SOLA9104 – Hybrid Renewable Energy Systems

Course Outline – Term 3, 2019

1 Course Staff

Convener & Lecturer: Dr Jose Bilbao, j.bilbao@unsw.edu.au
Dr Jessie Copper, jessie.copper@unsw.edu.au
Tutors: Dr Bhupendra Shakya, b.shakya@unsw.edu.au
Iskra Zafirovska, iskra.zafirovska@unsw.edu.au

Consultation time: Wednesdays from 3 pm to 5 pm (open door, no appointment needed). For all enquiries about the course please contact the course convener. For all other questions you are encouraged to ask the course lecturer after the studio or post your question in MS Teams.

Keeping Informed: All course material and announcements will be posted in MS Teams. Please note that it's your responsibility to check the site regularly for any updates and that you should take careful note of all announcements.

2 Course Details

2.1 Credits

This is a 6 UoC course with a total workload equivalent to 150 hours for the term, including all contact hours, learning activities and assessments.

2.2 Pre-requisites and Assumed Knowledge

For SOLA9104 Students should have a good working knowledge of university level introductory physics, circuit theory and mathematics. Furthermore, it is expected that students understand the technical components of PV systems and have already completed the courses SOLA2504/9001 AND either SOLA5054/9014 OR SOLA4012/9007.

2.3 Relationship to Other Courses

SOLA9104 is an Advanced Disciplinary Knowledge (ADK) course for the Master of Engineering Science programs in PV and Solar Energy, and Renewable Energy. It may also be taken with permission as an elective for the PV and Solar Energy, and RE Engineering degree programs.

2.4 Context and Aims

Energy services are critical for health, livelihoods, and enabling productive activities. However, more than a billion people around the world in rural areas and urban slums do not have access to modern energy. Hybrid renewable energy systems can deliver these energy services cost-effectively, but there are a number of challenges related to their design, and the integration of high penetration of renewables. During this course students will develop the skills and knowledge required for designing, sizing, and specifying hybrid renewable energy systems, and to develop control strategies to optimize their operation, with an emphasis on understanding context, appropriate design and technology selection, implementation models and capacity building for sustainable projects.

This course uses project-based learning to develop skills and knowledge for designing and specifying hybrid renewable energy projects, by working with a real target community and local partners. In this opportunity, the activities of the course will be focus around an island in Fiji, and the development of projects for delivering energy services to the local community.

2.5 Learning Outcomes (LO)

Learning Domain	Learning Outcomes *After successful completion of this course, you should be able to:*
Understanding	1. Understand the technical characteristics of components in renewable energy systems, including loads, storage and generation technologies
Applying	2. Interpret a brief, present proposals for feedback and assessment in a range of written, oral and visual formats.
Applying	3. Apply a range of multi-disciplinary methodologies, frameworks and best practices for the design and implementation of complex real-world problems focused on sustainable (humanitarian) engineering projects.
Analysing	4. Compare and prioritise energy access options according to the local context and energy service requirements.
Creating	5. Design, size and specify hybrid renewable energy systems using first principles and advanced simulations tools
Creating	6. Optimize a hybrid renewable energy system and its control strategy using appropriate dispatchability principles and techno-economic analysis

This course is designed to achieve the above LO to address the specific UNSW graduate capabilities listed in ***Appendix A***. This course also addresses the Engineers Australia (National Accreditation Body) Stage I competency standard as outlined in ***Appendix B***.

2.6 Indicative Lecture Schedule

Period	Lectures	Tutorials/Workshops	Deadlines
Week 01 – 16 Sep	Course outline, energy & sustainable livelihoods, and project context	Team building	
Week 02 – 23 Sep	Electricity access and intro to Hybrid Renewable Energy Systems (HRES)	Human-Centered Design and needs assessment	
Week 03 – 30 Sep	Assessing and understanding loads for HRES	Load curve and HOMER	
Week 04 – 07 Oct	HRES Laboratory		D1
Week 05 – 14 Oct	Dispatchable energy for HRES	Generators and HOMER	
Week 06 – 21 Oct	RE resources for HRES	RE systems and HOMER	
Week 07 – 28 Oct	Project planning and Storage for HRES	Storage and HOMER	D2
Week 08 – 04 Nov	Economics of HRES	Techno-Economic Analysis and Project work	
Week 09 – 11 Nov	Control and optimization of HRES	Optimization using HOMER and Excel/VBA	
Week 10 – 18 Nov	Energy transmission, distribution and monitoring with HRES	Project work	
Week 11 – 25 Nov			D3

2.7 Contact Hours

The course consists of 4 hours of studios each week as per table below. This course requires you to use a number of software packages that will be available via MyAccess and the TETB computers labs LG34 and LG35.

Activity	Day	Time	Location	Delivered by
Mix mode classes	Monday Week 1-10	02 pm – 06 pm	TETB G16	Lecturer & tutors

3 Assessment

Assessment		Percentage of Total Mark	Date Due
Deliverable 1 (D1) – Laboratory report	Individual	10%	Week 04
Deliverable 2 (D1) – Case study	Individual	30%	Week 07
Deliverable 3 (D1) – Main project	Team	30%	Week 11
Digital Exam	Individual	30%	

The assessment scheme in this course reflects the intention to assess your learning progress throughout the semester. The project proposal submissions will be done via Moodle – PDF files ONLY – while most of the individual tasks will be done via OneNote Class or the workshop tool in Moodle. The final poster must be submitted to Moodle before the presentation.

Late submissions of any of the assessments will attract a penalty of 0.4% per hour (including weekends). No marks will be granted to a work submitted after the marks have been released.

3.1 Deliverable 1 – Laboratory (10%)

The laboratory will be based on the minigrid in the TETB. You will have to study the system configuration, examine the design, and produce a complete SLD of the system. You will also be provided with data from the system that must be analysed and presented in graphical form. A lab report must be submitted containing all the information required.

3.2 Deliverable 2 – Case Study (30%)

For this assignment you will be working on a case study of a hybrid RE system. With the data available you must assess the energy services required for the local community and identify potential solutions, which will allow you to carry out a high-level system design using HOMER Pro®. The deliverable will include the load assessment and the load curves used to design the hybrid RE system and you must present the optimisation process and economic assessment of your energy system design using HOMER Pro®. The purpose of this assignment is to go from theory to the design of the whole system using techno-economic analysis.

3.3 Deliverable 3 – Main project (30%)

The major project is designed to give you a chance to apply your knowledge to real-world problems relating to the design of a sustainable hybrid minigrid. Details of assessment criteria and expectations for the project will be provided separately in the project brief. Students will work in teams of around 4 on the project. The outcome of this project is a detailed system design of a hybrid RE system using Australian Standards as a reference, including an optimised dispatch schedule using Excel/VBA. Team evaluation will used to allocate marks on the basis of contribution.

3.4 Digital Exam (30%)

The exam in this course is a closed-book 2 hours digital examination. 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, unless specifically indicated otherwise by the lecturer. Marks will be assigned according to the correctness of the responses.

3.5 Relationship of Assessment Methods to Learning Outcomes (LO)

	SOLA9104 LO					
Assessment	**1**	**2**	**3**	**4**	**5**	**6**
Deliverable 1	✓					
Deliverable 2	✓	✓		✓	✓	
Deliverable 3	✓	✓	✓	✓	✓	✓
Exam	✓			✓	✓	

4 Teaching Strategies

4.1 Delivery Mode

The teaching strategy for this course comprises independent self-study and work plus a series of studio sessions. Engagement with the course material will be centred around the major project, which, this year, will be focussed on sustainable energy services and systems for a remote Fijian island community, and the development of an appropriate implementation structure for the selected technologies and the local context.

Mixed-mode classes will support the major project, including:

- Presentations from the lecturer and other experts within class to describe the status and experiences with energy projects and technologies in developing countries; introduce development concepts and analysis frameworks; and to review best practices in design and implementation of projects.
- Guided interpretation of the project brief, needs assessment and human-centred design.
- Lectures and labs on technical design of sustainable energy systems, involving a combination of individual work and group work using simulation tools (such as HOMER and VBA for Excel). Teaching staff will be available to give assistance during each of the scheduled sessions.
- Lectures and workshops on techno-economic analysis and implementation planning for the project.

4.2 Learning in this course

You are expected to attend <u>all</u> classes in order to maximize learning. You will need to complete some pre-work for each of your classes, including preparation in your group. In addition to the lecture notes, you will be expected to read relevant papers and texts as required. Group learning is also encouraged but of course PLAGIARISM IS NOT. UNSW *assumes* that self-directed study of this kind is undertaken in addition to attending face-to-face classes throughout the course.

4.3 Class exemption

<u>You must attend all classes</u>. If, for any reason you cannot attend a class please contact the course convener.

5 Course Resources

There is no textbook for this course. However, readings and other resources related to lectures and the major project will be made available via MS Teams, which will be used as the main online system to disseminate teaching materials, share resources and host discussion forums. Assessment marks will be made available via Moodle.

Announcements concerning course information will be given in the lectures and/or MS Teams. A Discussion Board will be permanently open on MS Teams for you to post questions or initiate course-related discussions.

Other Resources

Climate Information

- NASA - eosweb.larc.nasa.gov/sse/
- NREL National Solar Radiation Database (weather data) - https://nsrdb.nrel.gov/
- Renewables Ninja - https://www.renewables.ninja
- Australian Bureau of Meteorology - http://www.bom.gov.au/climate/

Design Tools (all in TETB computer labs)

- HOMER Energy - Hybrid Renewable and Distributed Generation Power System Design and Optimization http://www.homerenergy.com/
- PVSYST - Software for photovoltaic Systems http://www.pvsyst.com/
- SAM - System Advisory Model https://sam.nrel.gov/
- RETScreen - Clean Energy Management Software system for energy efficiency http://www.retscreen.net/ang/home.php

Useful Standards (via UNSW Library)

- Building Code of Australia
- AS/NZS 1170.2:2011 - Structural design actions - Wind actions
- AS/NZS 1768:2007 - Lightning Protection
- AS/NZS 3000:2007 - Electrical Wiring Rules
- AS/NZS 3008.1.1:2017 - Electrical installations - Selection of cables
- AS/NZS 4777.1:2016 - Grid connection of energy systems via inverters - Installation requirements
- AS/NZS 4777.2:2015 - Grid Connections of Energy Systems via Inverters - Inverter requirements
- AS/NZS 5033:2014 - Installation and safety requirements for photovoltaic (PV) arrays

General Resources

- APVI Solar Maps - http://pv-map.apvi.org.au/
- Nearmap tool (via UNSW Network) - http://au.nearmap.com/
- Clean Energy Council - http://www.cleanenergycouncil.org.au/
- PVeducation - http://www.pveducation.org/pvcdrom

Drawing Tools

- LucidChart
- MS Visio
- Autocad
- Sketchup

Gantt Chart Tools

- MS Project

6 Other Matters

6.1 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.

6.2 Student Responsibilities and Conduct

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

6.3 Workload

You will spend around **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.

It is recommended for you to design a study workload plan for the term based on the activities and assignments of each of your courses. An example of a simple weekly study plan for SOLA9104 is presented in the table below.

Period	Self-directed Study	Face to Face	D1	D2	D3	Exam	Total Hours
Week 01	4	4		4			**12**
Week 02	4	4		4			**12**
Week 03	4	4		4			**12**
Week 04	2	2	8	2			**14**
Week 05	2	4		4	2		**12**
Week 06	2	4		4	2		**12**
Week 07	2	4		4	4		**14**
Week 08	2	4			6		**12**
Week 09	2	4			6		**12**
Week 10	2	4			6		**12**
Week 11					2	12	**14**
Exam weeks						12	**12**
Total Hours	**26**	**38**	**8**	**26**	**28**	**24**	**150**

6.4 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.

6.5 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.

6.6 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.

6.7 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://student.unsw.edu.au/special-consideration.

6.8 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 RESOC 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.

6.9 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

7 Appendix A: 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 students working through the Problem Sets and use of modelling software for the assignment.
- 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.

8 Appendix B: Engineers Australia (EA) Professional Engineer Competency Standard

	Program Intended Learning Outcomes		Relevant LO
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	✓	LO1
	PE1.4 Discernment of knowledge development and research directions		
	PE1.5 Knowledge of engineering design practice	✓	LO3, LO5, LO6
	PE1.6 Understanding of scope, principles, norms, accountabilities of sustainable engineering practice	✓	LO2, LO3, LO4
PE2: Engineering Application Ability	PE2.1 Application of established engineering methods to complex problem solving	✓	LO3
	PE2.2 Fluent application of engineering techniques, tools and resources	✓	LO3, LO4, LO5
	PE2.3 Application of systematic engineering synthesis and design processes	✓	LO5, LO6
	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)	✓	LO2
	PE3.3 Creative, innovative and pro-active demeanour	✓	LO7
	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	✓	LO2 to LO4