GSOE 9141
Smart Grids and Distribution Networks
Course Outline – Semester 1, 2016

Never Stand Still | Faculty of Engineering | School of Electrical Engineering and Telecommunications

Course Staff

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Consultations: You are encouraged to ask questions on the course material, after the lecture class times in the first instance, rather than via email. You can also post questions in the Moodle discussion forums. ALL email enquiries should be made from your student email address with GSOE9141 in the subject line, otherwise they will not be answered.

Preliminary consultation times for the course are: **Tuesday and Wednesday, 2:30 pm to 3:30 pm.**

Keeping Informed: The main announcements regarding the course and its assignments will be made through Moodle https://moodle.telt.unsw.edu.au/login/index.php. Announcements may also be made during classes but everything will be formally announced in the relevant sections of Moodle.

Please note that you will be deemed to have received this information, so you should take careful note of all announcements.

Course Summary

Contact Hours

The course consists of weekly sessions that are provided online through Moodle https://moodle.telt.unsw.edu.au/login/index.php.

There are also six, 2-hour face-to-face sessions throughout the semester. The preliminary dates for these lectures are the following:

Lectures	Day	Time	Location
Lecture 1	Monday 29 Feb 2016	10am - 12 pm	Goldhall G16
Lecture 2	Monday 14 March 2016	10am - 12 pm	Goldhall G16
Lecture 3	Monday 4 April 2016	10am - 12 pm	Goldhall G16
Lecture 4	Monday 18 April 2016	10am - 12 pm	Goldhall G16
Lecture 5	Monday 9 May 2016	10am - 12 pm	Goldhall G16
Lecture 6	Monday 23 May 2016	10am - 12 pm	Goldhall G16

Course Rationale

This course will offer flexible delivery, being conducted in blended mode combining six face-to-face workshops, online activities and workplace-based learning (if applicable). The course can be taken to contribute towards an Engineering Masters program (as 6 Units of Credit), or be taken as non-Award (without academic assessment), contributing instead towards Continuing Professional Development (CPD).

Implementation of Smart Grid strategies by power utilities necessitates a new set of skills, experiences and knowledge. Understanding the Smart Grid requires knowledge of numerous key engineering topics in electrical and power engineering, telecommunications and information technologies. Such key engineering disciplines also must intersect other disciplines including sciences, markets, business strategies and processes, energy related policies and regulation. The Smart Grid requires a suite of new standards to be developed and implemented from the technical point of view. Moreover, the Gmart Grid is a customer-centred transformation of aged electricity grids and promises to deliver many benefits to customers, hence consumer behaviour and social sciences also play an important role in smart grids.

Professionals and engineers working in the power industry and information and communications technologies will seek to upgrade and expand their practical skills to meet unprecedented market demand. This course provides a cross-disciplinary overview approach of the various topics of a Smart Grid ranging from the fundamentals of Smart Grids to renewable energy systems, energy storage, IT communications and standards. The course focuses mainly on intelligent electricity distribution networks and provides the basis for the new thinking and design methodology required by engineers and professionals for transforming the current distribution networks to become a major part of the future intelligent electricity network.

Handbook Description

A Smart Grid is the integration of numerous technologies, systems and processes with the aim to modernise and fully automate the entire electricity grid covering generation, transmission, distribution, utilisation plus conservation of energy. Smart grids will revolutionise the design, development, management, operation and maintenance of the grid to levels that were thought impossible some decades ago. The driving force behind Smart Grids include environmental awareness of people and governments; the need for further automation and energy efficiency; large capital investments for the renewal of the ageing infrastructure in most developed countries including Australia; adoption of competitive energy prices; security of supply; energy conservation and the ever increasing electricity demand that needs to be met. The course will provide advanced information and thinking required by engineers and professionals to deliver Smart Grid concepts from inception to implementation. The course will mainly focus on intelligent electricity distribution networks, present the latest technologies used to automated such networks and analyse the impact of these technologies on system design, operation, management and maintenance.

Context and Aims

The aims of the course are to:

- Present the fundamental concepts associated with Smart Grids.
- Review renewable energy generation, grid integration energy storage technologies and future developments
- Introduce advanced management and control concepts of Smart Grids.
- Construe the data management requirements and ICT technologies for Smart Grids.
- Present standards related to the development of smart grids, identify key stakeholders and potential impact.

Indicative Lecture Schedule

Period	Summary of Lecture Program
Week 1	Introduction to Smart Grids and Intelligent Distribution Networks
Week 2	Renewable Energy Integration in Smart Grids
Week 3	Energy Storage Technologies
Week 4	Demand Side Management, Demand Response and Demand Pricing
Mid - semester break, 25 Mar - 4 Apr	
Week 5	FDIR and Volt-var Optimisation - Asset Health Management
Week 6	Smart Meters - Electric Vehicles in Smart Grids
Week 7	IT Networks and Security
Week 8	Telecommunication Systems in Smart Grids
Week 9	Economics of Smart Grids
Week 10	Smart Grid Standards
Week 11	Impact, Policies, Demonstration Projects, Stakeholders and the way forward.
Week 12	Review of the Smart Grid Smart - City Project

Assessment

Pre-requisites to pass the course

In order to receive a passing mark for the course, submission and participation in all summative assessment and an overall passing mark of 50/100 is required.

Assessment Task 1	5%
Assessment Task 2	30% (3 x 10%)
Assessment Task 3	10%
Assessment Task 4	30% (20% + 10%)
Assessment Task 5	25 %

Course Details

Credits

This is a 6 UoC course and the expected workload is 8 - 10 hours per week throughout the 13 week semester.

Relationship to Other Courses

This is a postgraduate course in the School of Electrical Engineering and Telecommunications offered through the Graduate School of Engineering.

Pre-requisites and Assumed Knowledge

There are no pre-requisites courses for attending GSOE9141.

Learning outcomes

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

1. LO1: Identify the key elements of Smart Grids and visualise the roadmap towards next-Gen electricity networks.
2. LO2: Evaluate technology options pertaining to renewable energy generation, energy storage, data handling and communications for Smart Grids.
3. LO3: Justify technological and economical choices in the context of existing commercial Smart Grids projects and suggest improvements and expansions.
4. LO4: Determine the relevance of Smart Grids projects, develop ways to evaluate their impacts and implications
5. LO5: Analyse the new roles of utilities and consumers in Smart Grids and pinpoint business and market opportunities and potential gains.

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.

Syllabus

Smart grids; Intelligent Distribution Networks; Renewable Energy; Distributed Generation; DG Integration; Solar; Wind; Energy Storage Technologies; Chemical, Mechanical and Electrical Energy Storage; Demand Side Management; Load Management; Demand Side Response; Conservation Voltage Reduction; Demand Pricing; Time of Use; Real Time Pricing; Peak Time Pricing; FDIR; Reactive Power Optimisation; Volt-Var Optimisation; Distribution Automation; Advanced Asset Management; Electric Vehicles; Smart Meters; Advanced Measuring Infrastructure; Distribution Management Systems; Smart Grid ICT; Common Information Model; Cyber-Security; Wide Area Measurement Systems; Smart Grid Communications; SCADA; SG costs; Markets; Ancillary Markets; Smart Grid Standards; Substation Automation; Stakeholders and Benefits;

Teaching Strategies

Delivery Mode

Delivery Mode.

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

- Monthly Seminars
- Course material provided through Moodle
- Supplementary video resources
- Relevant Assessment Tasks

You are expected to attend the six face-to-face lectures of the course. The facilitator will discuss assessment and assignment criteria and comment on current assessment tasks and marks during these six sessions.

The material of the course will be provided on-line through UNSW's Moodle page. The students are expected to follow the material of the course as it is weekly updated on the website but they are free to study on their own pace.

Additional video resources will be also linked. These resources have been selected as they provide valuable insights from industrial meetings and forums, enhance the coverage of the material and should be considered as content of the course. You can view these resources at your own pace, and you will be required to comment and express your opinions and ideas during lectures.

The rationale behind these methods of delivery for the course is that the Smart Grid is a complex collection of different technologies and the course offers a "bird's eye" view of the core components. The course is not designed to be a power system analysis or telecommunication course but provides the students with the knowledge and the resources in order to identify and tackle the requirements in the current transformation of the electricity networks.

Learning in this Course

You are expected to attend all lectures, tutorials, labs, and mid-semester exams in order to maximise learning. You must prepare well for your laboratory classes and your lab work will be assessed. In addition to the lecture notes/video, 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.

Assessment

The assessment scheme in this course reflects the intention to assess your learning progress through the semester. Ongoing assessment occurs through bi-weekly learning journal submissions and early assessment submission requirements.

Final Exam

The course does not have a final exam.

Assignments

The course does not include a final exam and all assessment (formative and summative) will take place throughout the semester. The assessment tasks include:

- ASMT1: Week 1 to week 12 brief assignment (1 page maximum) (5 marks)
- ASMT2: 3 reports which include brief literature reviews or research related to the topics discussed in the course. Bi-weekly reports (learning Journals) are due by the end of week 4, week 7, week 10, (3 x 10 marks = 30 marks)
- ASMT3: Multiple choice test (1 x 10 marks = 10 marks)
- ASMT4: A literature review of a topic of your choice relevant to Smart Grids. A list of suggested topics will be made available in Week 2 (Report 20 marks - Presentation 10 marks).
- ASMT5: A comprehensive report on the economic assessment and impact of the Smart Grid-Smart City project based on the modelling available by AusGrid. (25 marks)

Submission of Assessment Tasks

Assessment tasks will be submitted via the Moodle page of the course. Each assessment task will have two deadlines, a soft deadline for the submission of each assignment after which submissions will incur a 10% penalty per day of delayed submission. The soft deadline will be followed by a hard deadline three days later, after which no marks will be given to an assignment. Submission of an assignment past the hard deadline will be accepted via email.

Marking of the assessments will be based on a detailed rubric that will be made available in Moodle during the first week of the semester and explained in detail at the first face-to-face session of the course.

Relationship of Assessment Methods to Learning Outcomes

	Learning Outcomes				
Assessment	**1**	**2**	**3**	**4**	**5**
ASMT 1	✓			✓	
ASMT 2	✓	✓	✓	✓	✓
ASMT 3	✓	✓			
ASMT 4	✓	✓	✓	✓	✓
ASMT 5	✓	✓	✓	✓	✓

Course Resources

Textbooks

Prescribed textbook

No textbook is required for the course and the presentations – notes include material from a wide range of sources that cover the different aspects of the Smart Grid. References to related books and supplementary reading and video material) will be provided when deemed necessary. Major references of the subject include the

- IEEE Transactions on Smart Grid
- IEEE Innovative Smart Grid Technologies Conference (ISGT) family of conferences

Additional References

Links to supplementary resources and material will be given each week at the course's Moodle website. Some references related to the subject are the following:

- CW Gellings, "The Smart Grid, Enabling Energy Efficiency and Demand Side Response"- CRC Press, 2009.
- J Ekanayake, K. Liyanage, J.Wu, A. Yokoyama, N. Jenkins, "Smart Grid: Technology and Applications"- Wiley, 2012.
- James Momoh, "Smart Grid: Fundamentals of Design and Analysis"- Wiley, IEEE Press, 2012.
- The Smart Grid: Adapting the Power System to New Challenges, Bollen, Math H J, Morgan & Morgan Publishers, 2011
- The Smart Grid: An Introduction, Department of Energy (US)
- Towards Smart Power Networks – Lessons learned from European Research Framework Program 5 Projects, European Union
- S.E. Collier, Ten Steps to a Smarter Grid, IEEE Industry Applications Magazine, Volume: 16, Issue: 2, 2010, pp. 62-68
- V.C. Gungor, D. Sahin, T. Kocak, S. Ergut, C. Buccella, C. Cecati, G.P. Hancke, G.P.; "Smart Grid Technologies: Communication
- Technologies and Standards", IEEE Transactions on Industrial Informatics, Vol. 7, No 4, 2011 , pp. 529-539
- G.W. Arnold, "Challenges and Opportunities in Smart Grid: A Position Article", Proceedings of the IEEE, Volume: 99 , Issue: 6, 2011, pp. 922-927
- N. Hatziargyriou, H. Asano, R. Iravani, C. Marnay, "Microgrids", IEEE Power and Energy Magazine, Vol.: 5 , No: 4, 2007, pp. 78-94
- F. Bouhafs, M. Mackay, M. Merabti, "Links to the Future: Communication Requirements and Challenges in the Smart Grid", IEEE Power and Energy Magazine, Volume: 10 , Issue: 1, 2012, pp. 24-32
- H. Gharavi, R. Ghafurian, "Smart Grid: The Electric Energy System of the Future [Scanning the Issue]", Proceedings of the IEEE, Volume: 99 , Issue: 6, 2011, pp. 917-921

- F. Benzi, N. Anglani, E. Bassi, L. Frosini, "Electricity Smart Meters Interfacing the Households", IEEE Transactions on Industrial Electronics, Volume: 58 , Issue: 10, 2011, pp. 4487-4494
- Koutsopoulos, L. Tassiulas, "Challenges in demand load control for the smart grid", IEEE Network, Vol.: 25 , Issue: 5, 2011, pp. 16-21

On-line resources

Moodle

As a part of the teaching component, Moodle will be used to disseminate teaching materials, host forums and occasionally quizzes. Assessment marks will also be made available via Moodle: 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.
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), 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

Attendance of the six seminars expected. However, if you are unable to attend part or a whole seminar due to scheduling conflicts or work, you should notify (preferably via e-mail) the course convener ahead of time and discuss how to address these issues.

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.

Based on the feedback from the last two years,**for Semester 1, 2016** the following changes have been implemented:

1. The face-to-face lectures have been increased from three to six.
2. The presentation session for the reports of Assessment Task 4 has been reintroduced.
3. The number of reports during the semester has been reduced from five to three and their weight on the mark has increased from 7% to 10%. This change is also reflected in the requirements for the report.
4. Suggested video material has been introduced for the course. This is not a recording of the lectures but presentations from experts on the various topics of the smart grid.
5. The choice of topics for Assessment Task 5 has been removed and all will be working on a common topic, the Smart Grid, Smart City report.

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

Appendices

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 <select those which apply (maybe 3-5) and adapt to suit course>:

- 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 by the laboratory experiments and interactive checkpoint assessments and lab exams during the labs.
- Developing capable independent and collaborative enquiry, through a series of tutorials spanning the duration of the course.
- Developing digital and information literacy and lifelong learning skills through assignment work.
- Developing ethical practitioners who are collaborative and effective team workers, through group activities, seminars and tutorials.
- Developing independent, self-directed professionals who are enterprising, innovative, creative and responsive to change, through challenging design and project tasks.
- Developing citizens who can apply their discipline in other contexts, are culturally aware and environmentally responsible, through interdisciplinary tasks, seminars and group activities.

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	