Department of Engineering Science

COURSE HANDBOOK

2019/2020

MSc Energy Systems

This handbook applies to students starting the MSc Energy Systems in October 2019.

The Examination Regulations relating to this course are available at:

http://www.admin.ox.ac.uk/examregs/information/contents/

MSc in Energy Systems (full-time):

https://gazette.web.ox.ac.uk/files/07-11-19mscinenergysystemsfull-timepdf

MSc in Energy Systems (part-time):

https://gazette.web.ox.ac.uk/files/07-11-19mscinenergysystemspart-timepdf

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 concerns, please contact:

mscprogrammes@eng.ox.ac.uk

The information in this handbook is accurate as at 12 November 2019; however, it may be necessary for changes to be made in certain circumstances, as explained at:

http://www.ox.ac.uk/admissions/graduate/courses/changes-to-courses

MSc Energy Systems
2019: version 6.2
For the latest version of this handbook please see
https://www.eng.ox.ac.uk/mscenergy/

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1. Introduction

1.1 Welcome

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

Transitioning worldwide energy systems towards cleaner sources, while providing energy to over 1.3 billion people currently without access to electricity, is one of the biggest challenges of the 21st century. We aim to equip you with the best possible appreciation of complex interdisciplinary challenges for energy system development to ensure that industry and government policies can address these challenges effectively.

No other UK University matches Oxford's strengths across physical and social sciences in this area, and 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 (nine in MPLS, nine in Social Sciences and one in Humanities).

In this multi-disciplinary course, you will be taught by energy researchers from across Oxford, including academics in the departments of Engineering Science (which is hosting the course), Physics, Materials Science, Chemistry, Economics, International Development, and the School of Geography and the Environment. Together these departments have formed the Oxford Energy Network to address the major technical, social, economic and policy challenges of providing secure, affordable and sustainable energy for all. We engage with small and large energy companies, and governments, 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.

I 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 and enriching series of opportunities to learn new skills, and I encourage you to make the most of what is on 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

Dr Sarah Sparrow

Deputy Course Director

1.2 Important dates

2019-2020 Academic Year (1-year, 2-year, & 3-year students)

Monday 7 October 2019	Departmental Induction
Sunday 13 October	Start of Michaelmas Term
Friday 29 November	R1. Energy Sources assignment deadline (All)
Saturday 7 December	End of Michaelmas Term
Friday 20 December	Sy1. Energy Infrastructure assignment deadline (FT & 2-year PT)
Friday 3 January 2020	Se1. Energy Demand assignment deadline (FT)
Friday 10 January	R2. Energy Conversion 1 assignment deadline (All)
Sunday 19 January	Start of Hilary Term
Friday 6 March	R3. Energy Conversion 2 assignment deadline (All)
Saturday 14 March	End of Hilary Term
Friday 20 March	Se2. Energy and Society assignment deadline (FT)
Friday 27 March	Sy3. Digitization, Smart Energy and Communication assignment deadline (FT & 2-year PT)
Friday 3 April	Se3. Energy Policy and Governance assignment deadline (FT)
Friday 10 April	Sy4. Energy Systems: Economics and Markets assignment deadline (FT & 2-year PT)
Sunday 26 April	Start of Trinity Term
Friday 1 May	Whole Cohort Exercise presentation and event (FT)
Friday 15 May	Small Group Case Study report deadline and presentation (FT & 3-year PT)
Saturday 20 June	End of Trinity Term
Monday 7 September	Dissertation deadline (FT)

2020-2021 Academic Year (2-year and 3-year students)

Sunday 11 October 2020	Start of Michaelmas Term
Saturday 5 December	End of Michaelmas Term
Friday 18 December	Sy1. Energy Infrastructure assignment deadline (3-year PT)
Friday 1 January 2021	Se1. Energy Demand assignment deadline (2-year PT)
Sunday 17 January	Start of Hilary Term
Friday 12 March	Sy2. Energy for Development assignment deadline (3-year PT)
Friday 19 March	Se2. Energy and Society assignment deadline (2-year PT)
Saturday 13 March	End of Hilary Term

Friday 26 March	Digitization, Smart Energy, and Communication assignment deadline (3-year PT)
Friday 2 April	Se3. Energy Policy and Governance assignment deadline (2-year PT)
Friday 30 April	Whole Cohort Exercise, including presentation and event (2-year & 3-year PT, with full-time 2020-2021 cohort)
Friday 9 April	Sy4. Energy Systems: Economics and Markets assignment deadline (3-year PT)
Sunday 25 April	Start of Trinity Term
Friday 14 May	Whole Cohort Exercise report deadline and presentation (2-year PT, with full-time 2020-2021 cohort)
Saturday 19 June	End of Trinity Term
Monday 6 September	Dissertation deadline (2-year PT)

2021-2022 Academic Year (Provisional Term Dates - 3-year students)

Sunday 10 October 2021	Start of Michaelmas Term
Saturday 4 December	End of Michaelmas Term
Friday 31 December	Se1. Energy Demand assignment deadline (3-year PT)
Sunday 16 January 2022	Start of Hilary Term
Saturday 12 March	End of Hilary Term
Friday 18 March	Se2. Energy and Society assignment deadline (3-year PT)
Friday 1 April	Se3. Energy Policy and Governance assignment deadline (3-year PT)
Sunday 24 April	Start of Trinity Term
Friday 13 May	Small Group Case Study report deadline and presentation (3-year PT, with 2-year PT 2020-2021 cohort & FT 2021-2022 cohort)
Saturday 18 June	End of Trinity Term
Monday 5 September	Dissertation deadline (3-year PT)

1.3 Key contacts

The Department of Engineering Science is the administrative base for the course, and a significant proportion of your teaching will be delivered here. Space for independent study and collaborative working in groups is also provided in the Department.

The course administrator, Dr Erin Nyborg, can be found in the Student Administration Office (8th floor, Thom Building).

The course director is Professor David Wallom (david.wallom@oerc.ox.ac.uk, room 160 in the OeRC building) and the deputy course director is Dr Sarah Sparrow (sarah.sparrow@oerc.ox.ac.uk, room 164 in OeRC building)

Other useful general contact email addresses:

Student Administration Office – for all general queries relating to course administration and teaching
mscprogrammes@eng.ox.ac.uk
Tel: 01865 283254

Engineering Science IT Helpdesk – for help with IT
https://thehub.eng.ox.ac.uk
Tel: 01865 273069

Engineering Science Print Room – for printing/binding of dissertations, project reports etc.
printroom@eng.ox.ac.uk

1.4 Disability

If you have any form of disability, we strongly encourage you to disclose this to the Head of Student Administration in Engineering Science, Jo Valentine (jo.valentine@eng.ox.ac.uk), in order that we can make provision for you. Furthermore, 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 at www.ox.ac.uk/students/welfare/disability.

1.5 Virtual Learning Environment

This course uses a Virtual Learning Environment (VLE), which is a web-based application using Canvas.

https://canvas.ox.ac.uk/

Access to the course VLE is via an internet browser and using your Single Sign-On (SSO) account. When the course has started and you have activated your SSO, you will have access to module materials, the student forum, and information about student support. If you are unable to access Canvas please email the Student Administration Office with details of your SSO (msprogrammes@eng.ox.ac.uk).

Canvas will be used to house:

- Induction materials
- Pre-module reading and 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

Throughout the course you will also be required to submit work through a secure submission portal based on Weblearn, another VLE. A link to this platform will be provided on Canvas.

1.5 Sources of information

The University Student Handbook provides general information and guidance you may need to help you to make the most of the opportunities on offer at the University of Oxford. It also gives you formal notification and explanation of the University's codes, regulations, policies and procedures. It is available to download at

https://www.ox.ac.uk/students/academic/student-handbook?wssl=1

The student portal at www.ox.ac.uk/students provides a single point of access to information, services and resources for students.

The University has a wide range of **policies and regulations** that apply to students. These are easily accessible through the A-Z of University regulations, codes of conduct and policies available on the Oxford Students website at www.ox.ac.uk/students/academic/regulations?wssl=1.

Annual Registration

You can access the Student Self Service port at the link below:

https://www.ox.ac.uk/students/selfservice?wssl=1

You will be able to register, view and update your personal and academic information throughout your studies at Oxford. You must register at the start of the course and each successive year.

Graduate Supervision Reporting

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 as well: https://www.ox.ac.uk/students/selfservice?wssl=1.

2. Course content and structure

2.1 Course aims and learning outcomes

The course is designed to be accessible to those who have a first degree in engineering, the physical sciences or geography. Due to the programme's interdisciplinary nature, introductory material on thermodynamics, climate change, and the history of energy transition will be provided in the first module to enable all students to fully access the course material.

At the end of the course you will have acquired:

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

2.2 Course structure

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

Candidates will complete and be assessed on the following parts:

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

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

[1] https://www.qaa.ac.uk/docs/qaa/quality-code/qualifications-frameworks.pdf
[2] https://www.qaa.ac.uk/docs/qaa/subject-benchmark-statements/sbs-engineering-15-masters.pdf?sfvrsn=fb91f681

3. Taught modules

3.1 Teaching and Learning

The course is split into three core themes:

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

Within each of these themes will be a set of taught modules as listed below. Four of the units are taught in the first term (Michaelmas term, or MT), including the three foundation modules (shown by a star) and six are taught in the second term (Hilary term or HT). Each module is either two weeks long in the case of the three, mandatory foundation modules and one week in all other cases. These will be delivered with lectures for five hours of each day with two hours of each day available for cohort discussion, exercises or seminar from a relevant external speaker.

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

Students on the part-time, 24-month course will take the Resources and Systems theme modules in the first year of the programme. In the second year, part-time students (24 months) will complete the Services modules, as well the Whole Cohort Exercise, Small Group Case Study, and dissertation. The two skills training weeks can be taken in either year of the course.

Students on the part-time, 36-month course will complete the Resources theme modules and Small Group Case study during their first year (elements indicated in red). In the second year, part-time students (36 months) will take the Systems theme modules and will complete the Whole Cohort Exercise (elements indicated in blue). In the final year, part-time students (36 months) will complete the Services theme modules and the dissertation (elements indicated in green). The two skills training weeks can be completed at any stage of the course.

	Resources	Systems	Services	Non-Taught
Michaelmas Term	R1. Energy Sources* (Weeks 1-2) R2. Energy Conversion 1, Fixed Generation sources (Week 8)	Sy1. Energy Infrastructure* (Weeks 4-5)	Se1. Energy Demand* (Weeks 6-7)	I1 Induction & Research Challenge (Week 0) Skills (Week 3)
Hilary Term	R3. Energy Conversion 2, distributed and renewable generation (Week 2)	Sy2. Energy for Development (Week 3) Sy3. Digitization, Smart Energy and communication (Week 5) Sy4. Energy Systems: Economics and Markets (Week 7)	Se2. Energy and Society (Week 4) Se3. Energy Policy and Governance (Week 6)	Dissertation project Planning 1 (Week 0) Whole Cohort Exercise Planning (Week 0) Skills (Week 1)
Trinity Term				Dissertation project Planning 2 (Week 0) Whole Cohort Exercise presentations and event (Week 1) Small Group case study, including report presentation (Weeks 2-3) Dissertation (Weeks 4-10)

Further detail on each of these is provided in Appendix 1.

During the first term, you will be put into groups of five or six and asked to address a small research challenge which covers the disciplinary breadth of the course. In each group there will be at least one student who has particular strength in each of the subject areas and is able to explain concepts to fellow students where needed. This is not assessed but will give you an initial appreciation of the domain and build community with your fellow students.

3.2 Assessment of taught modules

The assessment tasks from the taught modules are together worth 50% of the overall marks for your MSc.

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

Each taught module will have an assessment at the end. These may take a number of different forms from extended essay type questions through to specific worked problems given as take-away papers. The assessment of the foundation modules will be approximately twice the length and expected depth of the remaining seven single week modules.

For each module, the assessment will be distributed at midday of the penultimate day of the teaching of that module. You will then have five weeks to complete the exercise and submit it electronically through Weblearn (a link to the secure submissions portal will be provided via Canvas).

Online submission

You must submit your assignments online using Weblearn by the date specified on the assessment task. Through this process you will also be asked to attest that the work you are submitting is your own work ('declaration of authorship'). You should keep copies of all submitted work. There are penalties for work submitted late without prior agreement, and these are set out in the Examination Conventions

If you are unsure about any element of the procedure for submitting your work, or are encountering difficulty submitting your work, please contact the Student Administration Office.

There is provision for students to make a case for mitigating circumstances for late submission. Students are permitted to apply for mitigating circumstances from five calendar days before the deadline up to seven calendar days after the date of submission. Work submitted late without an approved extension will be subject to mark deductions as set out in the draft Examination Conventions.

Re-takes

Please see the Examination Conventions.

3.3 Programming and data skills

During one week in Michaelmas term and one week in Hilary term there will be skills teaching sessions on topics not directly aligned to energy but of general benefit. These are not assessed.

Michaelmas Term, Week 3	Topic
Day 1	Scientific Programming in Python
Day 2	Scientific Programming in Python
Day 3	Engineering Project Finance
Day 4	Brainstorming
Day 5	Cultural Dexterity

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

4. Group work

4.1 Case study project

During Hilary term you will plan an energy transition case study project as part of a small group exercise that will occur in Trinity term. The content of lectures from all courses (including skills training) will provide important context for this.

Each group will be assigned a relevant supervisor. Topics for these group work exercises will be made available at the beginning of the course to allow group members to collect relevant content throughout their period of study. The names of supervising academics for each group will be provided at the same time. Weeks 2 and 3 during Trinity term are dedicated time to allow you to work on this project in your groups. At the end of Week 3, you will give a presentation to the course examiners and director for assessment. You will be assigned your group membership to ensure balance between the different groups.

The output will constitute 20% of the marks for your MSc and will be assessed by a panel of academics and industrial partners. The assessment of the output will be through a presentation and accompanying report which are both equally weighted. The presentation will be recorded to ensure that moderation is possible and in case of any appeal.

4.2 Whole Cohort Exercise

During Hilary term, the cohort will organise an industrial visit related to energy that will take place in Trinity term.

There will be a relevant team of academic supervisors available to the group though the whole exercise will be overseen by the course director.

The exercise output will be a coherent set of presentations, posters and a multi-chapter report to which each member will have contributed through named authors per chapter.

The whole cohort exercise will be formally assessed as part of the final mark given to candidates, and is therefore a compulsory part of the course. The output will constitute 5% of the marks for your MSc. The entire cohort will receive the same mark from the academic panel that will be sitting as assessors. The industrial partner will provide informal input to the academic assessors. You will receive feedback from the problem submitting organization and the academic supervisors as part of the dissemination event organized. You cannot pass the course without successfully completing this exercise.

5. Dissertation

5.1 Scope, topic selection and approval

Your dissertation topic must be within one of the topics of energy systems as defined by the topics covered in the taught modules.

A list of potential dissertation projects with possible supervisors will be published at the start of Hilary term (Week 0) of each year. Alternatively, you can propose a dissertation topic provided that it fits within the headings covered by the taught modules. However, the dissertation topic will need to be approved by the Director and Co-director of the course and must be submitted by Tuesday of Trinity Term Week 1 to be finalised and approved by Friday of that week. Therefore, if you are considering proposing your own topic, we recommend that you start thinking about your dissertation topic as early as possible as this will enable you to have fruitful discussions with your supervisor during and in-between the residential weeks.

A briefing on the dissertation will be provided at the beginning of Hilary term (Week 0) as the start of the process of choosing your topic, and you will have an opportunity to meet potential supervisors throughout Hilary term. For part-time students, this will be in the second or third year of your course. Having discussed the title with the supervisor, you must then submit the dissertation proposal form in Appendix 3 by Trinity term Week 0 to the course administrator. The Course Director and Deputy Course Director will then consider your proposal and approve it, approve it subject to specific modifications, or reject the proposal. Their decision will be communicated to you by the end of Trinity term Week 0. If rejected, you must choose one of the topics proposed by the course tutors. All proposals must be finalised by Trinity term Week 3.

Please note that if you choose to be supervised by a researcher from the Oxford Institute for Energy Studies (OIES), you will also need a co-supervisor who is a member of the University of Oxford, as the OIES is an independent research institute external to the University.

5.2 IP and ownership of data

If you intend to base your dissertation on data collected at a company or other institution, it may be necessary to put in place an agreement to establish intellectual property and ownership of data and results. Please raise this with your dissertation supervisor if this is likely to be the case. In such circumstances, you will be required to sign a non-disclosure agreement and the project reports will be marked as confidential and not disclosed. External examiners might wish to see these reports, in which case a non-disclosure agreement can be signed if considered necessary. The reports will be reviewed very carefully by the company-based supervisor and anything sensitive can usually be identified in an early draft and dealt with.

5.3 Supervisor support

Over the period designated for the dissertation (see timeline), your supervisors will provide hour-long face-to-face or Skype meetings every two weeks. It is your responsibility to take the initiative to agree the dates for these meetings. You may also contact your supervisor by email to request advice.

Your supervisor will read one full draft of your dissertation and provide written feedback on it, providing it is sent to the supervisor by the Monday of the last full week in August.

5.4 Report design

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

5.5 Submission

Your dissertation must be electronically submitted by the deadline shown in section 1.2 (Important Dates). Submission will be via the secure Weblearn VLE, which will be linked to from Canvas.

5.6 Assessment of your dissertation

Your dissertation will account for 25% of the overall marks for your MSc.

Candidates who fail to achieve an overall mark of 50% or over in the dissertation may resubmit the failed assessment(s) on one occasion only.

6. Good academic practice and avoiding plagiarism

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

You are required to work through the following online courses on good citation practice and how to avoid plagiarism, and gain the associated certification:

https://weblearn.ox.ac.uk/portal/hierarchy/skills/generic/avoidplag

All dissertations will be screened by Turnitin software which will compare them to a wide range of material (both published and unpublished) and to the work of other candidates. Written assignments from the taught modules may also be screened by Turnitin. The examiners will be notified of the extent of any textual matches discovered by Turnitin, and will consider, for instance, whether any text that a candidate has copied from elsewhere is properly identified and the source duly acknowledged.

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

Study skills

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

7. Feedback on your course

At the end of each taught module you will be asked to provide feedback on all aspects of the teaching you have received through an anonymous online survey. It is very important that you complete this survey as it is a key tool to help us monitor teaching quality and make necessary adjustments or improvements.

In December, you and all students at Oxford will also be asked to complete the Student Barometer, which is the University's key survey for collecting feedback from all students and monitoring the quality of all aspects of the student experience: induction, teaching and learning, assessment and feedback, and support services.

Concerns

If you have any issues with teaching or supervision please raise these as soon as possible so that they can be addressed promptly. Details of who to contact are provided in Appendix 2 (complaints and appeals).

Student representation

Professor David Wallom and Dr Sarah Sparrow are the academic directors for the course and a Standing Committee, which meets three times a year, provides oversight of the course.

It is expected that there will be two student representatives selected by the cohort for each year (one male and one female) and that nominees will become members of the course standing committee. One representative should also attend the termly departmental Graduate Joint Consultative Committee.

8. Buildings and facilities

8.1 Engineering Science

All teaching for the course will take place in room 277 (OeRC Teaching Room) in the Oxford e-Research Centre. You will be expected to have your own laptop.

Independent study space is also available for all students on the MSc Energy Systems in the Student Study Area on the eighth 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.

8.2 The 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 all of your reading list items, and most of your library research will be done using this library's resources. The library is located less than 5 minutes away from the Engineering Science department, at the corner of Parks Road and South Parks Road.

The Subject Librarian responsible for Engineering Science is Alessandra Vetrugno (alessandra.vetrugno@bodleian.ox.ac.uk) and she 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 that may be relevant to some modules. The library is located less than 15 minutes away from the Engineering Science department, on Manor Road, just off South Parks Road, and opposite St Catherine's College.

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

Appendices

Appendix 1: Detailed syllabus

Resources Theme

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

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

Professor David Wallom (Department of Engineering Science)

Course Context and Content

Energy, its production/transformation and consumption, are one of the key enablers for our current lifestyle and are about to undergo a huge transformation 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. The module will used lectures and project based learning to cover this broad and foundational topic to the whole course.

Course Content and Structure

The course will cover the following content in 30 1.5 hour sessions:

1. **Intro to the Energy System**

2. **The Energy System**
   Discussion about the system and where there are key strengths and weaknesses laying the ground work for how we describe the Energy System within the course.

3. **Forms of Energy**
   i) What is energy
   ii) What is Work
   iii) What is Power
   iv) Units and Measurement

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

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

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

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

8. **The Climate Change Challenge**
Climate change is the single biggest challenge for society as it moves forward; as such it is an energy problem first and foremost and as such we must understand the mechanisms of climate change. 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.

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

10. **The System**
    a. **Current Energy sources and interconnection**
    What are the energy sources used in society now? What are the mechanisms used to transform their energy and make it usable? Resource location & distribution (local vs distributed)? Discussion on efficiency including full chain analysis.
    b. **Future Energy**

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

Course Text(s)

- Energy Science, Andrews and Jelley (OUP)
- Sustainable Energy –without the hot air, David J.C. MacKay
- Basic Engineering Thermodynamics(OUP), Whalley
- Thermodynamics, A complete undergraduate course, Andrew M. Steane
- National Grid Future Energy Scenarios
- 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.

R2. Energy Conversion 1 (Michaelmas Term Week 8)

Dr Anupama Sen (Oxford Institute for Energy Studies)

Course Context

Non-renewable energy (oil, gas, coal and nuclear) accounts for around ninety 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 and obvious 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 therefore 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 for the different fossil fuel types, that was necessary to support the use of these non-renewable fuels, in a centralised way.

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

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

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

Course Content and Structure

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

1. **Global overview of non-renewable energy systems**

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

2. **Energy Conversion and Conventional Power Generation System**

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

3. **Coal: persistence in the energy mix**

The early emergence of coal as a major non-renewable energy source; the development and organisation of infrastructure to support its use; coal production and consumption around the world; links between the coal sector and the wider economy including labour markets; environmental issues and the decline of coal; new 'clean coal' technologies; the future of coal – can we expect coal to 'disappear' from the energy mix?

4. **Oil: the world's dominant energy source**

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; new oil production technologies; oil and the energy transition; adaptation strategies of oil producers.

5. **Gas's evolving role in the energy system**

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

6. **Nuclear Energy**

Fission and fusion technologies – the nature of energy release, and the challenges associated with controlling nuclear reactions. Energy density and fuel tolerance – the need for a nuclear fuel cycle – proliferation and security of supply. The role of nuclear energy in current power generation – national norms and historical perspectives. Modern fuel cycles from mining to reuse/ storage. Possibilities for future development.

7. **Decarbonisation of fossil fuels**

Carbon footprint of different power generation technologies. Carbon sequestration and storage (CCS). Although there are several recommended / researched techniques, it has not yet been implemented on a large scale. Carbon capture methods: Pre- and post-combustion, Oxy-Combustion systems. Coal gasification through Integrated Gasification Combined Cycle (IGCC) plants. Geological 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?

8. **The transition away from the current non-renewable energy system**

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 renewables come to dominate energy systems and will they be centralised or decentralised; will we see increasing diversity or homogeneity between regions; what is the role of government policies vis-à-vis market instruments in catalysing change.

R3. Energy Conversion 2 (Hilary Term Week 2)

Professor Moritz Riede (Department of Physics)

Course Context and Content

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

Course Content and Structure

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

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

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

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

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

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

7. Energy Storage technologies and keeping the lights on

Due to the intermittent nature of renewables it will be necessary to provide mechanisms for storing energy provided in times of plenty but required in times of famine. What technologies are available at the moment and how can we use those currently available without environmental damage or external dependency?

8. Energy Transport

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

Course Text(s)

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

Systems Theme

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

Sy1. Energy Infrastructure (Michaelmas Term Weeks 4-5)*

Professor Malcolm McCulloch (Department of Engineering Science)

Course Context and Content

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

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

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

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

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

Course Content and Structure

1. Understanding the problem today and tomorrow.
    a. Basics.
    b. Energy density and timing of production and generation.
    c. Diversity.
    d. Moving energy through time and space: Storage, distribution and transmission.
2. Types, principles and characteristics of energy vectors.
    a. Types of energy vectors: Mechanical, Thermal, Chemical, Electrical
    b. Energy, power and ramping.

    c. Losses: Conversion, spatial, temporal
    d. Costs, capex and opex: Conversion, spatial, temporal
    e. Reliability and fault management. (Degradation and failure mechanisms, Identification and mitigation)
3. Low fidelity modelling
    a. First principles model
    b. Sankey diagram
    c. LCOE for energy vector
    d. Exercise 1 - Enhance an existing system
4. Detailed analysis of power grids
    a. Power, Reactive Power and Apparent power.
    b. DC and AC Single and Three phase analysis.
    c. Power through a resistor (DC) and an inductor (AC).
    d. Simple power flow analysis in Python
    e. Parameters: Transmission lines and transformers.
    f. Costings for different technologies (overhead lines, cables, transformers, switchgear)
    g. Exercise 2 - Analyse an existing system
5. Spatial analysis
    a. GIS systems: QGIS
    b. Analysis of existing transmission grids: UK and Africa
    c. Coupled with power flow analysis.
    d. Analysis of existing distribution grids.
    e. Spatial optimisation in Python.
6. Emerging grid topologies
    a. Fractal like grids.
    b. Space-time grids.
7. Module synthesis

Course Text(s)

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

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

https://www.qgis.org

Sy2. Energy for Development (Hilary Term Week 3)

Professor Malcolm McCulloch (Department of Engineering Science)

Course Context and Content

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

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

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

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

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

Lecturers

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

Course Content and Structure

1. Understanding the end user
    a. Energy Cultures as a framework of understanding the interplay of end-users and technology.
    b. Understanding norms and perceived value
    c. Social and productive uses: Information, motion, thermal
    d. Determining important energy services:

    e. Indicative load profiles and diversity.
    f. Willingness/ ability to pay
    g. Ethics
    h. Exercise 1: End users of West Ngosini
2. Spatial density
    a. Data sets
    b. Determining spatial density from discrete locations
        i. Nearest Neighbours
        ii. Kernal methods
        iii. Clustering techniques
    c. Exercise 2: Spatial analysis of West Ngosini

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

4. Institutions
    a. Weberian vs Northian States
    b. Power sector organisation
        i. Vertically integrated
        ii. Unbundling
        iii. Private sector
        iv. Synergistic frameworks
    c. Exercise 4: Institutions

5. Module synthesis

Course Text(s)

Topic 1

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

Topic 2

1. https://www.qgis.org

Topic 3

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

Topic 4

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

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

Professor David Wallom (Department of Engineering Science)

Course Context and Content

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)
Professor Malcolm McCulloch (Department of Engineering Science)
Dan Bentham (Ubitricity)
Ramon Granell (Department of Engineering Science)
Dr Masao Ashtine (Department of Engineering Science)

Course Content and Structure

The course will cover the following content:

Day 1

1. **The Power System, Dynamics, Stability and Control**
   How is the electrical system operated now, balancing demand and quality of supply?
2. **What is a smart grid?**
   a. International Definitions
   b. Generalised characteristics exercise to pull out key points from definitions
3. **Smartening the Energy system**
   a. Information and analytics in the electricity network
      i. Fixed point Generation
      ii. Transmission
         1. Operations
      iii. Distribution
         1. Network equipment
         2. Large Distributed generation connection points
      iv. Retail
         1. Metering
         2. Services
   b. Gas network

How do we **currently** make use of multiple types of input information to improve the efficiency of the electricity transmission network? What are the communications and control protocols and systems in use currently? What scope is there for smartening the gas network?

Day 2

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

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

3. **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
    e. The advantages and disadvantages of smart meters

Day 3

1. **How we can use Smart Meters and other enhanced data providers, Cornish Local Energy Market**
    a. **Demand Management, now and in the future**; How do you currently understand in depth the current state of the energy network, at all voltage levels? It is clear though that we will need to manage consumption in the future, from the management of large scale usage now to the domestic consumption in future.

    b. Enhancing data within the network through meter information; Upgrading of capabilities within the distribution network to match transmission
        i. System state estimation techniques have been used in the transmission and are now beginning to be seen in the distribution networks.
        ii. Voltage control

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

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

Day 4

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

5. **Security implications of energy systems**

    How as part of the critical national infrastructure should we be securing the communication channels, equipment and keeping data private in a new energy system where everything is 'smart'?

Day 5

6. **A global perspective on smart grids, where have we got to?**
7. **Summary, Synthetisation and conclusions**

Course Text(s)

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

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

Professor Cameron Hepburn (Smith School of Enterprise and the Environment)

Course Context and Content

Five of the seven largest companies in the world by revenue are in the energy sector, which is at the start of a remarkable, once-in-a-civilisation transition. Coal is under severe pressure and the oil and gas majors are rethinking their long-term strategies, given the transition towards greater electricity and renewable energy, driven by climate change and new technologies. After a brief background into the energy system, this course examines the shifts underway in technology, government energy and climate policy and economic and political issues across the energy supply chain. We examine the potential for value creation as the transition to zero-carbon energy, particularly solar and wind, occurs around the world, and the social scientific dimensions of integrating those technologies into energy systems.

General information

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

Two very readable books on energy are:

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

The *Oxford Review of Economic Policy* periodically has useful special issues on energy, including a 2016 issue on the Future of Fossil Fuels and an issue in 2019 on the Age of Electricity.

Those wanting a more academic input can peruse journals such as Nature Energy or Applied Energy. Basic facts and figures can be found at Our World in Data.

Almost every 3 hour session has at least an external speaker for some part of the session. The sessions also include a multi-player game and investment pitch exercise.

Course Structure

The course will cover the following content in eight 3-hour sessions:

1. **Energy sector history and the coming transition.** Concepts and definitions. Brief overview of energy system history. Trilemma (security, cost, environment). Introduction to the drivers of the coming transition (new technologies and climate change).

2. **Energy technologies.** Rates of progress, costs and wider implications of the following: Renewables (solar, wind, hydro), SMRs, CCS, Smart energy systems, demand side, grid.

3. **Climate Change and the final 25%.** Scientific basis of climate change. Political and policy response, including carbon markets. Non-fossil energy carriers and energy storage. Difficult to abate sectors.

4. **Power markets.** Challenge to power markets of very low marginal cost technologies. Balancing supply and demand. Functioning of wholesale power markets, balancing markets, capacity markets. Main approaches to regulation. Missing money problem.

5. **Nexus game.** The class will play a game used with energy sector CEOs to explore human behaviour and decision making under pressure in an energy context, drawing out the links between the energy-water-food nexus.

6. **Energy access.** Energy markets in developing countries. SE4All and SDG 7: role of business in providing electricity for the 1 billion people without it. Grids vs distributed power generation.

7. **Energy finance.** Scale of the coming financing challenge. Financing of the energy supply chain. Finance in the context of political risk. Bankability of different energy revenue streams.

8. **Future directions.** Threats and opportunities are created by newer technologies (including blockchain smart grid and DSR) and policy responses to climate change. Shifts in value pools. Future role of the oil and gas majors.

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)*

Dr Gavin Killip (Environmental Change Institute, School of Geography and the Environment)

Course Context and Content

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 the underlying service demands and units of energy used in different domains, framed by the Sustainable Development Goals of the United Nations. Key concepts include: socio-technical systems, energy services, energy efficiency, demand reduction, flexibility, and links beyond the energy system. 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

Dr Gavin Killip (Environmental Change Institute, School of Geography and the Environment)
Professor Nick Eyre (Environmental Change Institute, SoGE)
Dr Tina Fawcett (Environmental Change Institute, SoGE)
Dr Sarah Darby (Environmental Change Institute, SoGE)
Dr Debbie Hopkins (Transport Studies Unit, SoGE)

Course Content and Structure

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

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

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

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

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

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

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

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

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

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

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

Course Text(s)

TBC

Se2. Energy and Society (Hilary Term Week 4)

Dr Sarah Darby (Environmental Change Institute, School of Geography and the Environment)

Course Context and Content

Energy systems exist to provide energy services to people, and they are designed, operated, developed and (occasionally) sabotaged by people. It is reasonable, and important, to describe and analyse them as socio-technical systems.

This module aims to develop our understanding of how energy systems rely on interactions between technologies and people, and how they evolve in response to changes in human activities, infrastructures of demand and supply, actors, skills and governance.

Students will learn how to analyse energy transitions in terms of stakeholder priorities, local considerations, technology adoption and adaptation in real-life conditions, and the roles of different types of actor, knowledge and skill. The module will draw upon a range of disciplines and tools for analysing and addressing energy-related issues.

Lecturers

Dr Sarah Darby will lead the module with contributions from colleagues at the Environmental Change Institute and beyond, as indicated below.

Course Content and Structure

The course will cover the following content, mostly in 90-minute sessions. There will be two in the morning and one in the afternoon, with time after the afternoon session for queries, discussion and guidance.

Monday 10th February: *systems, concepts and theory*

1. Why, where and how energy systems are social: examples and issues arising. (SD, small group discussion)
2. An introduction to approaches and methods for analysing socio-technical systems and system change. Metrics, indicators and scales of operation. (SD)
3. Energy services, infrastructures of demand and supply and how we engage with them. SD. Short informal exercise for evening

Tuesday 11th February: *Energy use in relation to system development*

1. Report back from homework exercise. Changing household practices and implications for demand and supply, UK and worldwide (SD)
2. Serious game: peer to peer electricity trading. Visiting speaker from UCL (tbc)

3. Non-domestic buildings, what happens in them and what it means for energy systems. SD plus visiting speaker from University Estates Dept (tbc).

Wednesday 12th February: *Energy transition, local and global*

1. Innovation and transition as social and dynamic processes involving creative thought, design, testing and evaluation. Skills, knowledge and scope for social learning for energy transition. Professional and 'lay' competences for daily low-impact living, the built environment, transport systems, electricity system management, regulation and market design. SD
2. Business models for local energy transition. Dr Jake Barnes, ECI.
3. Group exercise using the tool and symbology for business models developed by Kock et al. at ECI. SD

Thursday 13th February: *Implementing change as a social process*

1. Communicating energy. What sorts of communication are needed for energy systems in order to make them effective in terms of workability, social and environmental outcomes? Dr Rob Morris, using examples such as the SWELL, ERIC and Low Carbon West Oxford projects/programmes.
2. Energy and equity. SD
3. Field visit, e.g. Barton, Osney, Bicester, Charlbury, to see local energy initiative in action, with a focus on social and equity aspects. (SD with colleague tbc)

Friday 14th February: *synthesis day*

1. 'Flipped' session – discussion based on smart city video(s). What visions of the future are out there and what do they mean in terms of social and energy outcomes? SD
2. Synthesis. What are the main takeaways and how might these be relevant for the final assessment exercise? Any unresolved issues? (SD)
3. Preparation for assignment (below) (SD)

Reading list (* = priority)

Systems, concepts, theory

*Verbong, G. and Geels, F. (2007) The ongoing energy transition: lessons from a socio-technical, multi-level analysis of the Dutch electricity systems (1960-2004). *Energy Policy* 35 (2), 1025-1037

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

Kemp, R. (2017) Electrical system resilience: a forensic analysis of the blackout in Lancaster, UK. *Proceedings of the Institution of Civil Engineers – Forensic Engineering*. https://doi.org/10.1680/jfoen.16.00030 [*access to be arranged]

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

Residential energy use in relation to system development

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

*Gram-Hanssen, K. (2014) New needs for better understanding of household's energy consumption – behaviour, lifestyle or practices? *Architectural Engineering and Design Management* 10 (1–2), 91–107

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

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

Energy transition, local and global

Darby, S.J. (2017) Coal fires, steel houses and the man in the moon: local experiences of energy transition. *Energy Research & Social Science* **31**, 120-127

Jolly, S., Raven, R., and Romijn, H. (2012) Upscaling of business model experiments in off-grid PV solar energy in India. *Sustainability Science* 7 (2), 199-212

Implementing change as a social process

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

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

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

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

Course Context and Content

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

The teaching will build on introductory material on policy in Se 1, and relies on the strong socio-technical understanding of the energy system delivered by earlier modules.

Course Content and Structure

The course will cover the following content in 8 ***3***-hour sessions *(with 15 min break):*

1. **Introduction to energy policy.** Why governments have energy policies. How energy policy has developed over recent decades, on the supply and demand side. Changing aims of energy policy. Different approaches to policy making: market-based instruments, regulation, voluntary agreements. The politics of energy policy. Challenges of policy-making for the energy transition.

2. **Governance and policy design.** Who makes energy policy and how does it change? Theories of policy making. Understanding multi-level governance and roles of non-government actors. Choices and trade-offs in policy design and implementation. Policy mixes. Contrasts in policy for people / organisations / technologies / markets.

3. **Renewable energy policy.** Why we have renewable energy policy – what problems policy is solving. Overview of policy instruments and policy mixes. Case study examples of policies – successful or otherwise. Costs and benefits, equity, effectiveness. Future prospects.

4. **Energy efficiency policy.** Why we have energy efficiency policy – what problems policy is solving. Overview of policy instruments and policy mixes. Case study examples of policies - successful or otherwise. Costs and benefits, equity, effectiveness. Future prospects.

5. **Case study of policy in India:** Introduction to energy use in India by sector, historical trends, future scenarios. Policy making institutions and processes. Overview of current policy, individual instruments & the policy mix. Key energy policy challenges & future options.

6. **Case study of policy in the EU:** Introduction to energy use in the EU by sector, historical trends, future scenarios. Policy making institutions and processes, interactions with member states. Overview of current policy, individual instruments & the policy mix. Key energy policy challenges & future options.

7. **Policy Debate: Is a carbon tax the answer?** Theoretical perspectives and real-world examples of carbon and energy taxes will inform a debate about the benefits / dis-benefits of carbon taxation, its effectiveness and equity implications.

8. **Future directions:** New challenges for policy – market structures, new technologies, new business models, peer-to-peer trading, 'smart' everything, decentralisation. New approaches to policy making. Ways of meeting the 1.5C challenge. The limits of policy.

Course Text(s)

Additional readings will be suggested for each session. These are some introductory readings.

Eyre , N. Darby, S.J., Grünewald, P. McKenna, E, Ford, R. (2018) Reaching a 1.5°C target: socio-technical challenges for a rapid transition to low-carbon electricity systems. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences* https://doi.org/10.1098/rsta.2016.0462

Paul Cairney (2012) Understanding public policy: Theory and Issues. Palgrave McMillan Chapter 2: What is public policy? How should we study it?

UK Energy Research Centre: Review of Energy Policy 2018: http://www.ukerc.ac.uk/publications/review-of-energy-policy-2018.html

Appendix 2: Complaints and appeals

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

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

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

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

Complaints

If your concern or complaint relates to teaching or other provision made by the faculty/department, then you should raise it with the Course Director (Professor David Wallom), Deputy Director (Dr Sarah Sparrow) or Director of Graduate Studies (Professor Robin Cleveland) as appropriate. Within the faculty/department the officer concerned will attempt to resolve your concern/complaint informally.

If you are dissatisfied with the outcome, then you may take your concern 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 (https://academic.web.ox.ac.uk/academic-appeals-complaints-and-conduct), the Student Handbook (https://www.ox.ac.uk/students/academic/student-handbook?wssl=1) and the relevant Council regulations (www.admin.ox.ac.uk/statutes/regulations/247-062.shtml)

If your concern or complaint relates to teaching or other provision made by your college, you should raise it either with your tutor or with one of the college officers, Senior Tutor, Tutor for Graduates (as appropriate). Your college will also be able to explain how to take your complaint further if you are dissatisfied with the outcome of its consideration.

Academic appeals

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

A concern which might lead to an appeal should be raised with your college authorities and the individual responsible for overseeing your work. It must not be raised directly with examiners or assessors. If it is not possible to clear up your concern in this way, you may put your concern in writing and submit it to the Proctors via the Senior Tutor of your college.

As noted above, the procedures adopted by the Proctors in relation to complaints and appeals are described on:

- the Proctors' webpage (https://academic.web.ox.ac.uk/academic-appeals-complaints-and-conduct)
- the Student Handbook (https://www.ox.ac.uk/students/academic/student-handbook?wssl=1)
- the relevant Council regulations (www.admin.ox.ac.uk/statutes/regulations/247-062.shtml).

Please remember in connection with all the academic appeals 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 you contact your examiners or assessors directly.

Harassment

The University condemns harassment as an unacceptable form or 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 is available at:

www.admin.ox.ac.uk/eop/harassmentadvice

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

The Department of Engineering Science has two confidential advisors. At present these are Ms Jo Valentine, Head of Student Administration, and Ms Helen Burton, HR Manager, either of whom may be consulted in relation to matters of harassment.

Appendix 3: Dissertation proposal form

Student Name & # (if student initiated)

Supervisor (Name, Department and email)

Title

External Involvement (Name and contribution)

Project Category (Open to all or for specific student)

Description *(Max 15 lines)*

Suggested preparatory work/reading *(Max 10 lines)*

Objectives (1 line per)

- Easily Attainable;
- Medium Attainable;
- Advanced;

Dissertation classification (% of each must add to 100)

- Literature
- Theoretical
- Experimental
- Numerical/computational

Primary location

External Resources required (e.g. Consumables, travel, technical workshops, IT support etc.)

Health & Safety Considerations

- Computer use: Y/N
- Using hazardous substances: Y/N
- Using nanomaterials: Y/N
- Using biological substances: Y/N
- Using lasers or high power LEDs: Y/N
- Using components or systems pressurized with gases or compressed air: Y/N
- Using liquefied gases e.g. liquid nitrogen: Y/N
- Other Hazard:

Safety Notes: None

Appendix 4: 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 is available from Oxford University Security Services on 01865 (2) 72944 or security.control@admin.ox.ac.uk