# Course Outline

# GSOE9111

## Energy Storage

School of Chemical Engineering

Term 3, 2020

# 1. **Staff**

| **Position** | **Name** | **Contact Details** | **Consultation times and locations** |
| --- | --- | --- | --- |
| Course Convenor | A/Prof. Da-Wei Wang | Room 221 Hilmer (enter via SEB Level 2)<br>da-wei.wang@unsw.edu.au | Via email, or by appointment |

# 2. Course information

Units of credit: 6

Pre-requisite(s):

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.

Teaching times and locations:

*Please refer to Moodle (https://moodle.telt.unsw.edu.au/ ) and (http://www.timetable.unsw.edu.au )*

## 2.1 Course summary

Electrochemical energy storage is the most widely applied clean energy technology in this age and will be the core content in this course. This course also covers other energy storage technologies with equivalent importance in difference fields of applications, such as chemical storage, thermal storage, mechanical storage and biomass energy. Basic principles of electrochemical technologies in energy storage engineering: rechargeable batteries, flow batteries, supercapacitors, fuel cells, electrolysers, photo-electrochemical reactions, etc.. Introduction to system integration, energy economy in the context of sustainability.

## 2.2 Course aims

This course will introduce electrochemical energy storage from the aspects of fundamental chemistry and applied technology. It is mainly concentrated on the science and engineering of electrochemical technologies for the conversion and storage of electrical energy in forms of chemical energy, so called electrochemical energy storage. It also covers essentially other energy storage technologies, such as chemical, solar, thermal or mechanical. The discussion of the technology integration is part of the course topic as well. The use of electrochemical technology is placed in an industrial-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.

## 2.3 Course expectation

GSOE9111 is a 6 UOC course and has no final exam, and therefore you are expected to spend a minimum of 10 hours per week during term to complete the requirements of this course. Most of this time will be spent in private study or training.

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.

## 2.4 Relationship between course learning outcomes and assessments

| Course Learning Outcome (CLO) | CLO Description | Related Assessment |
|---|---|---|
| CLO 1 | Identify energy storage technologies and explain their principles | 1, 2, 3 |
| CLO2 | Assess the technology readiness and feasibility for different fields of energy applications | 1, 2, 3 |
| CLO 3 | Recommend solutions based on energy storage principles and technologies for a specific energy application | 2, 3 |
| CLO 4 | Evaluate the techno-economic and environmental impact of an energy storage solution | 2, 3 |
| CLO 5 | Understand and analyse the local and international policy on the choices of energy storage solutions | 2, 3 |

# 3. Strategies and approaches to learning

## 3.1 Learning and teaching activities

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 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.

This course will prepare students to design and communicate professional solutions with relevance to energy storage applications within the scenario of practical energy storage needs. The students are expected to acquire good comprehension of the theoretical and technological contents of energy storage, to develop high levels of communication skills to offer technological and non-technological (e.g. environmental, political, economic) recommendations, to build up strong capabilities of critical thinking and collaboration through professional practice, and eventually to be able to make effective informed decisions.

## 3.2 Expectations of students

1- Attend the lectures, seminars and tutorials regularly

2- Prepare yourself in advance by pre-reading the content available on Moodle

3- Communicate your own perspectives on the energy storage choices in presentations

4- Discuss and refine your understanding of energy storage solutions in a group and showcase in presentations

5- Reflect your learning in the context of real life and linking with your own backgrounds

6- Engage yourself with the rapidly developing renewable energy sector and identify the future orientations of energy storage technologies

## 4. Course schedule and structure

This course consists of 36 hours of class contact hours, plus additional 4 hours of flexibility learning component. You are expected to spend 10 hours each week to improve your understanding and learning effectiveness of the contents. You should make good use of the flexibility learning to acquire broader and more profound knowledge with relevance to the course contents.

| Week/Dates | Tuesday 16pm-18pm<br>Microsoft Teams | Thursday 15pm-17pm<br>Microsoft Teams |
|---|---|---|
| **Week 1**<br>**15 Sep & 17 Sep** | a) course outline<br>b) how to write report and prepare slides | General Energy Storage |
| **Week 2**<br>**22 Sep & 24 Sep** | Chemical Energy Storage<br>– *broad context* | Electrochemical Energy Storage (1)<br>Fundamentals |
| **Week 3**<br>**29 Sep & 1 Oct** | Electrochemical Energy Storage (2)<br>Lead-Acid Battery | Electrochemical Energy Storage (3)<br>Li-ion Battery |
| **Week 4**<br>**6 Oct & 8 Oct** | Electrochemical Energy Storage (4)<br>Post Li-ion Batteries | Electrochemical Energy Storage (5)<br>Flow Batteries |
| **Week 5**<br>**13 Oct & 15 Oct** | Electrochemical Energy Storage (6)<br>Fuel cells and Electrolysers | Electrochemical Energy Storage (7)<br>Supercapacitors |
| **Week 6**<br>**20 Oct & 22 Oct** | **Flexibility Learning Seminars**<br>(Guest speakers and topics to be announced) | |
| **Week 7**<br>**27 Oct & 29 Oct** | Electrochemical Energy Storage (8)<br>System Integration | Bio-energy Storage |
| **Week 8**<br>**3 Nov & 5 Nov** | Thermal Energy Storage | Mechanical Energy Storage |
| **Week 9**<br>**10 Nov & 12 Nov** | Tutorial (1) | Tutorial (2) |
| **Week 10**<br>**17 Nov & 19 Nov** | **ALL-DAY** Individual interview (1)<br>(schedule to be determined) | **ALL-DAY** Individual interview (2)<br>(schedule to be determined) |

# 5. Assessment

## 5.1 Assessments

| Assessment | Description | Mark | Due date |
|---|---|---|---|
| **Individual project** | a) Individual 3MT presentation (Live or Recording) related to your choice of an energy storage topic<br>b) Individual interview (3 mins presentation + 5 mins Q&A) | 30 for presentation<br>20 for interview | Submission of presentation PPT or recording on Moodle no later than 9am on the date of interview ($17^{th}$ or $19^{th}$ November) |
| **Group project** | a) A comprehensive written group report containing technical, economic, environmental analyses, and other relevant aspects<br>b) justification of individual contribution to the group project work (presentation and report) | 40 for group report<br>10 for individual contribution | Group report and justification submitted on Moodle no later than 5pm on $27^{th}$ November |
| **Total mark** | | 100 | |

**Further information**

UNSW grading system: https://student.unsw.edu.au/grades

UNSW assessment policy: https://student.unsw.edu.au/assessment

## 5.2 Assessment criteria

| Assessment task | Assessment criteria |
|---|---|
| **Individual project** | **3MT Presentation (30 marks)** - Every student will give a 3-minute presentation (Live or Recording) on the selected topics of the major streams of energy storage.  The criteria will be based on the level of understanding and communication skills of individual students.<br><br>Marking criteria contains 1) explaining background (6 marks), relevance (6 marks), significance (6 marks); 2) content  flow (6 marks); and 3) presentation skills (including slide design, engagement, eye contact, timing, use of terms) (6 marks).<br><br>**Interview (20 marks)** – Every student will be interviewed regarding the technical and broader context of the presentation. Students are expected to provide evidence of comprehension and communication capabilities. The interview will take place approximately 5 minutes following the live presentation or replayed recording. |
| **Group project** | Students will be assigned to different groups and the group will select a topic to complete a project related to energy storage solutions.<br><br>**Group report (40 marks)** – The group is expected to rationally demonstrate their proposed solutions to address one selected energy storage problem which will provided separately on Moodle. The presentation will be assessed based on 1) project introduction (aims, background, motivation, significance, benefit) (10 marks); 2) quality of proposed solutions (creativity, clearness, feasibility study, economic-political-environmental impact analysis) (25 marks); 3) presentation style (including formatting, use of figures, referencing, etc.) (5 marks).<br><br>**Justification (10 marks)** – The group must justify the individual contribution to the group project. The assessment of individual contribution affects the allocation of the group marks to each student. To earn fully the group mark, each group member needs to acquire 10 marks for the individual contribution. In case one group member fails to actively engage with the team, penalty will apply as a factor of the justification score. Justification is made by the cohort of the group, not by the lecturer or tutor. |

## 5.3 Submission of assessment tasks

All assessments should be submitted as indicated. Late submission will cause a penalty of 10% per day.

**Individual project** should be submitted on Moodle no later than 9am on the date of your interview (**refer to section 5.1**).

**Group project** should be submitted on Moodle no later than 5pm on 27th November.

# 6. Academic integrity, referencing and plagiarism

**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. ***Reference a website is not appropriate unless it refers to suitable sources of information such as governmental reports***.

Further information about referencing styles can be located at https://student.unsw.edu.au/referencing

**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.[1] 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 https://student.unsw.edu.au/plagiarism, and
- The *ELISE* training site http://subjectguides.library.unsw.edu.au/elise/presenting

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.

# 7. Readings and resources

**The following books may be of used for the effective learning:**

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.

Students seeking resources can also obtain assistance from the UNSW Library. One starting point for assistance is:
http://www.library.unsw.edu.au/servicesfor/students.html

# 8. Administrative matters

For any on the above please

- contact one of the staff, School of Chemical Engineering.
- Or visit https://www.engineering.unsw.edu.au/chemical-engineering/study-with-us

# 9. Additional support for students

- The Current Students Gateway: https://student.unsw.edu.au/
- Academic Skills and Support: https://student.unsw.edu.au/academic-skills
- Student Wellbeing, Health and Safety: https://student.unsw.edu.au/wellbeing
- Disability Support Services: https://student.unsw.edu.au/disability-services
- UNSW IT Service Centre: https://www.it.unsw.edu.au/students/index.html