



## MSc Smart Grids and Energy Systems Programme Specification

Academic Year:	2020/21
Degree Awarding Body:	University of Bradford
Final and interim award(s):	[Framework for Higher Education Qualifications (FHEQ) level 7]  MSc Smart Grids and Energy Systems  Postgraduate Diploma Smart Grids and Energy Systems  Postgraduate Certificate Smart Grids and Energy Systems
Programme duration:	January intake 1 Year Full-time
Date last confirmed and/or minor modification approved by Faculty Board	December 2020

Please note: This programme specification has been published in advance of the academic year to which it applies. Every effort has been made to ensure that the information is accurate at the time of publication, but changes may occur given the interval between publishing and commencement of teaching. Any change which impacts the terms and conditions of an applicant's offer will be communicated to them. Upon commencement of the programme, students will receive further detail about their course and any minor changes will be discussed and/or communicated at this point.

### Introduction

A smart grid is an electricity network based on digital technology that is used to supply electricity to consumers via two-way digital communication. This system allows monitoring, analysis, control and communication within the supply chain to help improve efficiency, reduce energy consumption and cost, and maximize the transparency and reliability of the energy supply. The smart grid was introduced to overcome the weaknesses of conventional power systems by using smart meters. Many government institutions around the world have been encouraging the use of smart grids for their

potential to control and deal with global warming, emergency resilience and energy independence scenarios<sup>1</sup>.

The advent of smart grids has brought about phenomenal changes in the electric power supply systems, transitioning from conventional power plants to renewable ones. Governments worldwide have set to decarbonise energy in order to mitigate global climate change. One of the key areas being implemented is the integration of renewable energy sources such as wind turbines, solar cells and electric vehicles into existing power systems. According to the “UK Renewable Energy Roadmap<sup>2</sup>”, the UK and EU have targets to supply 15% of the energy demand from renewables by 2020. This has mainly been driven by increasing power generation by renewable energy sources, growth in flexible transmission to meet CO<sub>2</sub> reduction commitments while producing a reliable and secure supply, developments in the transportation of electricity.

As well as in the UK and EU, there has been a global effort in renewable energy development. According to the Global Trends in Renewable Energy Investment 2018 report<sup>3</sup>, global investments in renewables exceeded £160 billion. China accounted for 45% of the global total in 2017, with 13 offshore wind projects that will generate jobs in all stages of construction and operation. Fossil fuel-rich countries are also showing strong progress. The United Arab Emirates for example recorded a 29-fold increase in renewable energy investment in 2017.

Technological advancement such as Internet of Things (IoT), Big Data Analytics and Artificial Intelligence exploited for system control together with regulatory and policy changes have all contributed to the increasing adoption of renewables.

The current rollout of smart meters and smart metering infrastructure in UK and Europe will open up wide opportunities for connecting the smart homes, smart buildings and industry 4.0 with the energy grids. The smart operation of electrical systems provides bidirectional information flows to enable different stakeholders involved, from producers to consumers, making decisions about its operation.

Since the problem of the integration of large amount of renewable energy sources has not been considered in the initial design of the existing power systems, renewable energy sources integration gives rise to safety concerns over system operations, voltage profile, line losses, and system reliability and quality. Currently there is a shortage of professionally qualified Smart Grids and Energy Systems engineers to design, model, analyse and to ensure safe and reliable control and operations of smart grids and energy systems.

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<sup>1</sup> <https://www.techopedia.com/definition/692/smart-grid>

<sup>2</sup> [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/255182/UK\\_Renewable\\_Energy\\_Roadmap\\_-\\_5\\_November\\_-\\_FINAL\\_DOCUMENT\\_FOR\\_PUBLICATION\\_.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/255182/UK_Renewable_Energy_Roadmap_-_5_November_-_FINAL_DOCUMENT_FOR_PUBLICATION_.pdf)

<sup>3</sup> Frankfurt School-UNEP Centre, “Global Trends in Renewable Energy Investment 2018”, <http://www.fs-unesp-centre.org>

This new postgraduate programme aims to meet this precise need by preparing graduates with the required knowledge and expertise in the modern world of IoT-enabled smart sustainable energy systems.

It will give graduates a unique advantage in the job market with expertise in:

- Operating principles of renewable energy integrated power systems.
- The economic and regulatory frameworks for power and energy systems planning and optimisation.
- Operation and planning of restructured power and energy systems with integration of high penetration of renewable energy sources.
- Analysing the huge amount of data generated by smart meters and renewable sources big data systems using applications of Big-Data Analytics Design.

All modules are designed to respect the overarching themes of smart grids, delivering research informed teaching in lectures, tutorials, and laboratory sessions. The recently refurbished electronics teaching laboratories and Internet of Things laboratory equipped with state-of-the-arts facilities enables a variety of teaching methodologies to be used and provides excellent laboratory space for students to conduct practical work for coursework and MSc projects.

This programme is endorsed by Bradford Council, well-known industries and research centres within the UK and internationally including:

- Electricity North West Limited, UK
- Northern Power Grid
- Wilson Power Solution
- N-Ergy, UK
- Northech Online, UK
- DEPSYS, Switzerland
- International Energy Research Centre, Ireland
- Elin BioFuel, Greece.

Several companies have expressed an interest to provide placements and internships for students studying this course. Whilst the programme does not offer or require formal placements, workplace learning is provided for every student (industrially or at the University) through solving real industrial problems, with opportunities to compete for a limited pool of summer internships/projects offered by industries. These opportunities are open to all students including international students and can be paid, unpaid or expenses paid, depending on the company's policy and circumstances at the time of offering.

The programme will be delivered by academics within the Faculty of Engineering and Informatics with expertise relevant to smart grids and energy systems areas, including power systems, Big Data Systems and Analytics and IoT. Our Faculty hosts and leads several activities in the Digital Catapult Yorkshire. The team has complementary and

diverse research strength and is organised into four major research groups in complementary technical areas:

- Energy and Smart Grids focusing on energy and smart grids operation, planning and control.
- Communications Systems and Networks focusing on mobile, wireless, satellite communications networks, RF and antenna design.
- IoT and Applied Computing focusing on the application of IoT and computing technologies such as cloud computing to different industrial applications.
- Artificial Intelligence focusing on machine learning, deep learning, big data analytics and so on.

The team is a key contributor to the £13M BIS funded Digital Health Enterprise Zone (DHEZ). Most of the research activities in these research groups are funded by national, EU and other international research funding councils in high profile flagship projects, which are directly relevant to the programme including:

- EU SCORE project on smart cities using IoT to improve public service delivery.
- British Council BLESS U project for enhanced smart health services with IoT.
- BIS funded Digital Health Enterprise Zone (DHEZ) and host of the Digital Catapult Yorkshire for promoting the use of IoT and digital technologies for healthcare and other applications.
- British Council SITARA project for smart grids operation with IoT and satellite communications.
- EU CASAGRAS2 project on IoT services, architecture and protocols.

This course strongly aligns with the strategic academic themes of the University giving students the benefit of the inter-disciplinary research carried out in the university:

Programme Focus Themes	Related University Strategic Theme(s)
Renewable Energy Systems Integration into the grid	Sustainable Societies
Smart Grids	Innovative Engineering
Sustainable Energy	Advanced Healthcare

These themes are particularly relevant to this programme with energy playing a vital role as an enabler for sustainable and economic growth of our societies, for healthcare delivery through innovative energy system design.

The academic theme of Sustainable Societies will support growth in economic, political and relational well-being for current and future generations. This theme will be reflected in the module “Sustainable Energy”.

Our academic enterprise in innovative engineering centres on research that advances the fundamental understanding of engineering and applied science to create technological solutions to real world problems and needs. This theme will be reflected in the modules “Smart Grids Operation and Economics” and “Smart Grids and Power Systems Analysis”.

With a strong track record in health research and a major provider of healthcare practitioners to UK and global healthcare industries this theme seeks to develop new models of health care delivery, health promotion and technology enabled treatment modalities.

Smart grids and smart cities rely heavily on sensors to perceive parameters such as power grid status, temperature, humidity, allergens, pollution and traffic conditions. The values of these parameters provide a context that helps a system to understand the state of a citizen at any given time.

The impact of power quality disturbances and how they affect the operation of the electrical equipment connected to the grid, especially in industrial and healthcare facilities is very important aspect. The monitoring and analysis of power quality disturbances are generally performed with specialised measuring equipment, such as power analysers, based on the standards.

Students will learn about power quality issues and smart grid management in modules “Smart Grids and Power Systems Analysis” and “Sustainable Energy” which can be applied in healthcare area.

## **Programme Aims**

The programme is intended to:

- Provide an advanced education in smart energy systems engineering.
- Give graduates the education, the knowledge and the skills that they need to make sound decisions in a rapidly changing energy supply industry.
- Provide students with in-depth knowledge of the issues and problems faced by renewable energy sources and their integration into the power grid.
- Provide industry with graduates able to develop solutions and techniques to address challenges in the design, development and operation of smart energy systems.

## **Programme Learning Outcomes**

To be eligible for the award of Postgraduate Certificate at FHEQ level 7, students will be able to:

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|-----|---|
| LO1 | Evidence comprehensive understanding and critical awareness of electrical power generation distribution and transmission                            |
| LO2 | Evidence understanding and critical evaluation of the operating principles, monitoring, optimisation and control of modern energy and power systems |
| LO3 | Evaluate existing methodologies in the literature and propose new methodologies for addressing challenges in smart grid development                 |
| LO4 | Communicate the results and conclusion on smart energy systems development clearly to specialist and non-specialist audiences                       |

- LO5 Evidence the independent learning ability required for continuing professional development
- LO6 Evidence understanding of environmental challenges and renewable energy generation

To be eligible for the award of Postgraduate Diploma at FHEQ level 7, students will be able to:

- LO7 Apply skills in dealing with complexity in smart grid and energy systems projects for design, development and deployment
- LO8 Evidence ethical implications of technological advancement and usage with regard to the smart energy systems

Additionally, to be eligible for the award of Degree of Master at FHEQ level 7, students will be able to:

- LO9 Plan, implement, monitor and adjust a self-directed and managed research-informed original project, demonstrating a critical analysis and evaluation of relevant material and the ability to apply relevant skills and research methodologies in the production of an advanced report

## Curriculum

FHEQ Level	Module Title	Core/Option Elective	Credits	Semester Jan-May	Module code
7	Smart Grids Operation and Economics	C	20	2	ELE7032-B
6	Sustainable Energy	C	20	2	ENG6005-B
7	Research Methods and Skills	C	20	2	ELE7008-B

FHEQ Level	Module Title	Core/Option Elective	Credits	Semester (s) March-Nov	Module code
7	MSc Project	C	60	1,2,3	ENG7002-E

FHEQ Level	Module Title	Core/Option Elective	Credits	Semester Sep-Jan	Module code
7	Smart Grids and Power Systems Analysis	C	20	1	ELE7031-B
7	Big Data Systems and Analytics	C	20	1	COS7006-B
7	Internet of Things	C	20	1	COS7039-B

Students will be eligible to exit with the award of Postgraduate Certificate if they have successfully completed 60 credits and achieved the award learning outcomes.

Students will be eligible to exit with the award of Postgraduate Diploma if they have successfully completed at least 120 credits and achieved the award learning outcomes.

Students will be eligible for the award of Degree of Master if they have successfully completed at least 180 credits and achieved the award learning outcomes.

The curriculum may change, subject to the University's programme approval, monitoring and review procedures.

## **Learning and Teaching Strategy**

The University of Bradford's *modus operandi*, Making Knowledge Work, is embedded in the philosophy of this programme.

Our strategy begins with the end in mind. We want students to become great engineers; that means great problem solvers, great team-workers with an inquisitive and curious mind. This should mean that by the end of their study with us they can move seamlessly into the world of work, academic research or become an entrepreneur.

The teaching and learning methods have been selected to engage students in developing their knowledge and understanding of engineering fundamentals, through formal learning opportunities such as lectures and tutorials, experiential learning through practical classes and lab sessions, informal and social learning through team-working in projects.

Study with us will include on-line and face-to-face teaching. Online lectures may be pre-recorded, so you can watch them at your convenience, or live interactive webinars via Zoom and/or Microsoft Teams platform. Tutorials and seminars will often be in smaller groups and highly interactive.

Formal lectures will facilitate acquisition of knowledge and understanding, discipline specific skills, and apply this learning to industry practices. Laboratory sessions using state-of-the-art, purpose-built laboratories run in conjunction with the theoretical components gives students the opportunity to enhance their understanding of particular topics.

We want to develop students' understanding of the vast array of opportunities open to today's professional engineer and therefore we look to incorporate aspects of real-world engineering problems and solutions where possible. This will be done through interactions with members of the programme advisory board from industries and Bradford Council indicated above.

We also want to teach students about ethical issues in relation to the use of smart grids and energy systems and this will be embedded in the module "Sustainable Energy". Engineers from industries will be invited to give talks in the module "Research Methods and Skills", specifically focusing on energy regulatory and policy frameworks that governs the ethical use of energy systems.

Furthermore, in the Sustainable Energy module an introductory session will be used to review the historic trends and analyse factors contributing to the gender imbalance and

other social issues in the sector workforce. These issues may be further discussed in the Research Methods and Skills as a presentation topic for students.

As part of our focus on building a learning experience, which will prepare students for the world of work, our curriculum has incorporated the CDIO concept.

The CDIO concept is an educational framework that stresses engineering fundamentals set in the context of Conceiving, Designing, Implementing and Operating real-world systems and products. Throughout the world, CDIO concept collaborators have adopted CDIO as the framework of their curricular planning and outcome-based assessment. The CDIO approach uses active learning tools, such as group projects and problem-based learning, to better equip engineering students with technical knowledge as well as communication and professional skills.

The main objectives of this initiative are: (1) to provide the students with a platform of knowledge to conceive, design, implement, and operate energy systems that involve power and energy systems, Big-Data systems and analytics and energy policy; (2) to improve student competencies in teamwork, communication skills, and project management; and (3) to address the need of industry to have engineers educated in the important area of Smart Grids and Energy Systems.

For example, in the modules “Smart Grids Operation and Economics”, “Smart Grids and Power Systems Analysis” and “Sustainable Energy”, students will be divided into groups to do their coursework. Each group will be asked to design smart grid and power systems. The CDIO concept will be embedded in the coursework of the modules “Smart Grids Operation and Economics”, “Smart Grids and Power Systems Analysis” and “Sustainable Energy” as follows:

- Conceive: Students will construct the system concept.
- Design: Design according to the requirements specified in the coursework.
- Implement: Implement the design in a simulation model.
- Operate: Analyse the system operation through simulation.

The CDIO concept is also embedded in other modules such as “Big-Data Systems and Analytics” and “Internet of Things” in a similar manner.

The programme utilises a range of learning methods to offer a research-led, and digitally rooted learning experience with a holistic focus. At the centre of this strategy is the focus on problem solving to stimulate creative, analytical, logical and innovative thinking, which are all student-centric components. Potential placement and internship opportunities are available from industry and research centres that make up our programme advisory board.

In addition, case studies from publicly funded high profile projects, in which our programme delivery team has been involved, will be used to ensure that the content is fresh and cutting-edge. We also integrate knowledge and experience from industrial partners in our programme advisory board together with challenging case studies, lab-based activities and invited talks from external speakers to ensure that research findings are at the heart of our curriculum and that students are exposed to the very latest and future developments.

Innovative, creative and rich methods have been used in designing of this course, which prove that it is student-centric such as:

**Problem-based learning:** Students work in groups to solve complex, multifaceted, and realistic problems, researching and learning necessary background material as needed in all modules.

**Case studies:** Students draw inferences and make decisions given a detailed description of a real case study. In modules “Big-Data Systems and Analytics” and “Internet of Things “real case studies from industrial partners will be provided.

**Computer simulations:** Students use interactive computer simulations to visualize phenomena, test predictions, receive prompt, targeted feedback to refine their intuitions, and conduct and analyse virtual experiments in modules Big-Data Systems and Analytics”, “Internet of Things “, “Smart Grids and Power Systems Analysis”, “Sustainable Energy” and “Smart Grids Operation and Economics”.

**Problem sets in groups:** Students work on problem sets in teams and submit one set of solutions per team in modules Big-Data Systems and Analytics “and “Internet of Things “.

**Tutorial worksheets:** Students work through worksheets that lead them through a chain of logic to solve a problem or overcome a conceptual difficulty in modules “Sustainable Energy”, “Smart Grids and Power Systems Analysis” and “Smart Grids Power Systems Economics”. Students complete the exercises in small groups, while the lecturer circulates among the groups to ask targeted questions or to facilitate discussion.

## The Bradford Graduate

This MSc programme suits students and professionals from diverse backgrounds, including engineers, environmentalists, and policy makers.

Moreover, it gives graduates and engineering professionals interested in finding sustainable solutions to climate change and energy security the theoretical and practical skills needed to pursue careers in the growing field of smart grids and renewable energy technology all over the world.

Students will have opportunities to carry out much of their MSc project in collaboration with major national and international energy companies, plant and equipment manufacturers, leading industrial firms and research centres. This means that students’ education will be at the forefront of scholarship and practice, covering the most up-to-date industry knowledge.

The primary destinations of graduates are manufacturing industries, energy and environmental consultancy companies, energy advice and research centres, academia, and national and international non-governmental organisations.

At Bradford, we provide many opportunities and experiences within our degree programme and beyond – work-based learning, professional support services,

volunteering, mentoring, sports, arts, clubs, societies, and much, much more. Students are encouraged to make use of them.

All students enrolled in the course will have the opportunity to develop real-world professional skills including collaborative teamwork, effective interactions and communications, project management, industrial standards and working environment through group coursework in different modules, invited talks from industrial partners, etc. Our laboratories are well equipped with an excellent range of facilities to support the research work and courses. In addition, students will be provided with cutting-edge smart grids and energy systems analysis software programmes and tools including MATLAB/SIMULINK, GAMS and PSCAD.

## The University

The University of Bradford has four key strategic objectives: excellence; internationalisation; equality and diversity; and sustainability. We believe in doing research and teaching to deliver career opportunities for our students as well as for economic development and job creation. The Faculty of Engineering and Informatics strongly believes that each programme subscribes to these four objectives through the three key streams of the University vision:

- The creation of knowledge through fundamental and applied research.
- The dissemination of knowledge by teaching students from all backgrounds.
- The application of knowledge for the prosperity and wellbeing of people.

The lecturers at Bradford are active researchers in their fields of expertise, developing new knowledge, contributing to peer-reviewed journals and books. This research permeates to their teaching practice giving students access to world leading professionals, equipment and ideas within the University's academic themes of Innovative Engineering, Advanced Healthcare and Sustainable Societies. The programmes of study will include research with an emphasis on application, experiential learning and real-world engagement. This will contribute to student's skill set, in the skills and attributes for enhanced employability.

We recognise that society benefits from the talents of all, and that the development of creative, collaborative engineers, skilled in communication and teamwork is vital. Diverse engineering teams are known to be more innovative. We help students to contribute to and learn from the varied perspectives of their tutors and peers. We want to equip our graduates with the knowledge and skills to respond to the many different needs of our businesses and communities. The Faculty welcomes and celebrates the diverse cultural and national backgrounds of our students. We are committed to an educational experience that is inclusive, one where gender and ethnicity are central elements in developing engineering solutions that address the needs of a diverse society. The University currently holds Bronze Athena Swan accreditation from the Equality Challenge Unit.

## Assessment Strategy

Assessment is a key part of the learning process, it is only through challenging themselves to express what they have learned or put it to practical use can students complete the

learning journey and assess for themselves if they have understood what they have been taught and are able to apply and use that skills and knowledge. Our assessment methods are designed to meet the needs of industry, the accrediting bodies as well as prepare students for a potential academic research career.

There are two forms of assessment, namely formative and summative assessments. Formative assessment provides an opportunity for our staff to give students feedback during their learning. This feedback is designed to help and guide learning. All the modules will have some formative assessment and this may be in various forms including discussions or questioning from the supervisor, tests, practical activities, etc. These formative activities are crucial if students are to make best use of their learning experience and they are designed to prepare students for their summative assessment. Summative assessment is how we grade the work on a module and the details of this assessment will be available from the beginning of the module so that students understand how the grade will be determined.

A main method of assessment (as is common on all professional engineering degree programmes) is by written examinations which may be closed or open book and coursework. Examples and tutorial sheets will also be used to support the lectures and laboratory work.

## Programme team

The project team members have distinctive expertise to cover the specialised areas of the new proposed MSc as follows:

Module Title	Lecturers
Smart Grids Operation and Economics	Geev Mokryani and Raed Abd-Alhameed
Sustainable Energy	Geev Mokryani and Tim Gough
Big Data Systems and Analytics	Daniel Neagu
Smart Grids and Power Systems Analysis	Geev Mokryani and Fun Hu
Research Methods and Skills	Fun Hu and Raed Abd-Alhameed
Internet of Things	Irfan-Ullah Awan
MSc Project	The team

## Assessment Regulations

This Programme conforms to the standard University Taught Postgraduate Regulations, which are available at the link below: [www.bradford.ac.uk/regulations](http://www.bradford.ac.uk/regulations)

## Admission Requirements

We take into consideration a number of factors when assessing your application. It's not just about your grades; we take the time to understand your personal circumstances and make decisions based on your potential to thrive at university and beyond.

In addition to satisfying the general admissions requirements of the University of Bradford, the candidates must have:

2:2 or equivalent bachelor's degree in an engineering discipline such as Energy or Power Engineering, Electrical and Electronics Engineering, Mechanical Engineering, or Chemical Engineering. Applications from other engineering disciplines such as Computer Science, Physics and Maths will be considered.

For international applicants, a test of written and spoken English normally needs to have been passed at grade 6.0 for IELTS or 550 for TOEFL (or 250 for the computer-based test) or above.

Whether students need to improve their English skills before they begin their University of Bradford degree, or they need some extra support during their studies, we provide courses, classes, workshops and study resources.

The Language Centre provides Pre-sessional English Language Programme (PREP). PREP is a flexible suite of courses, which improve your English language and academic skills to enable you to engage fully with higher education study. The flexibility of this course allows you to enter at one of the four entry points throughout the year, depending on the English level. Further details can be found in:

<https://www.bradford.ac.uk/courses/other/pre-sessional-english-language-programme/>

The Language Centre also offers a range of free classes, workshops, one-to-one tutorials and online support to help they get the most from their studies at the University of Bradford. Further information can be found in the link

<https://www.bradford.ac.uk/language-centre/>

## Recognition of Prior Learning

If applicants have prior certificated learning or professional experience which may be equivalent to parts of this programme, the University has procedures to evaluate and recognise this learning in order to provide applicants with exemptions from specified modules or parts of the programme.

## Minor Modification Schedule

Version Number	Brief description of Modification	Date of Approval (Faculty Board)
1	Update January intake	December 2020
2	Specification reformatted and made accessible	February 2021