

| Programme Information | | |
|------------------------------|----------------|-----------------------|
| Programme Title | Programme Code | HECoS Code |
| MSc in Future Power Networks | H6U7 | For Registry Use Only |

| Award | Length of Study | Mode of Study | Entry Point(s) | Total Credits | |
|----------------|-----------------------------|---------------|---------------------|---------------|------|
| | | | | ECTS | CATS |
| MSc | 1 Calendar year (12 months) | Full time | Annually in October | 90 | 180 |
| PG Diploma | N/A | Full time | N/A | 60 | 120 |
| PG Certificate | N/A | Full time | N/A | 30 | 60 |

The PG Certificate and the PG Diploma are exit awards and are not available for entry. All students must apply to and join the MSc. These exit awards are not currently accredited by the IET.

| Ownership | | | |
|----------------------|-------------------------|---------------------------|---------------------------------------|
| Awarding Institution | Imperial College London | Faculty | Faculty of Engineering |
| Teaching Institution | Imperial College London | Department | Electrical and Electronic Engineering |
| Associateship | N/A | Main Location(s) of Study | South Kensington Campus |

| External Reference | |
|--|-------------------------------|
| Relevant QAA Benchmark Statement(s) and/or other external reference points | Masters Degree in Engineering |
| FHEQ Level | Level 7 |
| EHEA Level | 2nd Cycle |

| External Accrator(s) (if applicable) | | | |
|--------------------------------------|---|------------------------|------|
| External Accrator 1: | The Institution of Engineering and Technology (IET) | | |
| Accreditation received: | 2018 | Accreditation renewal: | 2023 |

| Collaborative Provision | | | |
|-------------------------|--------------------|--------------------------|-----------------------|
| Collaborative partner | Collaboration type | Agreement effective date | Agreement expiry date |
| N/A | N/A | N/A | N/A |

| Specification Details | |
|-----------------------|-------------------|
| Programme Lead | Balarko Chaudhuri |

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|--|---------------|
| Student cohorts covered by specification | 2022-23 entry |
| Date of introduction of programme | 2015/16 |
| Date of programme specification/revision | September 22 |

Programme Overview

Decarbonisation of the electric power sector is the key towards achieving the 'net-zero' emission targets that several nations around the world have committed to. This necessitates radical changes in the way the electric power networks are planned, operated, and controlled in future which is the focus of this MSc programme. You will learn about the unique set of challenges posed by the rapidly changing power generation mix with increasing fractions of clean energy sources such as wind and solar. You will study the enabling technologies and the system-level solutions to facilitate the decarbonisation of the electric power sector in a secure and cost-effective way. The interplay with decarbonisation of the heat and the transport sector will also be part of your programme.

Throughout the programme there are many opportunities for you to work on your own as well as part of a team in group work; experiences which test your communication, leadership, and interpersonal skills as well as your technical competence, time, and project management skills are developed throughout the programme.

The programme is structured in three parts. The taught component of the programme is delivered in two parts, during the Autumn and Spring Terms. In the Autumn term you will acquire core knowledge in the topics of fundamental importance to the future power networks whereas in the Spring Term the programme content is more applied and shows how your core knowledge can be used to address future power challenges and problems. During the third part of the programme, to build on your modules previously studied, you will work on your individual research project.

The degree is assessed by written examination, coursework – either individually or as a group, and an individual research project, run as a part-time activity from January to May and then full time from May to end of August/start of September. It may be possible for MSc projects to be carried out with industry. The taught modules are confined to the autumn and spring terms, with all examinations held during the summer term. The programme will be delivered within the Department of Electrical and Electronic Engineering.

The Future Power Networks MSc programme is delivered by research-leading academics with backgrounds in power systems, power electronics, control, and power economics. The programme draws upon their extensive and diverse portfolio of research and their experience in providing advice and guidance to the UK and overseas governments and international agencies, and industry. The teaching is supported by guest speakers from industry to enable you to connect your learning to the ongoing developments in practice. This would also provide you the networking opportunity to enhance your career prospects in industry.

The graduates from this MSc programme generally take up a career within the transmission or distribution network operators, power technology developers and equipment manufacturers, power/energy consulting companies or pursue PhD research in the UK and worldwide.

Learning Outcomes

On completion of the MSc in Future Power Networks course, you will be able to:

1. Demonstrate a thorough conceptual understanding of power systems, power electronics and control theory.
2. Recognise the challenges associated with deep decarbonisation of the electric power sector.
3. Critically evaluate various technology options that are critical for secure operation of a low (or zero) carbon electric power system.
4. Model and analyse the steady-state and dynamic behaviour of electric power networks with different generation mix.
5. Appreciate the main considerations behind the planning and operation of electric power systems with high fractions of clean energy sources.
6. Appraise and apply mathematical and computational concepts underpinning the behaviour of low-carbon power systems
7. Evaluate and solve common power engineering problems in a skilled and confident way, independently and as part of a team

8. Employ advanced skills to conduct a piece of independent research that demonstrates a contribution to knowledge in a research area of interest.
9. Interpret state-of-the-art technical and scientific publications related to a research topic and critically review the results of others as well as your own.
10. Approach challenges with curiosity and creativity while keeping the practical constraints in mind.
11. Innovatively apply your know-how and skills to tackle complex real-world problems.
12. Display a strong sense of personal and professional identity.

On completion of the PG Diploma, you will be able to cover items (1) to (7) from the above list.

On completion of the PG Certificate, you will be able to cover items (1) to (5) from the above list.

The Imperial Graduate Attributes are a set of core competencies which we expect students to achieve through completion of any Imperial College degree programme. The Graduate Attributes are available at: www.imperial.ac.uk/students/academic-support/graduate-attributes

Entry Requirements

| | |
|------------------------------|---|
| Academic Requirement | Normally a first-class UK Bachelor's Degree with Honours in Electrical Engineering (or a comparable qualification recognised by the College) and basic knowledge of power system, power electronics and control system. We do that by looking at the applicants' marks in relevant modules from their under-graduate degree to gauge their background in these areas. For further information on entry requirements, please go to www.imperial.ac.uk/study/pg/apply/requirements/pgacademic |
| Non-academic Requirements | None |
| English Language Requirement | Standard requirement (PG) Please check for other Accepted English Qualifications |
| Admissions Test/Interview | No admission test is required but a shortlisted applicant may be invited for a face-to-face or virtual online interview, if necessary |

The programme's competency standards documents can be found at:
<http://www.imperial.ac.uk/electrical-engineering/study/undergraduate/applicants-with-disabilities/>

Learning & Teaching Approach

Learning and Teaching Delivery Methods

You will experience different learning and teaching delivery methods that most likely include:

- **Lectures:** Typically delivered to the entire cohort ranging from 1-2 hours in length as timetabled. Lectures will be delivered as traditional style lectures, flipped classroom, online learning supported through pre-recorded lectures. Most lectures involve student engagement with questions posed to the class and, in others, a lecturer may include small-group exercises or discussions to reinforce learning of the recently covered material.
- **Quizzes:** These will be deployed in some modules where you will have the opportunity of testing your knowledge through short exercises and quizzes. These exercises are used as part of formative learning and practice; for you to test your understanding of concepts taught and your ability to build on and apply that knowledge.
- **Computer sessions:** To train you in the use of specialist software appropriate timetabled sessions will be run from our computer room facilities. These sessions are often supported by a team of Graduate Teaching Assistants (GTAs) to assist you in your learning.
- **Laboratory:** You will benefit from live experimental demonstration of a prototype microgrid in our 'state of the art' Maurice Hancock Smart Energy laboratory. To prepare you for the laboratory part a software-based exercise is set at the start of the modules to reinforce your learning and understanding of the steady-state and dynamic behaviour of a microgrid.

- **Individual Research Project:** You will be working on a research project of your choice, supervised by one or more members of our academic staff, who are leaders of international renown in their field of research. This will allow you to undertake in-depth research in areas of interest to you, be exposed to state-of-the-art knowledge and develop the communication skills to effectively present your research findings and deliver a research output that contributes to knowledge and understanding.

As part of the learning and teaching delivery you will be encouraged to be creative in the art of communication in both written and oral presentations, and during the programme you will be challenged to produce different types of output for assessments that rely on your communication skills. These include group/individual coursework report, programming code, lab report, an individual research dissertation and a research poster presentation.

Overall Workload

Your overall workload consists of face-to-face sessions and independent learning. While your actual contact hours may vary according to the elective modules you choose to study, the following gives an indication of how much time you will need to allocate to different activities at each level of the programme. At Imperial College London, each ECTS credit taken equates to an expected total study time of 25 hours. Therefore, the expected total study time is 2,250 hours per year for an average student.

The Department expects you to allocate approximately 4 hours in self-study for every hour spent in lectures and tutorials for a typical lecture-based module.

The pattern of work is greatly dependent on your selected elective modules, however on average you can expect to spend about 200 hours in lectures over the autumn and spring terms, while devoting a further 800 hours to independent study. You will spend approximately 250 hours for laboratory work. You will also be expected to spend 1,000 hours on research work for your Individual Research Project, starting from the spring term but full time from May until the end of August/start of September.

Assessment Strategy

Assessment Methods

A range of summative and formative assessment methods are utilised throughout the programme to maximise your learning. Summative assessment refers to those that will test whether you have met the intended learning outcomes of each module and contribute towards the programme-level intended learning outcomes. Formative assessments are designed for you to identify your areas of strength and weakness to enhance your learning.

Written examinations are utilised for modules where theoretical knowledge and its applications are introduced. In addition to a final summative assessment, such modules will typically offer opportunities for you and/or your instructors to assess your level of understanding and progress through formative assessments such as problem-solving exercises (in class and for self-study), quizzes and coursework exercises carried out individually or as part of a group with peer assessment in some cases. The individual research project is evaluated on the quality of the submitted report, its originality and technical contribution, and through a poster presentation.

The exact balance of the summative assessment across the programme depends upon your choice of elective modules, but an indicative breakdown is:

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|------------|-----|
| Coursework | 50% |
| Exams | 40% |
| Practical | 10% |

Academic Feedback Policy

The Department of Electrical and Electronic Engineering recognises that feedback is an essential part of learning and gives high priority to the timeliness and quality of feedback offered to you on all modules. The primary purpose of feedback is to assist learning and the development of skills, by highlighting strengths and weaknesses

on one hand, and by identifying actions for improvement on the other. It is important to recognize that: 1) feedback comes in various forms and 2) feedback requires your active engagement.

Feedback will be provided for all assessments carried out as part of Future Power Networks MSc programme. For examinations, the published model answers will be annotated to highlight the common mistakes, and alternate approaches to the solutions. For coursework and the laboratory-based exercises, written feedback will normally be provided within two working weeks of submission. For the research project, feedback will be provided by the supervisor(s) on a continuous basis during the regular project supervision meetings. Oral feedback on the research project will be provided immediately by assessors during/after the poster presentation.

Some of the modules will further aim to provide you with the opportunity to receive feedback ahead of any major summative assessment. Such feedback may be provided in the form of in-class quizzes, problem sheets, etc. You should keep in mind that not all feedback is structured, and important feedback may be obtained from self-reflection on your progress to date, from peers when studying or working together in a team, in dialogue with a lecturer in or outside of a class or laboratory, or by email.

The Board of Examiners will meet to consider the results of the examinations and the research project in mid-late October and results will be released to you only via student e-service within 10 days. Students who have not managed a clear pass will be informed, setting out possible courses of action within 10 days of the examiner's board.

The College's Policy on Academic Feedback and guidance on issuing provisional marks to students is available at:

www.imperial.ac.uk/about/governance/academic-governance/academic-policy/exams-and-assessment/

Re-sit Policy

The College's Policy on Re-sits is available at: www.imperial.ac.uk/student-records-and-data/for-current-students/undergraduate-and-taught-postgraduate/exams-assessments-and-regulations/

Mitigating Circumstances Policy

The College's Policy on Mitigating Circumstances is available at: www.imperial.ac.uk/student-records-and-data/for-current-students/undergraduate-and-taught-postgraduate/exams-assessments-and-regulations/

Additional Programme Costs

This section should outline any additional costs relevant to this programme which are not included in students' tuition fees.

| Description | Mandatory/Optional | Approximate cost |
|-------------|--------------------|------------------|
| N/A | N/A | N/A |

Important notice: The Programme Specifications are the result of a large curriculum and pedagogy reform implemented by the Department and supported by the Learning and Teaching Strategy of Imperial College London. The modules, structure and assessments presented in this Programme Specification are correct at time of publication but might change as a result of student and staff feedback and the introduction of new or innovative approaches to teaching and learning. You will be consulted and notified in a timely manner of any changes to this document.

| Programme Structure ¹ | | | | | |
|--|--|----------------------------------|-------|------|---------|
| Year 1 – FHEQ Level 7 | | | | | |
| You have to do all compulsory and core modules (Group A and B) | | | | | |
| You must choose 3 out of 12 elective modules (Group C) | | | | | |
| Code | Module Title | Core/ Elective/ Compulsory | Group | Term | Credits |
| ELEC70044 | Role and Value of Smart Grid Technologies | Compulsory | A | 1 | 5 |
| ELEC70047 | HVDC Technology and Control | Compulsory | A | 1 | 5 |
| ELEC70064 | Selected Topics in Power Systems | Compulsory | A | 1 | 5 |
| ELEC70074 | Power System Dynamics, Stability and Control | Compulsory | A | 2 | 5 |
| ELEC70087 | Stability and Control of Low Carbon Power Systems | Compulsory | A | 2 | 5 |
| ELEC70100 | Individual Research Project | Core | B | 2, 3 | 40 |
| ELEC70088 | Laboratory | Core | B | 3 | 10 |
| ELEC70075 | Power System Economics | Elective | C | 1 | 5 |
| ELEC70076 | Sustainable Electrical Systems | Elective | C | 2 | 5 |
| ELEC70098 | Optimisation | Elective | C | 1 | 5 |
| ELEC70086 | Topics in Control Systems | Elective | C | 2 | 5 |
| ELEC70067 | Traffic Theory and Queuing Systems | Elective | C | 2 | 5 |
| ELEC70048 | Probability and Stochastic Processes | Elective | C | 1 | 5 |
| ELEC70077 | Digital Signal Processing and Digital Filters | Elective | C | 2 | 5 |
| ELEC70001 | Adaptive Signal Processing and Machine Intelligence | Elective | C | 2 | 5 |
| ELEC70091 | Stability and Control of Non-linear Systems | Elective | C | 1 | 5 |
| ELEC70006 | Design of Linear Multivariable Control Systems | Elective | C | 2 | 5 |
| ELEC70092 | Systems Identification and Learning | Elective | C | 1 | 5 |
| ELEC70039 | Wavelets, Representation Learning and their Applications | Elective | C | 1 | 5 |
| ELEC70099 | Electric Vehicle Technologies | Elective | C | 2 | 5 |
| Credit Total | | | | | 90 |

¹ **Core** modules are those which serve a fundamental role within the curriculum, and for which achievement of the credits for that module is essential for the achievement of the target award. Core modules must therefore be taken and passed in order to achieve that named award. **Compulsory** modules are those which are designated as necessary to be taken as part of the programme syllabus. Compulsory modules can be compensated. **Elective** modules are those which are in the same subject area as the field of study and are offered to students in order to offer an element of choice in the curriculum and from which students are able to select. Elective modules can be compensated.

Progression and Classification

Classification of Postgraduate Taught Awards

Award of a Postgraduate Certificate (PG cert):

To qualify for the award of a Postgraduate Certificate, you must have accumulated at least 30 ECTS credits at Level 7 or above.

Award of a Postgraduate Diploma (PG Dip):

To qualify for the award of a Postgraduate Diploma you must have:

- a) accumulated at least 60 ECTS credits at Level 7 or above
- b) no more than 10 credits as a Compensated Pass.

Award of a Postgraduate Degree (MSc):

To qualify for the award of a postgraduate degree you must have:

1. accumulated credit to the value of no fewer than 90 credits at level 7 or above;
2. and no more than 10 credits as a Compensated Pass as this programme is accredited by the Institution of Engineering and Technology.

Classification of Postgraduate Taught Awards

The College sets the class of Degree that may be awarded as follows:

1. Distinction: The student has achieved an overall weighted average of 70.00% or above across the programme.
2. Merit: The student has achieved an overall weighted average of above 60.00% but less than 70.00%.
3. Pass: The student has achieved an overall weighted average of 50.00% but less than 60.00%.
 - a. For a Masters, you must achieve a distinction (70.00%) mark in the dissertation or designated final major project (as designated in the programme specification) to be awarded a distinction.
 - b. For a Masters, you must achieve a minimum of a merit (60.00%) mark in the dissertation or designated final major project (as designated in the programme specification) to be awarded a merit.

Programme Specific Regulations

The accreditation body (IET) requires no more than 10 ECTS credits as compensated pass

| Supporting Information |
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| The Programme Handbook is available at: TBC |
| The Module Handbook is available at: TBC |
| The College's entry requirements for postgraduate programmes can be found at: www.imperial.ac.uk/study/pg/apply/requirements |
| The College's Quality & Enhancement Framework is available at: www.imperial.ac.uk/registry/proceduresandregulations/qualityassurance |
| The College's Academic and Examination Regulations can be found at: www.imperial.ac.uk/about/governance/academic-governance/regulations |
| Imperial College is an independent corporation whose legal status derives from a Royal Charter granted under Letters Patent in 1907. In 2007 a Supplemental Charter and Statutes was granted by HM Queen Elizabeth II. This Supplemental Charter, which came into force on the date of the College's Centenary, 8th July 2007, established the College as a University with the name and style of "The Imperial College of Science, Technology and Medicine". www.imperial.ac.uk/admin-services/secretariat/college-governance/charters/ |
| Imperial College London is regulated by the Office for Students (OfS) www.officeforstudents.org.uk/advice-and-guidance/the-register/ |
| This document provides a definitive record of the main features of the programme and the learning outcomes that a typical student may reasonably be expected to achieve and demonstrate if s/he takes full advantage of the learning opportunities provided. This programme specification is primarily intended as a reference point for prospective and current students, academic and support staff involved in delivering the programme and enabling student development and achievement, for its assessment by internal and external examiners, and in subsequent monitoring and review. |

| Modifications | | | |
|-------------------|----------------------|----------|-----------------|
| Description | Approved | Date | Paper Reference |
| Curriculum Review | Programmes Committee | 22/03/22 | PC.2021.57 |