School of Electrical Engineering and Telecommunications

Term 1, 2019
Course Outline

ELEC9715
Electricity Industry Operation and Control

Course Staff

The primary course coordinator and lecturer is:

Dr Iain MacGill
Joint Director (Engineering), Centre for Energy and Environmental Markets (CEEM)
Associate Professor, School of Electrical Engineering and Telecommunications.
Room TETB316 (Tyree Energy Technology Building), i.macgill@unsw.edu.au

Providing joint coordination support, and a number of lectures will be:

Dr Navid Haghdadi
Postdoctoral Research Associate, Centre for Energy and Environmental Markets
School of Electrical Engineering and Telecommunications
Level 3, Tyree Energy Technology Building, n.haghdadi@unsw.edu.au

Several guest lectures will also be arranged with research and industry experts during the term.

Consultations: You are, of course, encouraged to ask questions on the course material during the lectures. Iain and/or Navid will be available for additional consultation on the lectures, assignments and projects before, during and after lectures, or by appointment (arranged at lectures or by email). There will be a number of discussion forums on the course Moodle for questions regarding logistics, lecture materials and assessment tasks. Please always check these first to see if your questions has already been asked and answered, and post your questions here if you think they are relevant to other students. Please note that Iain and Navid are unlikely to be available for consultations without an appointment.
Scheduled consultation times for the assignments and projects will be advised during lectures, and on the course *Moodle*. Note that ALL email enquiries must be made from your student email address with ELEC9715 mentioned in the subject line. We are unlikely to reply to emails that do not meet these requirements.

Course Details

Credits

This is a 6 UoC course and the expected workload is around 15 hours per week throughout the 10 week term. As noted below, most of this time must be self-directed learning.

Contact Hours

As a post-graduate offering, the course consists of 4 hours of lectures each week from weeks 1 to 8. The last two weeks of term will involve student seminar presentations in the same room. There are no tutorials or laboratories. However, there may be tutorial like sessions within some of the Friday lecture slots. Consultation periods prior to the submission of assignments will be offered – further details will be provided over the term. The provisional syllabus of these weekly lectures is outlined below.

Lectures	Day	Time	Location
	Tuesday	9-11am	Electrical Engineering G22 (K-G17-G22)
	Friday	2-4pm	Electrical Engineering G23 (K-G17-G23)

Note that there will be some scheduled consultations for the assignments, and group project discussions. Details will be made available in the lectures and on Moodle. Also, due to the loss of one Friday lecture (Good Friday), there will be one class in week 11 - Wed 2-4pm in Electrical Engineering G23 (K-G17-G23)

Indicative Lecture Schedule

WEEK	LECTURE	Class tasks		
1	Introduction; important features and attributes of the electricity industry; definition of the key problems and challenges of industry operation and control. Key technologies for generation, networks, loads and their control capabilities	Student surveys and quiz tasks.		
2	Generation technology operational characteristics Decision making tools Economic dispatch (utilisation of operating generators & loads)	Quiz tasks [out] Information on group projects and possible topics		
3	Continuous voltage and frequency control Contingencies and their management	Quiz tasks [out] Assignment 1		
4	Unit commitment (selection of generators & loads to operate)	Quiz tasks Group project topics finalized by end week 4		
5	Energy constraints: hydro, fuel management and maintenance scheduling	Quiz tasks [in] Assignment 1 [out] Assignment 2		
6	Practical electricity industry arrangements for operation and control	Quiz tasks		
7	Operation and control issues associated with variable and only partially controllable generation	Quiz tasks [in] Assignment 2		
8	The operational challenges of distributed energy resources Electricity industry operation in a 'smart grid' low carbon future	Quiz tasks Project group discussions with course coordinators		
9	Student group project presentations	Presentation to be loaded into Moodle one hour prior to class		
10	Student group project presentations	Presentation to be loaded into Moodle one hour prior to class [out] Exam prep. guidance and sample questions		
11	Course overview and exam discussion (note that this is a makeup lecture for the loss of one lecture due to Good Friday holiday)	Project group wikis finalized and reports due week 11		

Assessment

Assessment activity	Assessment (%)
Group project reports on an agreed topic (topic confirmed by end week 4, submission by end week 10)	15
Group student wikis, project pitch on their report topics	5
Individual student participation in selected class surveys, discussion forums and other project wikis, class quizes	10
Individual student assignments during the term	20
Final exam (2 hours)	50

Context and Aims

The purpose of this course is to introduce students to the main issues involved in electricity industry operation and control – that is, decision making approaches and methods to meet industry objectives through appropriate operation of existing power system equipment. Industry operation and control will be discussed in the context of both traditional monopoly utility run power systems and the restructured market-based industries now becoming more common worldwide. The course, therefore, will explore the broader issue of electricity industry operation and control rather than the narrower traditional power system focus. Furthermore, it will also explore the challenges and opportunities that distributed energy resources – generation, storage and demand-side participation – bring to electricity industry operation.

Considerable attention is given to practical implementation and experience to date in Australia, with comments on other countries when appropriate. Students taking this course will therefore gain a critical appreciation of the operation of Australia's restructured industry, and the emerging opportunities and challenges that the industry faces.

Relationship to Other Courses

This is a postgraduate course in the School of Electrical Engineering and Telecommunications. The course is available in the following programs: Master of Engineering Science; Doctor of Philosophy in Engineering, Master of Engineering and Bachelor of Engineering (4th Year Elective substitution). Students undertaking other courses may also be permitted subject to agreement with the School of Electrical Engineering and Telecommunications, and the Course Coordinator.

The companion course, ELEC9714 Electricity Industry Planning and Economics explores issues of electricity industry structure, market design and technical, economic and environmental regulation with a particular focus on the investment decision making timescale. These courses can be taken separately, or in either sequence. This course replaces the old *ELEC9202 Power System Operation and Control*.

Pre-requisites and Assumed Knowledge

Although this subject has no formal prerequisites, it is assumed that each student has a basic working knowledge of power systems, and the electricity industry more generally. A number of texts are available for students whose undergraduate training did not include this type of material, or who feel that they require revision. Please contact the lecturer to discuss if you have questions regarding this matter. It is further assumed that students are familiar with Standard Office software tools including Excel, Word and Powerpoint (or equivalents).

Following Courses

The course is not a pre-requisite for other courses at UNSW. However, it does have close links to its companion course, *ELEC9714 Electricity Industry Planning and Economics*. There is some cross-over between the two courses but they are also carefully designed to complement each other whilst not requiring that you take them in sequence, or take both of them.

Learning outcomes

After successful completion of this course, you should be able to:

1. Understand the fundamental objectives, constraints and concepts of electricity industry operation and control
2. apply basic conventional economic dispatch, unit commitment, hydro-scheduling, production costing, reliability assessment and operation planning techniques to simple electricity industry problems
3. describe the implementation of power system operation and control in a restructured industry context including ancillary services, and energy spot and derivative markets
4. apply basic models for electricity markets to simple restructured electricity industry problems
5. appreciate how electricity industry restructuring, technology development and environmental concerns are changing the way in which power system operation and control is defined and undertaken
6. describe the opportunities and challenges that emerging distributed energy resources pose for future electricity industry operation and control

This course is designed to provide the above learning outcomes which arise from targeted graduate capabilities listed in ***Appendix A***. The targeted graduate capabilities broadly support the UNSW and Faculty of Engineering graduate attributes (listed in ***Appendix B***). This course also addresses the Engineers Australia (National Accreditation Body) Stage I competency standard as outlined in ***Appendix C***.

Syllabus

Introduction to the evolving electricity industry drivers of restructuring, technological developments and environmental concerns, and their impact on power system operation. Conventional approaches and tools for economic dispatch, unit commitment, hydroscheduling, production costing, reliability measures and operations planning in traditional industry structures. Power system operation within restructured electricity industries-wholesale spot electricity markets, bilateral trading, forward markets and full retail competition. Operation of power systems with renewable energy resources

Teaching Strategies

Delivery Mode

The teaching in this course aims at establishing good fundamental understandings of the areas covered via:

- Formal face-to-face lectures, which provide you with a focus on the core analytical material in the course, together with qualitative, alternative explanations to aid your understanding;
- A number of guest lectures from industry and research experts
- Small periodic Quizzes during the lectures

Learning in this course

You are expected to attend lectures in order to maximise learning. In addition to the lecture notes, you should read relevant sections of any recommended texts and other materials. Reading additional texts and reports will further enhance your learning experience. Group learning is also encouraged. UNSW *assumes* that self-directed study of this kind is undertaken in addition to attending classes throughout the course.

Lectures will make extensive use of PowerPoint slides and white board work. Summary PowerPoint printouts will be provided on the course Moodle website. Additional information and reading materials will also be progressively made available on Moodle, but they are no substitute for accurate notes, and active student participation through questions and informal exercises during the lectures. It is also intended that you will be provided with access to a number of on-line data sources for the Australian National Electricity Market including an open-source tool *NEM-Data*, developed by a former student and current CEEM researcher, Nicholas Gorman.

Indicative Lecture Schedule

Note that the schedule provided above is provisional at this stage and may be updated during the session. You should attend lectures and regularly check the course *Moodle* website for possible updates. Note that there may be tasks (non-assessable) to undertake on *Moodle* each week as well – be sure to keep up to date with developments. A number of guest lectures are also intended to be included in the second half of term.

Assessment

The assessment scheme in this course reflects the intention to assess your learning progress through the term. Assessment will consist of a group report on an agreed topic related to material covered in the course; a group wiki and project pitch to the class, various class participation activities, class assignments taken individually and the final exam. **Satisfactory performance in both the class-based assessment and examination is required to pass this course.**

Assignments

The assignments allow self-directed study leading to the solution of partly structured problems. Marks will be assigned according to how completely and correctly the problems have been addressed and the understanding of the course material demonstrated by the report.

These assignments must be undertaken by students individually. It is expected that there will be two such assignments during the term. Provisional dates for assignment distribution and submission are provided in the course syllabus.

Project report and wiki

The project will involve students in an activity suited to their interests and skills in the area of electricity industry operation and control. Groups of four to five students are very strongly preferred, although smaller groups may also be permitted if and as appropriate – groups and topics must be approved by the course coordinators. In particular, students undertaking a fourth year engineering thesis or post-graduate research thesis should not choose an elec9715 project topic that closely relates to their other thesis research. Similarly, students are strongly encouraged not to choose a project that closely relates to any other projects that they have undertaken – for example, in elec9714 or other electricity industry related courses.

The intent of these group elec9715 projects is to expose you to electricity industry operational and control issues other than those you might already have already worked on, or are currently working on. Note also that the large student numbers this year will make smaller groups than 4 students particularly challenging to manage.

Projects will either focus on

- development and testing of a simple software, spreadsheet or Matlab power system modelling and optimisation tool, or
- an in-depth literature survey of some aspect of electricity industry operation and control (around 5000 words plus tables, diagrams, references etc.).

More information on these projects and suitable topics will be distributed in week 2 and project topics are to be negotiated and finalised by week 6. Details on the formal requirements for the project reports will also be provided at this time. It should contain a significant review of the literature relevant to the topic and a comprehensive bibliography. All source material must be adequately referenced in the body of the report and it is expected that there will be 25 or more scholarly references in a literature survey. It is also required that the project will include some analysis of actual electricity industry operational and control data. The report will be assessed on the quality of the content and presentation.

Given student numbers, we will be using group wikis this year. Each group is required to establish a wiki on Moodle and use this to communicate their project work and findings with other students taking the course. It is envisaged that you will post early discussions regarding your topic and host a question forum where other students can come and ask questions or provide comments. You will also need to prepare a slide pack and are invited to undertake additional communication activities such as brief videos. You will also have a chance to do a 5-7 minute pitch of your project in week 9 or 10 – a short presentation on how your particular topic is relevant to the future of the electricity industry here in Australia, and/or internationally. A computer and projector for PowerPoint presentations will be available for this. **All students are required to attend all of these project seminar sessions and provide a peer mark for each group.**

Assessment of the wikis will be based on the quality and comprehensiveness of the materials and discussion with other students in the course, with extra marks for innovative communication strategies. Each student will receive an individual mark according to the quality and extent of engagement in other student group projects through the wikis, as well as other on-line activities over the term.

More details will be provided on the projects and wikis during the lectures, and on Moodle. *For all of the non-exam assessment tasks in this course, it is essential that you have a complete understanding of the UNSW official position on 'In-class assessment and plagiarism' as outlined below. Please note that there are severe penalties associated with plagiarism offences.*

Final Exam

The exam in this course is a standard closed-book 2 hour written examination, comprising four compulsory questions. University approved calculators are allowed. The examination tests analytical and critical thinking and general understanding of the course material. Questions may be drawn from any aspect of the course unless specifically indicated otherwise by the lecturer.

Relationship of Assessment Methods to Learning Outcomes

	Learning outcomes					
Assessment	**1**	**2**	**3**	**4**	**5**	**6**
Assignments	✓	✓	✓	✓	✓	
Group project, seminar and wiki	✓		✓	✓	✓	✓
Quizes	✓	✓	✓	✓	✓	
Final exam	✓	✓	✓	✓	✓	✓

Course Resources

Textbooks

There is no assigned textbook for this subject. The following book is a useful reference on the traditional, monopoly utility, approach to many of the topics covered in this course, and the third edition also has some useful materials on electricity restructuring:

> Allen J Wood and Bruce F Wollenberg, *Power Generation, Operation and Control*, Wiley, 3rd Edition, 2014.

The UNSW library has a number of copies at PJ621.31. It is also available online via the UNSW library – search for 'wood wollenberg' to find the online resource. Note that there is a third edition (September 2013) which should now be available on-line at the UNSW library.

On-line resources

More recent concepts relevant to electricity industry operation and control in restructured industries are not easily found in textbooks. Instead, regular updates and course materials will be added to the course Moodle. Materials will include pdf versions of the lecture PowerPoints (also provided as printouts prior to each lecture). A range of reports, papers and websites will be uploaded throughout the term to provide more background on electricity industry operation and control within the restructured Australian electricity industry, as well as internationally. Another useful website is that of the UNSW Centre for Energy and Environmental Markets (CEEM) found at www.ceem.unsw.edu.au. It contains useful papers and presentations covering many of the topics that are explored during the course.

As a part of the teaching component, *Moodle* will be used to disseminate teaching materials, host forums and weekly quizzes. Assessment marks will also be made available via Moodle: https://moodle.telt.unsw.edu.au/login/index.php.

Other Matters

Academic Honesty and Plagiarism

Plagiarism is the unacknowledged use of other people's work, including the copying of assignment works and laboratory results from other students. Plagiarism is considered a form of academic misconduct, and the University has very strict rules that include some severe penalties. For UNSW policies, penalties and information to help you avoid plagiarism, see http://www.lc.unsw.edu.au/plagiarism. To find out if you understand plagiarism correctly, try this short quiz: https://student.unsw.edu.au/plagiarism-quiz.

Student Responsibilities and Conduct

Students are expected to be familiar with and adhere to all UNSW policies (see https://my.unsw.edu.au/student/atoz/ABC.html), particular attention is drawn to the following:

Workload

It is expected that you will spend around **15 hours per week** studying a 6 UoC course, from Week 1 until the final assessment, including both face-to-face classes and *independent, self-directed study*. In periods where you need to need to complete assignments or prepare for examinations, the workload will be greater. Over-commitment is a common challenge for students. You should take the required course workload into account when planning how to balance study with employment and other activities.

Attendance

Regular and punctual attendance at all classes is expected. UNSW regulations state that if students attend less than 80% of scheduled classes they may be refused final assessment.

General Conduct and Behaviour

Consideration and respect for the needs of your fellow students and teaching staff is an expectation. Conduct which unduly disrupts or interferes with a class is not acceptable and students may be asked to leave the class.

Work Health and Safety

UNSW policy requires each person to work safely and responsibly, in order to avoid personal injury and to protect the safety of others.

Keeping Informed

Announcements may be made during classes, via email (to your student email address) or via online learning and teaching platforms like Moodle. From time to time, UNSW will send important announcements via these media without providing any paper copy. Please note that you will be deemed to have received this information, so you should take careful note of all announcements.

Special Consideration and Supplementary Examinations

You must submit all assignments and attend all examinations scheduled for your course. You should seek assistance early if you suffer illness or misadventure which affects your course progress. All applications for special consideration must be **lodged online through myUNSW**, not to course or school staff. For more details on these arrangements, you can consult https://my.unsw.edu.au/student/atoz/SpecialConsideration.html.

Continual Course Improvement

This course is under constant revision in order to improve the learning outcomes for all students. Please forward any feedback (positive or negative) on the course to the course convener or via the Course and Teaching Evaluation and Improvement Process. You can also provide feedback to ELSOC who will raise your concerns at student focus group meetings. As a result of previous feedback obtained for this course and in our efforts to provide a rich and meaningful learning experience, we have continued to evaluate and modify our delivery and assessment methods.

Administrative Matters

On issues and procedures regarding such matters as special needs, equity and diversity, occupational health and safety, enrolment, rights, and general expectations of students, please refer to the School and, more generally, UNSW policies:
http://www.engineering.unsw.edu.au/electrical-engineering/policies-and-procedures
https://my.unsw.edu.au/student/atoz/ABC.html

Appendix A: Targeted Graduate Capabilities

Electrical Engineering and Telecommunications programs are designed to address the following targeted capabilities which were developed by the school in conjunction with the requirements of professional and industry bodies:

- The ability to apply knowledge of basic science and fundamental technologies;
- The skills to communicate effectively, not only with engineers but also with the wider community;
- The capability to undertake challenging analysis and design problems and find optimal solutions;
- Expertise in decomposing a problem into its constituent parts, and in defining the scope of each part;
- A working knowledge of how to locate required information and use information resources to their maximum advantage;
- Proficiency in developing and implementing project plans, investigating alternative solutions, and critically evaluating differing strategies;
- An understanding of the social, cultural and global responsibilities of the professional engineer;
- The ability to work effectively as an individual or in a team;
- An understanding of professional and ethical responsibilities;
- The ability to engage in lifelong independent and reflective learning.

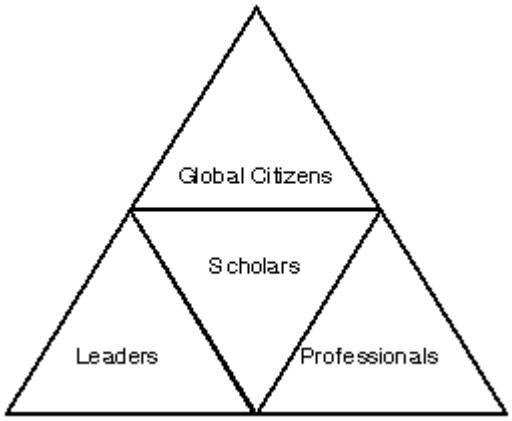
Appendix B: UNSW Graduate Attributes

The course delivery methods and course content addresses a number of core UNSW graduate attributes, as follows:

UNSW graduates will be -

Scholars who are:

- understanding of their discipline in its interdisciplinary context
- capable of independent and collaborative enquiry
- rigorous in their analysis, critique, and reflection
- able to apply their knowledge and skills to solving problems
- ethical practitioners
- capable of effective communication
- information literate
- digitally literate



Leaders who are:

- enterprising, innovative and creative
- capable of initiating as well as embracing change
- collaborative team workers

Professionals who are:

- capable of independent, self-directed practice
- capable of lifelong learning
- capable of operating within an agreed Code of Practice

Global Citizens who are:

- capable of applying their discipline in local, national and international contexts
- culturally aware and capable of respecting diversity, acting in socially just/responsible ways
- capable of environmental responsibility

Appendix C: Engineers Australia (EA) Professional Engineer Competency Standard

	Program Intended Learning Outcomes
PE1: Knowledge and Skill Base	PE1.1 Comprehensive, theory-based understanding of underpinning fundamentals
	PE1.2 Conceptual understanding of underpinning maths, analysis, statistics, computing
	PE1.3 In-depth understanding of specialist bodies of knowledge
	PE1.4 Discernment of knowledge development and research directions
	PE1.5 Knowledge of engineering design practice
	PE1.6 Understanding of scope, principles, norms, accountabilities of sustainable engineering practice
PE2: Engineering Application Ability	PE2.1 Application of established engineering methods to complex problem solving
	PE2.2 Fluent application of engineering techniques, tools and resources
	PE2.3 Application of systematic engineering synthesis and design processes
	PE2.4 Application of systematic approaches to the conduct and management of engineering projects
PE3: Professional and Personal Attributes	PE3.1 Ethical conduct and professional accountability
	PE3.2 Effective oral and written communication (professional and lay domains)
	PE3.3 Creative, innovative and pro-active demeanour
	PE3.4 Professional use and management of information
	PE3.5 Orderly management of self, and professional conduct
	PE3.6 Effective team membership and team leadership