School of Chemical Engineering

UNSW Engineering

GSOE9111

Energy Storage

Term 3, 2022

Course Overview

Staff Contact Details

Convenors

Name	Email	Availability	Location	Phone
Da-Wei Wang	da-wei.wang@unsw.edu.au	appointment via email	Hilmer 221 (enter via SEB)	

School Contact Information

For assistance with enrolment, class registration, progression checks and other administrative matters, please see the Nucleus: Student Hub. They are located inside the Library – first right as you enter the main library entrance. You can also contact them via http://unsw.to/webforms or reserve a place in the face-to-face queue using the UniVerse app.

If circumstances outside your control impact on submitting assessments, Special Consideration may be granted, usually in the form of an extension or a supplementary assessment. Applications for Special Consideration must be submitted online.

For course administration matters, please contact the Course Coordinator.

Course Details

Units of Credit 6

Summary of the Course

Electrochemical energy storage is the most widely applied clean energy technology in this age and will be the central focus in this course. However, the course will also cover other energy storage technologies with equivalent importance in different fields of application, such as chemical storage, thermal storage, mechanical storage and biomass energy. Students will learn the basic principles of electrochemical technologies in energy storage engineering: rechargeable batteries, flow batteries, supercapacitors, fuel cells, electrolysers, photo-electrochemical reactions, etc.. Students will also be introduced to system integration and energy economy in the context of sustainability.

Course Aims

This course aims to introduce students to electrochemical energy storage from the perspectives of fundamental chemistry and applied technology. While the course is mainly concentrated on the science and engineering of electrochemical technologies for the conversion and storage of electrical energy in forms of chemical energy (i.e. electrochemical energy storage), it also covers essentially other energy storage technologies, such as chemical, solar, thermal or mechanical. The course also considers factors affecting technology integration. The use of electrochemical technology is placed in an industry-related background, with general orientation towards how the various electrochemical technologies are complementary to the contemporary energy systems, such as renewable power plant, smart grid systems and management, and their techno-economic impact.

Course Learning Outcomes

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

Learning Outcome	EA Stage 1 Competencies
1. Outline the principles and engineering design for energy storage and conversion using electrochemical technologies such as batteries and fuel cells and compare these with conventional fossil fuel systems.	PE1.1
2. Demonstrate and assess the feasibility and competency of batteries and alternative energy storage technologies within the context of real-world problems.	PE1.3, PE2.1
3. Explain and compare the strengths and weaknesses of batteries and alternative energy sources, such as hydrogen systems and fuel cells and the available technologies for the storage and transport of energy.	PE1.5, PE2.4
4. Integrate appropriate energy storage technology with a particular energy generation.	PE1.5, PE2.3

At the successful completion of this course you should be able to:

1. Learn and apply theory in the context of electrochemical energy storage from technologies relying on electrochemical principles, with breadth covering other storage technologies, and

2. Recognise, describe and investigate various electrochemical energy storage systems in the context of techno-economic-political-environmental impact, and

3. Design a solution to be implemented for a practical energy storage scenario.

Teaching Strategies

This course will include lectures, seminars and tutorials. The outcome of learning will be assessed in the formats of problem-solving projects to encourage active learning. The lectures, seminars and tutorials will train the students to learn collectively and gain broad knowledge on the science and technologies related to electrochemical energy storage applications. The combination of personalized and grouped assessments will encourage the students to establish their skills and capabilities toward solving complicated problems in the context of energy storage based on critical thinking and rational collaboration.

Additional Course Information

This course is designed to illustrate the application of energy storage fundamentals and technologies in the new era of clean energy economy. In principle, this course provides comprehensive coverage on electrochemical, chemical, thermal, biological energy storage, etc. A special focus is placed on electrochemical energy storage (including batteries, hydrogen, fuel cell, supercapacitor, etc) and the correlated general electrochemical engineering principles. It assumes knowledge of the fundamentals of chemistry, chemical engineering, electrical engineering, mechanical engineering, materials science, good background in technical thermodynamic, as well as familiarity with basic concepts in physics, e.g. semiconductors, nanomaterials.

Assessment

All assessments are team assessments. Each team will have **pre-allocated** members.

Weekly design meetings **must** be documented with minutes. Minutes should be uploaded in a timely manner to a folder located in the Files tab of the Meetings channel in your designated Microsoft Teams team.

Assessment task	Weight	Due Date	Course Learning Outcomes Assessed
1. Quiz	25%	Week 3, Week 4, Week 5, Week 8, Week 9	1, 2, 3
2. Technical Analysis	45%	27/10/2022 11:59 PM	1, 2, 3, 4
3. Group Report	30%	18/11/2022 11:59 PM	1, 2, 3, 4

Assessment 1: Quiz

Due date: Week 3, Week 4, Week 5, Week 8, Week 9

Students will be able to evaluate their learning efficacy by completing several tests on the core contents related to electrochemical energy principles. Students will receive feedback through tutorial and after-class contact hours.

Assessment 2: Technical Analysis

Due date: 27/10/2022 11:59 PM

Following this assessment students will be able to recognize, describe and investigate one or more energy storage systems to assess their feasibility and integration in the context of techno-economic-political-environmental impact. Students are expected to comprehend the engineering principles of the chosen energy storage system and it's integration with an application and/or generation system, and then prepare the presentation using slides or videos.

Students will be offered the opportunity to communicate/discuss their knowledge and knowhow with a panel of experts in energy storage research. The panel will evaluate the depth and breadth of the students' comprehension of the energy storage technology of their choice. Students will receive immediate feedback on their learning outcomes.

Assessment criteria

This assessment will be marked by a combination of the quality of the presentation (a submitted video or PPT show), and the capability and competency of the student during the panel interview. The presentation quality has a full mark of 30, and the interview has a full mark of 15. Total full mark for technical analysis is 45. To acquire full mark, the students are expected to deliver the below criteria: 1. Provide Clear information, good reference, and in-depty critical analysis of the study, in regrads of the background, motivation and significance. 2. The presentation should flow with clear context and have no interruptions. 3. The presentation should come with good timing, active engagement, clear instruction to

the contents, attractive slide design, and plain language is always preferred.

Assessment criteria with marking rubric

Criteria	Fail	Pass	Credit	Distinction	High distinction
Content narration (contains but not limited to background, motivation, impact, and analysis)	Work is not submitted or submitted work does not contain meaningful contents (0 mark)	Work is submitted and the contents contains basic information that is sufficient to justify the analysis (1-5 marks)	Work is submitted and the contents are clear. The analysis is appropriately justified. (6-10 marks)	Work is submitted with clear contents that are rationally organised. The analysis is appropriately referenced. (11-15 marks)	The submitted work meets all expectations: content is clear and logically connected, the discussions are professionally supported by good references, the analysis is critical and reasonably comprehensive. (16-20 marks)
Presentation skills	Unable to submit the work or the presentation is not relevant or is too short (less than 3 mins) (0 mark)	The presentation runs overtime (more than 5 mins). The speaker does not appear to actively engage with audience. The speaker merely recite the prepared scripts. The message fails to be transmitted. (1-3 marks)	The presentation is on time (3 to 5 mins). The speaker can narrate the story without reciting the prepared contents. The message is clear. (4-6 marks)	The presentation is on time (3-5 mins). The speaker has shown efforts to engage with audience. The speaker is a good story teller and is able to deliver the message effectively. (7-9 marks)	The presentation is on time (3-5 mins). The speaker is able to blend a combination of tools (animation, video, etc.) to ensure active engagement with the audience. The speaker is a great story teller and does not use complex professional terms. The slides are clear, attractive, interactive and sharp. (10

					marks)
Panel interview	Unable to present at the interview or cannot communicate with the panel (0 mark)	Able to comprehend the questions but cannot give the correct answers (1-5 marks)	Comprehend the questions but gives limited relevant information in the answers. (6-8 marks)	Comprehend the questions and is able to give clear answers with good relevance (9-12 marks)	Very effective communication with the panel, fully comprehend the questions, and provide answers with good satisfaction and correctness. (13-15 marks)

Additional details

Technical analysis is for each student to provide critical analytical report on self-selected commercial energy-related product. The format of techanical analysis is Presentation. The presentation could be a recorded video of Powerpoint Slides. The presentation should be as concise as possible and the recommended length is 3-5 mins. Following this assessment students will be able to recognize, describe and investigate the solution of their self-selected energy products. Students are expected to comprehend the engineering principles and develop the capabilities to assess the applicability of the chosen energy storage solutions.

The presentationwill be assessed by a panel interview through face to face approach. For students who cannot attend the interview in person, or if the COVID-10 contact rules do not allow face to face, it can be an online conference.

Assessment 3: Group Report (Group)

Due date: 18/11/2022 11:59 PM

This Group Report aims to prepare students to design and communicate professional solutions to energy storage applications addressing practical energy storage needs. The students are expected to demonstrate good comprehension of the theoretical and technological aspects of energy storage, employ high-level communication skills to offer technological and non-technological (e.g. environmental, political, economic) recommendations, and develop strong capabilities in critical thinking and collaboration through professional teamwork. Student teams will document the process and outcomes of their research in a technical report. Students will also complete team evaluations exercise to provide feedback to their team mates and moderate grades.

Assessment criteria

This group-based major project report is a written report. As a general guide, a report usually contains these parts: Introduction, Results and Analysis, Conclusion/Recommendation, and Reference. It will be marked considering the quality and competency of the Introduction&Conclusion/Recommendation (5 out of 30), Results and Analysis (20 out of 30), and Report Presentation (including Reference) (5 out of 30). The report will be assessed on a group base, which means each member of the group will be given the same mark, unless otherwise noted due to justified reasons. Failing to submit the report or the report

does not meet the requirements will not let the group pass this assessment.

Assessment criteria with marking rubric

Criteria	Fail	Pass	Credit	Distinction	High distinction
Introduction and Conclusion/Recommendation	Report is not submitted or the report does not contain meaningful contents. (0 mark)	The report is submitted and provides basic level of information. (1 mark)	The report is submitted and provides clear information with good relevance. (2-3 marks)	The report is submitted and provides detailed information with good coverage and relevance. (4 marks)	The report is submitted and provides detailed yet concise information with good relevance and coverage, while presenting good comprehension of the topic. (5 marks)
Results and Analysis	Report is not submitted or the report does not contain meaningful contents. (0 mark)	The report is submitted and provides basic level of information about the study outcomes. (1-5 marks)	The report is submitted and provides clear description of the solution. But the solution lacks creative insights and does not conduct feasibility and/or impact analysis in terms of non-technical factors (eg. economic, political, environmental). (6-10 marks)	The report is submitted and provides detailed description of the solution. The report has complete analysis on feasibility and economic-political-environmental analysis. (11-15 marks)	The report is submitted and provides detailed and concise discussion on the solutions. The report completed in-depth feasibility and impact analysis. The report demonstrates clear advantages in terms of creativity. (16-20)
Presentation (including Reference)	Report is not submitted or the report is not formatted. (0 mark)	The report is formatted but there is obvious inconsistency throughout the report. (1	The report is formatted with clear organisation. (2-3 marks)	The report is clearly formatted and organised with referencing. (4 marks)	The report is professionally formatted and organised with consistent referencing style that

		mark)			follows a certain standard, such as UNSW writing style guide. (5 marks)

Attendance Requirements

Students are strongly encouraged to watch all lecture videos.

Attendance is required at all Studio Classes. If your absence equates to more than 20% of Studio Classes, you may fail the course, or be denied special consideration.

You must be available for all assessments.

Course Schedule

View class timetable

Timetable

Date	Type	Content
Week 1: 12 September - 16 September	Lecture	Wednesday Lecture: Course Introduction and General Aspects of Energy Storage Thursday Lecture: Energy Conversion and Storage
Week 2: 19 September - 23 September	Lecture	Wednesday Lecture: Solar Refinery and Biological Energy Storage Thursday Lecture: Thermal and Mechanical Energy Storage
Week 3: 26 September - 30 September	Lecture	Wednesday Lecture: Chemical Energy Storage Thursday Lecture: Electrochemical Fundamentals
	Assessment	Quiz
Week 4: 3 October - 7 October	Lecture	Wednesday Lecture: General Battery Chemistries Thursday Lecture: Lithium Batteries and their Futures
	Assessment	Quiz
Week 5: 10 October - 14 October	Lecture	Wednesday Lecture: Sodium Batteries and Beyond Thursday Lecture: Flow Batteries for Large System
	Assessment	Quiz
Week 6: 17 October -	Seminar	Monday Seminar: Battery Nanotechnologies

21 October		
Week 7: 24 October - 28 October	Lecture	Wednesday Lecture: Battery Recycling and Sustainability Thursday Lecture: Battery Safety Chemistry and Engineering
	Assessment	Technical Analysis
Week 8: 31 October - 4 November	Lecture	Wednesday Lecture: Supercapacitors for High Power Uses Thursday Lecture: Hydrogen Energy
	Assessment	Quiz
Week 9: 7 November - 11 November	Lecture	Wednesday Lecture: Report Consultations Thursday Lecture: Panel Interview A
	Assessment	Quiz
Week 10: 14 November - 18 November	Lecture	Wednesday Lecture: Panel Interview B Thursday Lecture: Panel Interview C
	Assessment	Group Report

Resources

Recommended Resources

- 1- Energy Storage: Fundamentals, Materials and Applications (2nd Edition), R. A. Huggins, Springer, 2016.

  2- Lithium Batteries: Science and Technology, G-A. Nazri, & G. Pistoia, Springer, 2009.

  3- Electrochemical Supercapacitors: Scientific Fundamentals and Technological Applications, B. E. Conway, Kluwer Academic, 1999.

  4- Chemical Energy Storage, Robert Schlogl (Ed.), Walter de Gruyter GmbH, 2013

Course Evaluation and Development

Feedback on the course is gathered periodically using various means, including the UNSW myExperience process, informal discussion in the final class for the course, and the School's Student/Staff meetings. Your feedback is taken seriously, and continual improvements are made to the course based, in part, on such feedback.

Submission of Assessment Tasks

In the School of Chemical Engineering, all written work will be submitted for assessment via Moodle unless otherwise specified. Attaching cover sheets to uploaded work is generally not required; when you submit work through Moodle for assessment you are agreeing to uphold the Student Code.

Some assessments will require you to complete the work online and it may be difficult for the course coordinator to intervene in the system after the due date. You should ensure that you are familiar with assessment systems well before the due date. If you do this, you will have time to get assistance before the assessment closes.

All submissions are expected to be neat and clearly set out. Your results are the pinnacle of all your hard work and should be treated with due respect. Presenting results clearly gives the marker the best chance of understanding your method; even if the numerical results are incorrect.

Marking guidelines for assignment submissions will be provided at the same time as assignment details to assist with meeting assessable requirements. Submissions will be marked according to the marking guidelines provided.

Late penalties

Unless otherwise specified, submissions received after the due date and time will be penalised at a rate of 5% per day or part thereof (including weekends). For some activities including Moodle quizzes and Team Evaluation surveys, extensions and late submissions are not possible.

Special consideration

If you have experienced an illness or misadventure beyond your control that will interfere with your assessment performance, you are eligible to apply for Special Consideration prior to submitting an assessment or sitting an exam.

UNSW has a Fit to Sit / Submit rule, which means that if you attempt an exam or submit a piece of assessment, you are declaring yourself fit enough to do so and cannot later apply for Special Consideration.

For details of applying for Special Consideration and conditions for the award of supplementary assessment, please see the information on UNSW's Special Consideration page.

Note: UNSW does not require a medical certificate for COVID-related absences of 7 days or less, however you must provide formal evidence from your local/state health provider (e.g. NSW Health) that clearly states your name and the date you tested positive (i.e. confirmation of your RAT registration, PCR test result). Longer absences due to extended self-isolation or COVID-related illness will still need documentation such as a medical certificate.

Applications for special consideration **will still be required** for assessment and participation absences related to COVID-19. Special consideration requests should not be lodged for missing classes if there are no assessment activities in that class.

Academic Honesty and Plagiarism

Academic integrity is fundamental to success at university. Academic integrity can be defined as a commitment to six fundamental values in academic pursuits: honesty, trust, fairness, respect, responsibility and courage (International Center for Academic Integrity, 'The Fundamental Values of Academic Integrity', T. Fishman (ed), Clemson University, 2013). At UNSW, this means that your work must be your own, and others' ideas should be appropriately acknowledged. If you don't follow these rules, plagiarism may be detected in your work.

Further information about academic integrity and plagiarism can be located at:

- The Current Students site
- The ELISE training site

The Conduct and Integrity Unit provides further resources to assist you to understand your conduct obligations as a student: https://student.unsw.edu.au/conduct.

Referencing is a way of acknowledging the sources of information that you use to research your assignments. You need to provide a reference whenever you draw on someone else's words, ideas or research. Not referencing other people's work can constitute plagiarism. Further information about referencing styles can be located at https://student.unsw.edu.au/referencing.

For assessments in the School of Chemical Engineering, we recommend the use of referencing software such as Mendeley or EndNote for managing references and citations. Unless required otherwise specified (i.e. in the assignment instructions) students in the School of Chemical Engineering should use either the APA 7th edition, or the American Chemical Society (ACS) referencing style as canonical author-date and numbered styles respectively.

Academic Information

To help you plan your degree, assistance is available from academic advisors in The Nucleus and also in the School of Chemical Engineering.

Additional support for students

- Current Student Gateway
- Engineering Current Student Resources
- Student Support and Success
- Academic Skills
- Student Wellbeing, Health and Safety
- Equitable Learning Services
- IT Service Centre

Course workload

Course workload is calculated using the Units-Of-Credit (UOC). The normal workload expectation for one UOC is approximately 25 hours per term. This includes class contact hours, private study, other learning activities, preparation and time spent on all assessable work.

Most coursework courses at UNSW are 6 UOC and involve an estimated 150 hours to complete, for both regular and intensive terms. Each course includes a prescribed number of hours per week (h/w) of scheduled face-to-face and/or online contact. Any additional time beyond the prescribed contact hours should be spent in making sure that you understand the lecture material, completing the set assignments, further reading, and revising for any examinations.

On-campus class attendance

Physical distancing recommendations must be followed for all face-to-face classes. To ensure this, only students enrolled in those classes will be allowed in the room. Class rosters will be attached to corresponding rooms and circulated among lab demonstrators and tutors. No over-enrolment is allowed in face-to-face class. Students enrolled in online classes can swap their enrolment from online to a **limited** number of on-campus classes by Sunday, Week 1.

In certain classroom and laboratory situations where physical distancing cannot be maintained or the staff running the session believe that it will not be maintained, face masks will be designated by the course coordinator as **mandatory PPE** for students and staff. Students are required to bring and use their own face mask. Mask can be purchased from IGA Supermarket (Map B8, Lower Campus), campus pharmacy (Map F14, Middle Campus), the post office (Map F22, Upper Campus) and a vending machine in the foyer of the Biological Sciences Building (Map E26, Upper Campus).

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 advice can be found here. Do not come to campus if you have any of the following symptoms: fever (37.5 °C or higher), cough, sore throat, shortness of breath (difficulty breathing), runny nose, loss of taste, or loss of smell. If you need to have a COVID-19 test, you must not come to campus and remain in self-isolation until you receive the results of your test.

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. Further information is available on any course Moodle or Teams site.
For more information, please refer to the FAQs: https://www.covid-19.unsw.edu.au/safe-return-campus-faqs

Note: This course outline sets out description of classes at the date the Course Outline is published. The nature of classes may change during the Term after the Course Outline is published. Moodle should be consulted for the up to date class descriptions. If there is any inconsistency in the description of activities between the University timetable and the Course Outline (as updated in Moodle), the description in the Course Outline/Moodle applies.

Image Credit

Dr Peter Wich

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	