, D. (Ed) *The Future of Fossil Fuels*, Oxford Review of Economic Policy, Volume 32, Issue 2, Summer 2016.

Energy Conversion and Conventional Power Generation System

Energy: Resources, Utilisation, and Policies, by John H. Horlock, 2009, Krieger, ISBN-13: 978-1575242996

Energy Science – Principles, Technologies, and Impacts, John Andrews and Nick Jelley, 2017, Oxford University Press, ISBN-13: 978-0198755814

Life Cycle Analysis of Energy Technologies

Maalouf et al. (2023). 'A comprehensive review on life cycle assessment of commercial and emerging thin-film solar cell systems', *Renewable and Sustainable Energy Reviews*¸ Vol. 186. https://doi.org/10.1016/j.rser.2023.113652

Maalouf et al. (2023). 'Environmental performance of Kesterite monograin module production in comparison to thin-film technology,' *Solar Energy Materials and Solar Cells*, Vol. 251. https://doi.org/10.1016/j.solmat.2022.112161

Oil markets history and development AND Oil markets in transition

IEA, Global Energy Review 2026, https://www.iea.org/reports/global-energy-review-2026

Ed Hawkins, Climate Visuals https://ed-hawkins.github.io/climate-visuals/indicators.html

EU Carbon Permits, https://tradingeconomics.com/commodity/carbon

Comparative Analysis of Monthly Reports on the Oil Market, JODI, https://www.ief.org/news/comparative-analysis-of-monthly-reports-on-the-oil-market-66?s=09

Imsirovic. A: "OIL MARKET UNDER STRESS : OI WAR, INSTITUTIONS AND STRUCTURAL VOLATILITY" https://media.licdn.com/dms/document/media/v2/D561FAQFqxIC994dCqA/feedshare-document-url-metadata-scrapper-pdf/B56Z_YbaffHAA4-/0/1786042494253?e=1786651200&v=beta&t=V6V8umV2hvcsvGUgFAKYZkw7PmLt9VB4tmtCUQW_TF4

Seddon, J. and Imsirovic, A. (2026) : 'How Oil Benchmarks Survive,' https://www.energyintel.com/0000019f-3bb8-d302-afbf-7bbe305d0000

Imsirovic, A. (2022) Trading and Price Discovery for Crude Oils: Growth and Development of International Oil Markets. Palgrave Macmillan.

Imsirovic, A. (2024) International Oil Markets in the Age of Climate Change. Palgrave Macmillan.

Imsirovic, A. (2025) The Rivers of Money: Social and Economic History of Modern Oil Trading. Palgrave Macmillan.

Natural gas in the energy system

‘Challenges to JCC Pricing in Asian LNG Markets’, Howard Rogers & Jonathan Stern, NG OIES, NG 81, February 2014, https://www.oxfordenergy.org/publications/challenges-to-jcc-pricing-in-asian-lng-markets/

‘Asian LNG Demand: Key Drivers and Outlook’, Howard Rogers, OIES, NG106, April 2016, https://www.oxfordenergy.org/publications/asian-lng-demand-key-drivers-outlook/

Does the Portfolio Business Model Spell the End of Long-Term Oil-Indexed LNG Contracts?, Howard Rogers, April 2017, https://www.oxfordenergy.org/publications/portfolio-business-model-spell-end-long-term-oil-indexed-lng-contracts/

‘Shale Gas – the unfolding story’, Howard Rogers, Oxford Review of Economic Policy’, Volume 27, Number 1, Spring 2011, Pages 117 – 143

‘UK Shale Gas – Hype, Reality and Difficult Questions’, Howard Rogers, OIES, June 2013, http://www.oxfordenergy.org/2013/07/uk-shale-gas-hype-reality-and-difficult-questions/

Nuclear energy

PD Wilson, The nuclear fuel cycle, OUP https://global.oup.com/academic/product/the-nuclear-fuel-cycle-9780198565406?cc=gb&lang=en&

CD Ferguson, Nuclear Energy, What Everyone Needs to Know, OUP https://global.oup.com/academic/product/nuclear-energy-9780199759460?cc=gb&lang=en&#

Decarbonisation of conventional technologies

Energy: Resources, Utilisation, and Policies, by John H. Horlock, 2009, Krieger, ISBN-13: 978-1575242996

Carbon Capture: A Technology Assessment, Peter Folger, CRS Report for Congress, 2013, (https://fas.org/sgp/crs/misc/R41325.pdf)

Energy Science – Principles, Technologies, and Impacts, John Andrews and Nick Jelley, 2017, Oxford University Press, ISBN-13: 978-0198755814

LECTURER BIOS

Dr Anupama Sen, Associate Director, Smith School of Enterprise and the Environment, University of Oxford (Module Leader)

Anupama Sen is Associate Director (Impact) and Head of Policy Engagement for the Smith School of Enterprise and the Environment. Prior to the Smith School she spent 13 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. Anupama has published extensively on electricity sector restructuring and reform in the context of the energy transition in non-OECD Asia, the transition to renewables in resource-rich economies in the Middle East and North Africa, energy pricing reforms, and the impact of the energy transition on international energy markets. She has a strong interest in the socio-economic implications of the energy transition, its implications for energy consumers, producers and governments, and in the circular economy in relation to energy. Anupama holds a BA(Hons) in Economics from the University of Mumbai, MSc from the London School of Economics and PhD from the University of Cambridge. Anupama is a Fellow of the Cambridge Commonwealth Society, and has previously been a Junior Research Fellow and a Visiting Fellow at Wolfson College, Cambridge. She is currently also a Research Affiliate with the Copenhagen School of Energy Infrastructure.

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 Amani Maalouf, Senior Researcher, School of Geography and the Environment

Dr. Amani Maalouf is a Senior Researcher at the School of Geography and the Environment. Previous, she led waste management research at the Oxford Sustainable Finance Group, Smith School of Enterprise and the Environment, University of Oxford. She holds a Ph.D. in Environmental and Water Resources Engineering. Her work employs interdisciplinary methods, including environmental life cycle assessment, socio-economic analysis, life cycle costing, emission accounting, and material flow analysis, to support informed decision-making in waste management, renewable energy, the circular economy, sustainable finance, and climate change mitigation.

She has a distinguished record of international publications in high-impact peer-reviewed journals, conference proceedings, and book chapters. She has also made significant contributions to international scientific reports, strategic frameworks, and professional expert consultation reports. Her expertise in waste management has earned her invitations to chair conference sessions, serve on various scientific conference committees, and speak as an invited expert at prestigious international conferences. Additionally, she serves the international community by chairing and organising the International Solid Waste Association (ISWA) Young Professionals Group Online Conference, a leading platform in waste management organised by young professionals for young professionals. Amani has a strong track record of successful projects and collaborations with international institutions. Her work spans more than ten countries across Europe, North America, Latin America, the Middle East, and Asia. She has served as a senior environmental expert and team leader on multiple interdisciplinary research and development projects funded by organisations such as the World Bank, UNEP, UNDP, the International Solid Waste Association, the European Investment Bank, the European Commission, and the Royal Academy of Engineering.

Dr Adi Imsirovic, 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 books: *The Rivers of Money: Social and Economic History of Modern Oil Trading*, *International Oil Markets in the Age of Climate Change*, and *Trading and Price Discovery for Crude Oils: Growth and Development of International Oil Markets*. Adi also edited the book Brent Crude Oil: Genesis and Development of the World's Most Important Oil Benchmark, published by Palgrave in June 2023

Last reviewed: 09/26

R3. Energy Conversion 2: Distributed and Renewable Generation and Storage (Hilary Term Week 3)

TBC (Department of Physics)

Course Context

This module expands on the energy sources available to use in the form of renewables and distributed 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 batteries and more general 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 visits to distributed energy infrastructure near Oxford to ensure there is a full understanding of the implications. ***[AHEP 4.0 – M2, M3, M4, M5, M7]***

Course Content and Structure

1. The current capabilities of renewable energy ***[AHEP 4.0 – M1]***
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 ***[AHEP 4.0 – M1]***
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***[AHEP 4.0 – M1]***
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 ***[AHEP 4.0 – M1]***
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 & heat pumps ***[AHEP 4.0 – M1]***
What ways are there to convert the heat the earth (both surface and deep), water and air produces into other usable forms.

6. Power from water ***[AHEP 4.0 – M1]***
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 *[AHEP 4.0 – M1, M2, M3, M5, M7]*
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 *[AHEP 4.0 – M1]*
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 (4th ed), 2022
- Renewable Energy Resources, J. Twidell and T. Weir; Routledge (4th ed), 2021
- Principles of Sustainable Energy, F.Kreith, C.F. Kutscher, J.B. Milford; CRC Press (3rd ed), 2018
- IEA World Energy Outlook(s) (access via https://www.iea.org/analysis?type=report)
- Sustainable Energy- without hot air, David MacKay; UIT, 2009, (http://www.withouthotair.com/) (available free of charge)
- Electrify, S. Griffith; The MIT Press; 2022

Last reviewed: 09/26

13.2. 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: Power Systems (Michaelmas Term Weeks 4 & 5)*

Dr Scot Wheeler (Department of Engineering Science)

Useful energy is often not generated at the time or place that the end user requires it. This is exacerbated in the transition to net-zero energy systems due to the highly distributed and variable nature of renewable energy sources. Therefore, energy needs to be moved – via energy vectors – through space and time, from the source of production to the point of consumption. This module primarily considers the former challenge – that of distributing the energy to the end user efficiency (techno-economic) – using electricity as a vector, 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 core principles of power system modelling and infrastructure design and applies these to case studies of both established grids undergoing net-zero transition and energy development contexts, highlighting the common themes and challenges for distributing energy.

Learning Outcomes

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

1. Consider implications of the choice of energy vector on energy transmission and distribution. ***[AHEP 4.0 – M1, M6, M13]***
2. Understand the underlying physics and technical models of electrical power transmission. ***[AHEP 4.0 – M1]***
3. Model and evaluate the technical performance of electrical power systems using open-source python software. ***[AHEP 4.0 – M2, M3]***
4. Critically assess existing power system designs in terms of technical performance, cost and resilience. ***[AHEP 4.0 – M2, M4, M6]***
5. Design power system infrastructure for new grid designs serving energy access in developing regions. ***[AHEP 4.0 – M5, M6, M7***
6. Evaluate infrastructure reinforcement and energy storage as alternative or complementary solutions for changing demand and increasing renewable integration in existing grids. ***[AHEP 4.0 – M2, M5, M6, M7]***

Course prerequisites

A basic knowledge of coding in python and a working python installation with at least PandaPower, PyPSA and associated dependencies installed. This is covered in the Python for Energy Systems

Analysis Skills Week course. It is highly recommended you attend in the year prior to taking course. A basic knowledge of linear algebra, trigonometric and complex numbers is desirable but not essential.

Course Content and Structure

1. **Understanding the energy distribution problem today and tomorrow.**
    - Energy and Power basics
    - Types of energy vectors: Mechanical, Thermal, Chemical, Electrical
    - Timing of generation, demand, diversity and maximum demand
    - Moving energy through time and space: Storage, distribution and transmission.
    - Exercise: Energy distribution system scoping case study.

2. **Fundamental physics of power grids**
    - DC and AC
    - Power through a resistor (DC) and an inductor (AC).
    - Active Power, Reactive Power and Apparent power.
    - Three phase analysis.
    - Simple power flow analysis in Python
    - Exercises: 3-bus toy model

3. **Tools for power flow modelling**
    - AC Power Flow
    - DC approximation
    - Geopandas and QGIS for spatial analysis
    - Pandapower for power flow analysis
    - PyPSA for DC power flow and optimal dispatch
    - Exercises: DC and AC microgrid design

4. **Power Infrastructure design**
    - Transmission and distribution lines
    - Key design principles
    - Economics of power infrastructure
    - Exercises: DC and AC microgrid design

5. **Case Studies**
    - Sourcing power systems data
    - Design of new power infrastructure: Africa
    - Transforming existing power infrastructure: UK

Course Texts

Electrical and Electronic Technology: Hughes E. (Pearson)

https://www.pandapower.org/

https://pypsa.org/

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

https://overpass-turbo.eu/

https://www.neso.energy/data-portal

https://www.qgis.org

Last reviewed: 07/26

Sy2. Energy for Development (Hilary Term Week 1)

Prof Stephanie Hirmer (Department of Engineering Science)

Course Context

Modern energy is a necessary condition for development. This importance is recognised as a core part of Sustainable Development Goal 7. Providing the energy needed at an acceptable cost to deliver appropriate services efficiently, while protecting the environment, is a significant challenge in many low- and middle-income countries. New technologies are being developed to meet this need and there is a growing appreciation that they need to be appropriately targeted, designed, and delivered to provide sustainable energy access. Furthermore, energy systems must respond to changing customer needs. This is complicated by the institutional and economic local, regional, and country-level capacities, as well as equitability challenges.

This module introduces key principles in energy planning for development and then applies them to case studies that highlight the common themes and challenges for developing sustainable energy systems in low-resource settings.

This module is designed to enable the student to deeply understand the following principles:

- The people benefiting from energy systems are key in defining the service requirements and their consideration is essential for sustainable development.
- The choice of energy service delivery is dependent on spatial context including population density, effective load density, and generation potential.
- Key risks include social acceptability, system obsolescence, institutional backing, and financial viability.

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

1. Deploy different methods to understand customer requirements and capabilities. ***[AHEP 4.0 – M3]***
2. Understand and account for the complexities of what makes an energy system sustainable. ***[AHEP 4.0 – M7]***
3. Critically assess last-mile distribution system technologies and topologies for local contextual and techno-economic fit. ***[AHEP 4.0 – M2, M3, M4, M7]***
4. Develop an energy plan for a local area accounting for contextual factors, local demand (households, industry and institutions), and financial considerations. ***[AHEP 4.0 – M1, M2, M3, M4, M5, M7]***

Lecturers

Prof. Stepanie Hirmer (Department of Engineering Science)
Dr Alycia Leonard (Department of Engineering Science)
Guest speakers tbc

Course Content

The course will cover of the following themes. Each day will contain theory and practical exercise where the theory will be applied. It is designed to be participatory. A common theme throughout will be equity and justice.

1. **Understanding the end user**
   - Understanding the interplay of consumers needs and values with technology.
   - Social and productive uses (e.g., information, motion, thermal comfort)
   - Determining the importance and priority of energy services
   - Social and productive uses of energy
   - Indicative load profiles and diversity

2. **Spatial design**
   - Energy access technologies (i.e., SHS, micro-grids, mini-grids, grid extension)
   - Technical suitability of options based on spatial context
   - Spatial data used in energy planning (e.g., climate, population, socioeconomic)
   - Application of spatial data analysis in energy planning
   - Planning for placed-based impact of infrastructure systems

3. **Institutions**
   - Power sector organisations
   - Utility structures and unbundling
   - Political economy of energy planning
   - Regional energy markets and trade

4. **Financial viability**
   - Tariff structures (i.e., bands, cross-subsidy, relationship to affordability)
   - Willingness and ability to pay
   - Financial viability of utilities
   - Business models

Background reading

Understanding the end-user:
Energy cultures: A framework for understanding energy behaviours

The user-value of rural electrification: An analysis and adoption of existing models and theories

Mapping synergies and trade-offs between energy and the Sustainable Development Goals

A longitudinal study of electricity consumption growth in Kenya Accuracy of energy-use surveys in predicting rural mini-grid user consumption

Spatial design:
Predictive mapping of the global power system using open data

Mapping the cost competitiveness of African green hydrogen imports to Europe

Rural electrification through mini-grids: Challenges ahead

Lost in the dark: A survey of energy poverty from space

Data and analysis platforms e.g., Global Electrification Platform, Energy Access Explorer

Kenyan County Energy Plans e.g., Nyandarua, Embu, Kilifi

Institutions:
The political economy of least cost power planning in Kenya

Power sector organisations & Utility structures

What underlies the poor financial performance of electric utilities in sub-Saharan Africa?

Climate, power, and structural reforms: the political economy of international financial institutions and climate-resilient development

Financial viability:
Why Are Connection Charges So High?: An Analysis of the Electricity Sector in Sub-Saharan Africa

Assessing grid affordability for universal electricity access in Sub-Saharan Africa

Financial Viability of Electricity Sectors in Sub-Saharan Africa: Quasi-Fiscal Deficits and Hidden Costs

Monitoring Performance of Electric Utilities : Indicators and Benchmarking in Sub-Saharan Africa

Last reviewed: 21 July 2026

Sy3. Digitisation, Smart Energy and Communication (Hilary Term: Week 8)

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)
Dr 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? *[AHEP 4.0 – M1]***
    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 *[AHEP 4.0 – M4]***

7. **Creating insights from big data *[AHEP 4.0 – M1, M3]***
   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 *[AHEP 4.0 – M2, M5]***
   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 *[AHEP 4.0 – M1, M10]***
    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: 09/26

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

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

Course Context

The story of energy is not just one of technology, but also of money. Four of the six largest companies in the world by revenue are in the energy sector. Day by day, economics determines the dispatch of different energy flows. Year by year, energy systems are undergoing a remarkable, once-in-a-civilisation transition towards cleaner, smarter and more distributed technologies, with trillions of dollars at stake.

This module introduces the basics of energy economics and finance, focussing on electricity as a particularly fascinating and relevant energy vector. We examine the structures of electricity markets, their reform and potential for value creation as the transition to zero-carbon energy occurs around the world. We also explore the social, political and economic dimensions of integrating new technologies into energy systems. As well as lectures on theory and concepts, there will be coding exercises, games, and multiple guest speakers.

Lecturer

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

Course Structure and Content

The module will cover the following content:

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.

2. **Economics *[AHEP 4.0 – M1]***
    - Fundamentals of demand, supply and markets.
    - Price elasticity of demand and supply in the context of electricity.
    - Welfare optimisation.
    - Modelling electricity pricing using economic dispatch based on merit order considering network constraints.
    - Introduction to nodal pricing.

3. **Power markets**. ***[AHEP 4.0 – M3]***
    - Functioning of wholesale power markets, balancing markets, capacity markets.
    - Missing money problem.
    - Main approaches to regulation.
    - Challenge to power markets of very low marginal cost technologies.

4. **Market liberalisation**. ***[AHEP 4.0 – M4]***
    - 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.

5. **Nexus! Challenge**. A game exploring resilience across the energy-water-food nexus.

6. **Finance**. ***[AHEP 4.0 – M3, M4]***
    - Scale of the financing challenge for the energy transition.
    - Financial mechanisms for funding energy projects.
    - Finance in the context of political risk.
    - Case study in financing UK offshore wind.

7. **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.

8. **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.

Course texts

- IEA World Energy Outlook(s) (http://www.worldenergyoutlook.org/)
- Kirschen, D. and Strbac, G. (2018) Fundamentals of Power System Economics, 2nd Edition
- Helm, D. (2017) Burn Out: The Endgame for Fossil Fuels
- Yergin, D. (2012) The Quest: Energy, Security, and the Remaking of the Modern World

Last Reviewed: 07/2026

13.3 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 energy services, energy efficiency, sufficiency, 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)

Ms Pippa Amanta (Environmental Change Institute, School of Geography and the Environment)

Guest speakers
Professor Keith Hyams (Warwick University)
Prof Peter Taylor (Leeds University)
Wendy Stone (Global Academy)

Other speakers to be confirmed.

Course Content and Structure

The course will cover the following content*:*

- **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.
- **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.
- **Energy demand as a socio-technical system.** ***[AHEP 4.0 – M2, M3]***
  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.
- **Energy demand in buildings.** ***[AHEP 4.0 – M1]***
  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.
- **Energy demand in transport.** ***[AHEP 4.0 – M1]***
  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.
- **Energy demand in industry.** ***[AHEP 4.0 – M1]***
  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.
- **Energy efficiency and demand reduction.** ***[AHEP 4.0 – M1]***
  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.
- **Understanding and comparing data for energy demand.** ***[AHEP 4.0 – M2, M3, M4]***
  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.

- **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.
- **Thinking about future energy demand. *[AHEP 4.0 – M4, M7]***
  Models and scenarios are widely used in strategic and policy debates about the future.

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
- Satre-Meloy, A., Hampton, S., 2024. Physical, socio-psychological, and behavioural determinants of household energy consumption in the UK. Energy Efficiency 17, 86. https://doi.org/10.1007/s12053-024-10264-3
- 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: 09/26

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)

A well-off Georgian English home at Christmas time (probably 1820s to 1830's). Note the equipment needed for comfort: a coal fuelled stove, heavy clothes and furnishings, high backed chairs to keep the drafts out and a sight screen to stop the older lady's make up running from the radiant heat from the fireplace…

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 within systems. 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. It will introduce contemporary theory about how transitions come about and salient approaches for enacting change within systems.

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

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.

Learning Objectives

1. Demonstrate a socio-technical understanding of energy systems and *apply* socio-technical approaches to *propose, justify or evaluate* interventions that address contemporary energy challenges
2. Discuss socio-technical system transitions and transformations and their differences, applying core concepts of co-evolution, path dependence and lock-in to analyse system change
    a. Analyse contemporary energy issues through a just transition lens and evaluate different courses of action
    b. Introduce, demonstrate and apply a place-based understanding of supporting system transformation
3. Apply socio-technical research methods to contemporary energy issues

Assessment

The assessment will consist of a 2,500 word case study report on an energy service in its cultural, geographic and temporal context. The assessment tests your understanding of how socio-technical systems provide a range of energy services, how they are always rooted in socio-material and cultural contexts and how they evolve over time. It will also test your ability to propose, justify and evaluate interventions in systems to meet a just transition.

Course Content and Structure

The course is divided into three topics. A variety of teaching styles – lectures, exercises, discussions, case methods classes – keeps learning dynamic and student-led.

1. Energy Transitions: theory and practice
   Introduction to socio-technical systems and how they provide energy services; Exploration of their historical evolution and how they build up momentum and path dependence; Energy systems in diverse historical contexts (global north and global south); How systems change, transition and transformation; Engaging with and influencing socio-technical systems

2. Place-based approaches to energy transitions
   Thinking critically about people and place; The Capabilities Approach to understanding and enacting local place-based change; Energy planning, what it is, why its gaining ground; contemporary examples

3. Equity and fairness
   An introduction to the three tenants of energy justice; exploration of equity issues in contemporary global south and global north; the impacts of new energy infrastructures; recognising and addressing inequalities, fuel poverty

Course Texts

The below texts provide points of energy into the module content.

Foundational texts: arguing for a critical social perspective on energy systems

- Bridge, G., Stewart Barr, Stefan Bouzarovski, Michael Bradshaw, Ed brown, Harriet Bulkeley, & Gordon Walker. (2018). Chapter 1: Introduction A critical perspective on energy–society relations, *Energy and society: A critical perspective*. Routledge. https://doi.org/10.4324/9781351019026
- Miller, C. A., Iles, A., & Jones, C. F. (2013). The Social Dimensions of Energy Transitions. *Science as Culture*, *22*(2), 135–148. https://doi.org/10.1080/09505431.2013.786989

Introductions to transitions and transformations

- Hendriks, A., & Wesche, J. (2026). Sustainability Transitions Research: An Introduction. In A. Hendriks & J. Wesche (Eds.), *Introduction to Sustainability Transitions Research* (pp. 1–12). Cambridge University Press. https://doi.org/10.1017/9781009437318.002
- Geels, F. W. (2026). The Multi-level Perspective on Sustainability Transitions: Background, Overview and Current Research Topics. In J. Wesche & A. Hendriks (Eds.), *Introduction to Sustainability Transitions Research* (1st ed., pp. 15–33). Cambridge University Press. https://doi.org/10.1017/9781009437318.004

Place-based approaches

- Marsden, G., Bouzarovski, S., Balani, K., Bodden, S., Kasprowicz, V., Martiskainen, M., Rattle, I., Sugar, K., & Wade, F. (2025). (Re-)locating ‘place’ in energy demand: Implications for research and policy. *Geoforum*, *165*, 104375. https://doi.org/10.1016/j.geoforum.2025.104375
- Banks, N. W., & Darby, S. J. (2021). A capability approach to smart local energy systems: Aiming for “smart and fair.” *ECEEE Summer Study*, 5–105. https://ora.ox.ac.uk/objects/uuid:4c26fb86-deb5-4337-bd53-e34a975ff030

Energy justice and equity

- Jenkins, K., McCauley, D., Heffron, R., Stephan, H., & Rehner, R. (2016). Energy justice: A conceptual review. *Energy Research and Social Science*, *11*, 174–182. https://doi.org/10.1016/j.erss.2015.10.004
- Heffron, R. J. (2024). Energy justice – the triumvirate of tenets revisited and revised. *Journal of Energy & Natural Resources Law*, *42*(2), 227–233. https://doi.org/10.1080/02646811.2023.2256593

Last reviewed: 09/26

Se3. Energy Policy and Governance (Hilary Term: Week 6)

Dr Jake Barnes (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 and short exercises for students to work through. 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 Jake Barnes will lead the module, with contributions from colleagues at the Environmental Change Institute and beyond.

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. Theories of policy making – comparison with practitioners' experience. How does change happen? Evaluation – how do we know what works? Markets, governments and interventions. 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
- IEA (2025) Energy Efficiency Policy Toolkit 2025. International Energy Agency. https://www.iea.org/reports/energy-efficiency-policy-toolkit-2025

Policy making processes and evaluation

- EPATEE European project on evaluation – includes case studies from EU and USA: https://epatee.eu/case-studies
- Hampton, S. et al. (2021) Evaluation in an Emergency: Assessing Transformative Energy Policy amidst the Climate Crisis. Joule, Volume 5, Issue 2, 285 - 289

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/
- Lamb, W. et al (2020). Discourses of climate delay. Global Sustainability, 3, E17. doi:10.1017/sus.2020.13

- Kuzemko, C., Blondeel, M., Bradshaw, M., Bridge, G., Faigen, E., & Fletcher, L. (2024). Rethinking Energy Geopolitics: Towards a Geopolitical Economy of Global Energy Transformation. Geopolitics, 30(2), 531–565. https://doi.org/10.1080/14650045.2024.2351075

Policies for a better future

- 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
- Wiese, F., Taillard, N., Balembois, E. et al. (2024) The key role of sufficiency for low demand-based carbon neutrality and energy security across Europe. Nat Commun 15, 9043. https://doi.org/10.1038/s41467-024-53393-0
- UKERC (2025) Transport Evidence Compendium – Futures section: https://ukerc.ac.uk/publications/ukerc-transport-evidence-compendium/ https://doi.org/10.5286/UKERC.EDC.000988

Last reviewed: 09/26

Glossary: AHEP 4.0 Learning Outcomes

Science and Mathematics

M1 - Science, Mathematics and Engineering Principles
_Apply a comprehensive knowledge of mathematics, statistics, natural science and engineering principles to the solution of complex problems. Much of the knowledge will be at the forefront of the particular subject of study and informed by a critical awareness of new developments and the wider context of engineering.

Engineering Analysis

M2. Problem Analysis
_Formulate and analyse complex problems to reach substantiated conclusions. This will involve evaluating available data using first principles of mathematics, statistics, natural science and engineering principles, and using engineering judgment to work with information that may be uncertain or incomplete, discussing the limitations of the techniques employed.

M3. Analytical Tools and Techniques
_Select and apply appropriate computational and analytical techniques to model complex problems, discussing the limitations of the techniques employed.

M4. Technical Literature
_Select and critically evaluate technical literature and other sources of information to solve complex problems.

Design and Innovation

M5: Design
_Design solutions for complex problems that evidence some originality and meet a combination of societal, user, business and customer needs as appropriate. This will involve consideration of applicable health and safety, diversity, inclusion, cultural, societal, environmental and commercial matters, codes of practice and industry standards.

M6: Integrated/Systems Approach
_Apply an integrated or systems approach to the solution of complex problems.

The Engineer and Society

M7: Sustainability
_Evaluate the environmental and societal impact of solutions to complex problems (to include the entire life- cycle of a product or process) and minimise adverse impacts.

M8: Ethics
_Identify and analyse ethical concerns and make reasoned ethical choices informed by professional codes of conduct.

M9: Risk
_Use a risk management process to identify, evaluate and mitigate risks (the effects of uncertainty) associated with a particular project or activity.

M10: Security
_Adopt a holistic and proportionate approach to the mitigation of security risks.

M11: Equality, Diversity and Inclusion
_Adopt an inclusive approach to engineering practice and recognise the responsibilities, benefits and importance of supporting equality, diversity and inclusion.

Engineering Practice

M12: Practical and Workshop Skills
_Use practical laboratory and workshop skills to investigate complex problems.

M13: Materials, Equipment, Technologies and Processes
_Select and apply appropriate materials, equipment, engineering technologies and processes,

recognising their limitations.

M14: Quality Management
_Discuss the role of quality management systems and continuous improvement in the context of complex problems.

M15: Engineering and Project Management
_Apply knowledge of engineering management principles, commercial context, project and change management, and relevant legal matters including intellectual property rights.

M16: Teamwork
_Function effectively as an individual, and as a member or leader of a team. Evaluate effectiveness of own and team performance.

M17: Communication
_Communicate effectively on complex engineering matters with technical and non-technical audiences, evaluating the effectiveness of the methods used.

M18: Lifelong Learning
_Plan and record self-learning and development as the foundation for lifelong learning/CPD.