School of Electrical Engineering and Telecommunications
Semester 1, 2018
Course Outline

ELEC3111
DISTRIBUTED ENERGY GENERATION

Course Staff
Course Conveners: Iain MacGill, Room TETB 316, i.macgill@unsw.edu.au.
Daming Zhang, Room 650, Materials Science Building (E10)

Lecturers: Dr. Daming Zhang, daming.zhang@unsw.edu.au
A/Prof Iain MacGill, i.macgill@unsw.edu.au
Dr Guo Chen, guo.chen1@unsw.edu.au

Consultations: You are encouraged to ask questions on the course material, during or after the lecture class times in the first instance, rather than via email. Questions regarding course logistics should be made to the course conveners, Iain MacGill or Daming Zhang. Otherwise, consultation times regarding course content questions can be organized by email with the relevant lecturer. ALL email enquiries should be made from your student email address with ELEC3111 in the subject line, sent to the relevant lecturer’s UNSW email, otherwise they will not be answered.

Keeping Informed: Announcements may be made during classes, via email (to your student email address) and/or via online learning and teaching platforms – in this course, we will use Moodle https://moodle.telt.unsw.edu.au/login/index.php. Please note that you will be deemed to have received any and all information posted on the course Moodle, so you should take careful note of all announcements.

Course Summary

Contact Hours
The course consists of 2-3 hours of lectures and a 1-2 hour tutorial (tutorials start week 3). Note that tutorials may not run in all weeks – you will be advised in lectures and via Moodle on the schedule.

<table>
<thead>
<tr>
<th>Lectures</th>
<th>Day</th>
<th>Time</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Running weeks 1-12</td>
<td>Monday</td>
<td>1-2pm</td>
<td>Law Theatre G23 (K-F8-G23)</td>
</tr>
<tr>
<td></td>
<td>Wednesday</td>
<td>4-6pm</td>
<td>Old Main Building 229 (K-K15-229)</td>
</tr>
<tr>
<td>Tutorials</td>
<td>Thursday</td>
<td>3-5pm</td>
<td>Civil Engineering 101 (K-H20-101)</td>
</tr>
</tbody>
</table>
**Context and Aims**

Distributed energy generation is developing into a significant market in the generation, distribution and utilisation of electrical energy. It includes local fossil-fuel derived energy sources, for example, co-generation from natural gas, renewable energy sources, such as wind and hydro, and low-carbon hybrid energy systems that combine energy sources from more than one energy source, whether renewable or fossil-fuelled. This course will equip you with the fundamental technical and economic processes and drivers at play in the electrical power industry.

Issues that will be covered include the basics of distribution network modelling, the different types of distributed energy sources utilised (Co-generation/CHP, wind, hydro, photovoltaics) and where they are integrated onto the electrical grid, the impact of the integration of such sources on the fundamental operation of the distribution and transmission networks, and how distributed generation is impacting on the development and operation of market frameworks.

The material will be presented by a team of leading researchers in each of these key areas for distributed generation. The indicative lecture schedule is noted below, although note that it remains subject to change.

**Indicative Lecture Schedule and Syllabus**

<table>
<thead>
<tr>
<th>Week</th>
<th>Staff</th>
<th>Topic</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DZ</td>
<td>Overview of Power Systems and Distributed Generation Systems</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>DZ</td>
<td>Basic models of distribution systems and per-unit system</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>DZ</td>
<td>Introduction to distributed energy sources</td>
<td>Assign 1 out (13%)</td>
</tr>
<tr>
<td>4</td>
<td>DZ</td>
<td>Distribution networks – power flow and voltage management</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>DZ</td>
<td>The basic inverter and interfacing, real and reactive control</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>DZ</td>
<td>Issues related to bidirectional power flow on networks: voltage control, system protection</td>
<td>Assignment 1 due</td>
</tr>
<tr>
<td>7</td>
<td>DZ</td>
<td>HVDC vs HVAC networks: offshore and onshore applications</td>
<td>Assignment 2 out (13%)</td>
</tr>
<tr>
<td>8</td>
<td>IM</td>
<td>Wholesale energy markets and distributed resources</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>IM</td>
<td>Network regulation</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>IM</td>
<td>Retail market arrangements and the prosumer</td>
<td>Assignment 2 due</td>
</tr>
<tr>
<td>11</td>
<td>GC</td>
<td>Introductory smart grid concepts</td>
<td>Assignment 3 out (14%)</td>
</tr>
<tr>
<td>12</td>
<td>GC</td>
<td>Smart grid implementation</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td></td>
<td></td>
<td>Assignment 3 due</td>
</tr>
</tbody>
</table>

DZ – Dr Daming Zhang  
IM – A/Prof Iain MacGill  
GC – Dr Guo Chen

**Assessment**

Students will be assessed according to the following scheme (subject to change):

- Final Examination (2 hours) 60%
- Assignment work (3 assignments) 40%
Course Details

Credits
This is a 6 UoC course and the expected workload is 10–12 hours per week throughout the 13 week semester.

Relationship to Other Courses
This is a Third year undergraduate elective course in the School of Electrical Engineering and Telecommunications. It is an elective course for students following a BE (Electrical) or (Telecommunications) program and other combined degree programs, and an elective for SPREE students.

Pre-requisites and Assumed Knowledge
The pre-requisite for this course is ELEC2134. It is essential that you are familiar with AC and DC circuit analysis and the concepts of real and reactive power before this course is attempted.

Learning outcomes
After successful completion of this course, you should be able to:
1. Describe and explain the basic operation, control and modelling of distributed energy systems.
2. Describe the basic components of a range of distributed energy sources including wind, PV, hydro, cogeneration, and energy storage systems.
3. Describe and demonstrate through calculation the impacts that distributed energy sources are having on the control and operation of electrical networks including voltage control, power factor, power quality.
4. Describe the basic operation of a power electronics inverter and its interface to an electrical network and perform basic calculations.
5. Describe and understand HVDC systems and their advantages and disadvantages.
6. Describe the operation of electrical energy markets and the role distributed and intermittent energy sources play in the marketplace.
7. Describe how demand-side management alters the operation of energy markets.
8. Identify and demonstrate an understanding of applicable standards and grid codes.
9. Understand and describe common components found in intelligent networks including telecoms, power electronics, sensing and measurement.
10. Appreciate the key role that the smart grid will play in facilitating distributed generation.

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 capabilities (listed in Appendix B). This course also addresses the Engineers Australia (National Accreditation Body) Stage I competency standard as outlined in Appendix C.

Teaching Strategies

Delivery Mode
The teaching in this course aims at establishing a good fundamental understanding of the areas covered using:

- 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;
- Tutorials, which allow for exercises in problem solving and allow time for you to resolve problems in understanding of lecture material;

Learning in this course
You are expected to attend all lectures and tutorials in order to maximise learning. In addition to your lecture notes, you should read relevant sections of the recommended text. Reading additional texts 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 face-to-face classes throughout the course.

Tutorial classes
You should attempt all of your problem sheet questions in advance of attending the tutorial classes. The importance of adequate preparation prior to each tutorial cannot be overemphasized, as the effectiveness and
usefulness of the tutorial depends to a large extent on this preparation. Group learning is encouraged. Answers for these questions will be discussed during the tutorial class and the tutor will cover the more complex questions in the tutorial class. In addition, during the tutorial class, 1-2 new questions that are not in your notes may be provided by the tutor, for you to try in class. These questions and solutions may not be made available on the web, so it is worthwhile for you to attend your tutorial classes to gain maximum benefit from this course.

Assessment
The assessment scheme in this course reflects the intention to assess your learning progress through the semester. Ongoing assessment occurs through the assignment work.

Assignment
The assignments allow self-directed study leading to the solution of partly structured problems. Marks are assigned according to how completely and correctly the problems have been addressed, and the understanding of the course material evident in the submission.

Late submissions will attract a penalty of 10% per day (including weekends). Assignment submissions are to be made via Moodle. You must include a signed cover sheet (see http://scoff.ee.unsw.edu.au/forms/assignmentcover.pdf) declaring that the work submitted is your own work and this must be the first page of the report

Final Exam
The exam in this course is a standard closed-book two 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 in a controlled fashion. Questions may be drawn from any aspect of the course (including tutorials), unless specifically indicated otherwise by the lecturer. Marks will be assigned according to the correctness of the responses. Please note that you must pass the final exam in order to pass the course.

Relationship of Assessment Methods to Learning Outcomes

<table>
<thead>
<tr>
<th>Assessment</th>
<th>1-2</th>
<th>3-4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assignment</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Final exam</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>
Course Resources

Textbooks

**Reference books:** The following textbooks are recommended reading:

- Bollen, Hassan, ‘Integration of Distributed Generation in the Power System’, IEEE publication, available online from the UNSW library

On-line resources

Moodle

As a part of the teaching component, Moodle will be used to disseminate teaching materials, and will be the place to submit assignments. Assessment marks will also be made available via Moodle: [https://moodle.telt.unsw.edu.au/login/index.php](https://moodle.telt.unsw.edu.au/login/index.php).

Mailing list

Announcements concerning course information will be given in the lectures and/or on Moodle and/or via email (which will be sent to your student email address).

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](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](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](https://my.unsw.edu.au/student/atoz/ABC.html)), and particular attention is drawn to the following:

**Workload**

It is expected that you will spend at least **ten to twelve 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 may be greater. Over-commitment has been a common source of failure for many students. You should take the required 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.

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 within 3 working days of the assessment, not to course or school staff. For more detail, 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. For example, this course has undergone changes to staff numbers delivering the course.

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 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 Capabilities

The course delivery methods and course content directly or indirectly addresses a number of core UNSW graduate capabilities, as follows:

- Developing scholars who have a deep understanding of their discipline, through lectures and solution of analytical problems in tutorials and assessed by assignments and written examinations.
- Developing rigorous analysis, critique, and reflection, and ability to apply knowledge and skills to solving problems. These will be achieved through assignment work.
- Developing capable independent and collaborative enquiry, through a series of tutorials spanning the duration of the course.

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

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