School of Electrical Engineering & Telecommunications

UNSW Engineering

ELEC9781

Special Topics in Electrical Engineering 1

Term 3, 2021

Course Overview

Staff Contact Details

Convenors

Name	Email	Availability	Location	Phone
Dr Chaojie Li	chaojie.li@unsw.edu.au	MS Teams Friday 2:00pm-5:00pm	G17 Room 301	0410984430

School Contact Information

Consultations: Lecturer consultation times will be advised during the first lecture. You are welcome to email the tutor or laboratory demonstrator, who can answer your questions on this course and can also provide you with consultation times. ALL email enquiries should be made from your student email address with ELEC/TELExxxx in the subject line; 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 this information, so you should take careful note of all announcements.

Student Support Enquiries

For enrolment and progression enquiries please contact Student Services

Web

Electrical Engineering Homepage

Engineering Student Support Services

Engineering Industrial Training

UNSW Study Abroad and Exchange (for inbound students)

UNSW Future Students

Phone

(+61 2) 9385 8500 – Nucleus Student Hub

(+61 2) 9385 7661 – Engineering Industrial Training

(+61 2) 9385 3179 – UNSW Study Abroad and UNSW Exchange (for inbound students)

Email

Engineering Student Support Services – current student enquiries

- e.g. enrolment, progression, clash requests, course issues or program-related queries

Engineering Industrial Training – Industrial training questions

UNSW Study Abroad – study abroad student enquiries (for inbound students)

UNSW Exchange – student exchange enquiries (for inbound students)

UNSW Future Students – potential student enquiries

- e.g. admissions, fees, programs, credit transfer

Course Details

Units of Credit 6

Summary of the Course

1.An overview of energy storage technology; Review of the basic concepts on energy storage system used in power system analysis.

2.Mathematical modelling of energy storage system operation in power system: convex optimisation; MATLAB solver; charging/discharging model.

3.AI technique-based operation of energy storage system: LSTM neural networks, time series prediction; predict-then-optimise approach.

4.Planning approach of energy storage system: long-term demand prediction, renewable energy prediction, optimisation model under uncertainty.

5.Planning approach of charging stations for transportation electrification: game theoretical model, planning under uncertainty.

Course Aims

Climate changes caused by increasing greenhouse gas emissions (GHGs) pose a serious threat to our community, such as bushfires in extremely hot weather, which requests a significant decrease in GHGs. When integrating a large number of renewable energy resources into the power grid to achieve net-zero emissions in Australia by 2050, the power system reliability is confronting a great challenge due to the high variability of wind and solar power. To tackle this challenging issue, an energy storage system has been introduced for maintaining the stability of the power grid by the fast response to the derivation of the system frequency and voltage. However, the current capital investment of energy storage is still expensive. It is critical to efficiently coordinate different energy storage systems with renewable energy resources. In this course, you will learn the knowledge about the role of the energy storage system in the power system, how to use energy storage systems to support the power supply from residential to industrial areas. The prerequisites for students include power system analysis basics, MATLAB programming, and strong mathematical skills. The course will provide students with an introduction to energy storage system operation in the power system.

Course Learning Outcomes

After successfully completing this course, you should be able to:

Learning Outcome	EA Stage 1 Competencies
1. Understand major types of energy storage system used in electrical power systems.	PE1.1, PE1.2, PE1.5, PE1.6
2. Calculate the optimal operation of battery in a power system.	PE1.1, PE1.3, PE1.6, PE2.3
3. Perform time series prediction of renewable energy.	PE1.1, PE1.2, PE1.4, PE1.6, PE2.2

Learning Outcome	EA Stage 1 Competencies
4. Model the integration of energy storage system into power system.	PE1.1, PE1.2, PE1.3, PE1.4
5. Determine the optimal planning of EV charging station.	PE1.1, PE1.2, PE1.5, PE2.1

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.

Teaching Strategies

Delivery Mode

The course consists of the following elements: online activities, in-class discussions, exercise questions, tutorials and interactive quizzes.

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

- In-class discussions / lectures, which provide students with a focus on the core concept of the energy storage system in the course, together with qualitative, alternative explanations to improve understanding how to deploy energy storage system in the power grid;
- Mentoring sessions during the lecture that will promote group discussions and enhance deeper learning of the concepts;
- Coding explanation and programming demonstrations that will help students learn the pipeline of problem solving;
- Interactive quizzes focus on active, student-directed learning that encourage students engaging in an authentic lecture learning environment;
- Tutorials, which allow for exercises in problem solving and allow time for you to resolve problems in understanding of lecture material;
- Industry Guest Lecture, which will help students understand how energy storage system can be

practically applied in power grid.

Learning in this course

You are expected to attend all lectures, and mid-term/final exams in order to maximise learning. In addition to the lecture notes/video, you should read relevant sections of the recommended journal articles on the lecture topics. Implementing MATLAB/python programming on the design project will further enhance your learning experience. UNSW *assumes* that self-directed study of this kind is undertaken in addition to attending face-to-face sessions throughout the course.

Additional Course Information

Relationship to Other Courses

The course is a postgraduate course with a special topic of energy storage systems offered to students following a ME (ELEC) course at UNSW. The course gives the introduction for integration of energy storage systems and renewable energy resources into power system network; the course would normally be taken concurrently with thesis work in the energy systems area.

Pre-requisites and Assumed Knowledge

This is one of the special topic courses for Master of Engineering Science and Master of Engineering programs in Electrical Engineering where two industry guest lectures will be delivered. It is assumed that the students have good computer literacy, i.e., MATLAB and mathematical skills.

Assessment

Assessment task	Weight	Due Date	Course Learning Outcomes Assessed
1. Essays	40%	Not Applicable	1, 2, 3, 4
2. Quizzes and Online discussions	20%	Not Applicable	1, 2, 3, 4, 5
3. Mid-term exam	15%	29/10/2021 08:00 PM	1, 2, 3
4. Final exam	25%	Not Applicable	1, 4, 5

Assessment 1: Essays

Assessment length: 2000 words for each

Essay A is required to have a comprehensive literature review on energy storage systems technology.

It should be but not limited to:

1. The background of the energy storage system.

2. The state-of-art of research on energy storage system technology.

3. The future vision of energy storage system toward net-zero emission by 2050.

4. The conclusion of the literature review.

Essay B is required to design a home PV system with a battery for improving renewable energy usage.

The following questions should be answered but not limited to:

1. The background of the home battery system.

2. How to predict the renewable energy will be generated by the home PV system?

3. Given the size of the PV system in a house, what's the optimal size of the battery?

4. What is the likely payback period on this solar system plus the battery?

This assignment is submitted through Turnitin and students do not see Turnitin similarity reports.

Assessment criteria

The marking criteria for the essay A is as below.

- understanding / knowledge of the concept - 10 marks

- completion of the literature review - 15 marks

- report submission (2000 words) - 5 marks

TOTAL: 30 marks that will be scaled to 15% towards the course.

The marking criteria for the essay B is as below.

- understanding the engineering practice - 5 marks

- completion of the Project Design - 20 marks

- report submission (2000 words)- 5 marks

TOTAL: 30 marks that will be scaled to 25% towards the course.

Additional details

Essays A will start from 17/09/2021 12:00 AM and is due by 15/10/2021 11:59 PM.

Essay B will start from 22/10/2021 12:00 AM and is due by 26/11/2021 11:59 PM.

Assessment 2: Quizzes and Online discussions

There will be four online quizzes on various topics contributing to 10% towards the course. These quizzes will be via Moodle. The quizzes will aid understanding of the material. The quizzes should be submitted online on Sundays (8 pm) of the allocated weeks. Detailed course material and all lecture videos are available in OpenLearning (OL). To ensure that you use the materials effectively, a mark of 5% is allocated to the progress bar monitor in OL. Additionally, to apply the concepts learnt in the course to energy storage system, you are encouraged to complete Essay B with a system design, which is worth 25%. Your attendance and engagement during these lectures. You will have to attend 8 out of the 10 sessions to get a total of 8 x 5 = 40 marks, which will be scaled to 5% contribution towards the course.

Assessment 3: Mid-term exam

Start date: 29/10/2021 06:00 PM
Due date: 29/10/2021 08:00 PM

The mid-term examination tests your general understanding of the course material and is designed to give you feedback on your progress through the analytical components of the course. Questions may be drawn from any course material up to the end of week 4 (topics include up to AI technique-based operation of energy storage system). Marks will be assigned according to the correctness of the responses. The test will be online via Moodle STACK questionnaire, held during **Week 7 Friday 18-20 pm**.

Assessment 4: Final exam

The final exam in this course will cover the aspects of the course from week 5. Note that the material previous to week 5 cannot be completely ignored, although there may not be specific questions from those topics that are already covered in the mid-term exam. Thorough knowledge of these topics is essential to answer the exam questions. The exam format will be announced closer to the time. The examination tests analytical and critical thinking and a general understanding of the course material in a controlled fashion.

Additional details

Please note that you must pass the written exam (final exam + mid-term exam put together) in order to pass the course.

Attendance Requirements

Students are strongly encouraged to attend all classes and review lecture recordings.

Course Schedule

View class timetable

Timetable

Date	Type	Content
Week 1: 13 September - 17 September	Lecture	Introduction to Energy Storage Technology : 1. Energy storage technology 2. The role of energy storage system in power system
Week 2: 20 September - 24 September	Lecture	Solving optimization problems of energy storage system operation 1. Convex optimisation 2. Matlab for solving optimization problems in operation of energy storage system
	Homework	Quiz
Week 3: 27 September - 1 October	Lecture	AI techniques for energy storage operation 1. Python Programming for time series prediction 2. Forecasting technique for coordinating renewables with battery
Week 4: 4 October - 8 October	Lecture	Energy storage management system 1. Charging methodologies 1. SoC estimation techniques

	Homework	Quiz
Week 5: 11 October - 15 October	Lecture	Energy storage operation 1. Energy storage system for FCAS market 2. Autobidder
	Tutorial	Convex optimisation technique for the battery operation
Week 6: 18 October - 22 October	Lecture	Smart home battery system design 1. Machine learning technique for optimal control of energy storage system 2. Industry Guest Lecture (Energy storage system in the Australian power grid)
	Tutorial	Midterm revision (online only) Consultation Thu 19:30-21:00 pm
	Homework	Quiz
Week 7: 25 October - 29 October	Lecture	Planning of energy storage systems to renewable energy 1. Sizing and localising issues of energy storage system in distribution network 2. Case study----the three-phase rebalance problem
	Tutorial	Midterm revision (online only)
	Assessment	Mid-exam on Friday 18:00pm-20:00pm
Week 8: 1 November - 5 November	Lecture	Mobile energy storage in the electrification of transportations 1. Land-Marine-Space vehicle electrification 2. Charging/discharging management

	Tutorial	Time series analysis
	Homework	Quiz
Week 9: 8 November - 12 November	Lecture	Charging station planning for EV in urban area 1. The planning approach and solution of EV charging station 2.Case study---EV charging infrastructure planning in Sydney
Week 10: 15 November - 19 November	Lecture	Industry Guest Lecture：Community battery design
	Tutorial	Final exam revision
Study Week: 20 November - 25 November		

Resources

Prescribed Resources

[1] M., Sterner and I. Stadler (Eds.). (2019). *Handbook of energy storage: Demand, technologies, integration*. Springer.

Recommended Resources

[2] Asian Development Bank, Handbook on Battery Energy Storage System, 2018.

[3] M. Hannan, S. Wali, P. Ker, M. Abd Rahman, M. Mansor, V. Ramachandaramurthy, K. Muttaqi, T. Mahlia, Z. Dong,
Battery energy storage system: A review of technologies, optimization objectives, constraints, approaches, and outstanding issues, Journal of Energy Storage, Volume 42,
2021, 103023.

[4] C. Li, Z. Dong, G. Chen, B. Zhou, J. Zhang and X. Yu, "Data-Driven Planning of Electric Vehicle Charging Infrastructure: A Case Study of Sydney, Australia," in *IEEE Transactions on Smart Grid*, vol. 12, no. 4, pp. 3289-3304, July 2021, doi: 10.1109/TSG.2021.3054763.

Course Evaluation and Development

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 myExperience. 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.

Academic Honesty and Plagiarism

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 https://student.unsw.edu.au/plagiarism. To find out if you understand plagiarism correctly, try this short quiz: https://student.unsw.edu.au/plagiarism-quiz.

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.

Academic Information

COVID19 - Important Health Related Notice

Your health and the health of those in your class is critically important. You must stay at home if you are sick or have been advised to self-isolate by NSW health or government authorities. Current alerts and a list of hotspots can be found here. **You will not be penalised for missing a face-to-face activity due to illness or a requirement to self-isolate**. We will work with you to ensure continuity of learning during your isolation and have plans in place for you to catch up on any content or learning activities you may miss. Where this might not be possible, an application for fee remission may be discussed.

If you are required to self-isolate and/or need emotional or financial support, please contact the Nucleus: Student Hub. If you are unable to complete an assessment, or attend a class with an attendance or participation requirement, please let your teacher know and apply for special consideration through the Special Consideration portal. To advise the University of a positive COVID-19 test result or if you suspect you have COVID-19 and are being tested, please fill in this form.

UNSW requires all staff and students to follow NSW Health advice. Any failure to act in accordance with that advice may amount to a breach of the Student Code of Conduct. Please refer to the Safe Return to Campus guide for students for more information on safe practices.

Dates to note

Important Dates available at: https://student.unsw.edu.au/dates

Student Responsibilities and Conduct

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

Workload

It is expected that you will spend at least **15 hours per week** studying a 6 UoC course, from Week 1 until the final assessment, including both formal classes and *independent, self-directed study*. In periods where you 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.

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 can apply for special consideration when illness or other circumstances beyond your control interfere with an assessment performance. If you need to submit an application for special consideration for an exam or assessment, you must submit the application **prior to the start** of the exam or before the assessment is submitted, except where illness or misadventure prevent you from doing so. Be aware of the "fit to sit/submit" rule which means that if you sit an exam or submit an assignment, you are declaring yourself well enough to do so and cannot later apply for Special Consideration. For more information and how to apply, see https://student.unsw.edu.au/special-consideration.

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:

https://student.unsw.edu.au/guide

https://www.engineering.unsw.edu.au/electrical-engineering/resources

Image Credit

Synergies in Sound 2016

CRICOS

CRICOS Provider Code: 00098G

Acknowledgement of Country

We acknowledge the Bedegal people who are the traditional custodians of the lands on which UNSW Kensington campus is located.

Appendix: Engineers Australia (EA) Professional Engineer Competency Standard

Program Intended Learning Outcomes	
Knowledge and skill base	
PE1.1 Comprehensive, theory based understanding of the underpinning natural and physical sciences and the engineering fundamentals applicable to the engineering discipline	✓
PE1.2 Conceptual understanding of the mathematics, numerical analysis, statistics, and computer and information sciences which underpin the engineering discipline	✓
PE1.3 In-depth understanding of specialist bodies of knowledge within the engineering discipline	✓
PE1.4 Discernment of knowledge development and research directions within the engineering discipline	✓
PE1.5 Knowledge of engineering design practice and contextual factors impacting the engineering discipline	✓
PE1.6 Understanding of the scope, principles, norms, accountabilities and bounds of sustainable engineering practice in the specific discipline	✓
Engineering application ability	
PE2.1 Application of established engineering methods to complex engineering 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	
Professional and personal attributes	
PE3.1 Ethical conduct and professional accountability	
PE3.2 Effective oral and written communication in 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	