UNSW SYDNEY
Australia's Global University

Photovoltaic and Renewable Energy Engineering

Course Outline

Term 2 2021

SOLA9103

RE System Modelling and Analysis

Contents

1. Staff contact details

Contact details and consultation times for course convenor

Name: Dr Merlinde Kay
Office location: Room 215, TETB
Email: m.kay@unsw.edu.au

Contact details and consultation times for lecturers/demonstrators

Name: Kanyawee Keeratimahat
Email: k.keeratimahat@unsw.edu.au

Name: Abhnil Prasad
Email: abhnil.prasad@unsw.edu.au

Moodle: https://moodle.telt.unsw.edu.au/
Online Consultations: Please see the course Moodle.

For general enquiries about the course please contact the course convener. For all other questions or enquiries related to the course content, you are encouraged to ask the lecturers/demonstrators during or after class, or post your question on the Discussion Boards on Moodle.

2. Important links

- Moodle
- Health and Safety
- Student Resources
- UNSW Timetable
- UNSW Handbook
- Engineering Student Support Services Centre
- UNSW Photovoltaic and Renewable Energy Engineering

3. Course details

Credit points

This is a 6 unit-of-credit (UOC) course and involves 5 hours per week (h/w) of scheduled online contact.

The normal workload expectations of a student are approximately 25 hours per term for each UOC, including class contact hours, other learning activities, preparation and time spent on all assessable work.

You should aim to spend about 10–13 h/w on this course. The additional time should be spent in making sure that you understand the lecture material, completing the set assignments, further reading, and revising for any examinations.

Pre-requisites and Assumed Knowledge

Students should have a good working knowledge of university level statistics and mathematics. Furthermore, it is expected that students have taken SOLA2540-9001 Applied Photovoltaics (PV) and hence understand the technical components of PV systems, including how solar cells work and the effect of mismatch, shading and temperature on the operation of photovoltaic modules. It is also recommended that students have taken or are currently enrolled in SOLA4012 Grid-connected Photovoltaics.

It is also assumed that you can competently use Microsoft Excel (or equivalent software) for data manipulation and graphing.

Relationship to Other Courses

SOLA9103 is an advanced disciplinary course in the School of Photovoltaic and Renewable Energy Engineering (SPREE). It is a requisite course (Advanced Disciplinary Knowledge) for the Master of Engineering Science in Renewable Energy Engineering (SOLADS8338) and is an elective course for the Master of Engineering Science in Photovoltaic and Solar Energy (SOLACS8338).

Contact hours

The course consists of a 3-hour lecture and a 2-hour tutorial session each week, as listed below:

	Day	**Time**	**Location (Moodle)**
Lectures	Monday	3pm – 6pm	Online (Weeks 1-2, 4-10)
Tutorials	Thursday	1pm – 3pm	Online (Weeks 1-10)
(Tentative)	Thursday	3pm – 5pm	TETB LG35 (Weeks 1-10)
(Tentative)	Friday	2pm – 4pm	TETB LG35 (Weeks 1-10)

Please refer to your class timetable for the learning activities you are enrolled in and attend only those classes.

All lectures in T2 2021 will be online. Please consult this course’s Moodle module for details about delivery.

Summary and Aims of the course

How did weather and renewable energy forecasts contribute to the 2017 blackout in South Australia? How did the 2010/11 once in a 40-year rainfall event across Queensland influence *the uncertainty of predicting long term PV system performance? How are models used to assess performance guarantees?*

This course will try to answer these and many more questions by providing students with fundamental knowledge and relevant skills for renewable energy system performance analysis, modelling and monitoring. Students taking this course will develop a competency in using techniques for resource and energy performance assessment, understanding losses, diagnostics, monitoring and forecasting of renewable energy systems. There is a focus on the use of statistical techniques, data exploration and handling large data sets. Students will apply these techniques to real systems.

The course aims to provide students with the opportunity to explore and gain further understanding of Renewable Energy (RE) system modelling through the investigation and impact of model assumptions and uncertainties with a direct emphasis on their application to real world datasets from the field of renewable energy engineering. Students who take this course should become familiar with analysis techniques required to carry out resource and operational performance assessments of RE systems.

Student learning outcomes

This course is designed to address the learning outcomes below and the corresponding Engineers Australia Stage 1 Competency Standards for Professional Engineers as shown. The full list of Stage 1 Competency Standards may be found in Appendix A.

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

Learning Outcome		EA Stage 1 Competencies
1.	Apply appropriate data cleaning and data visualisation techniques to manage, query, explore and communicate information from large weather and energy data sets.	PE1.1, PE1.2, PE2.2, PE2.4, PE3.2, PE3.4
2.	Use analysis and modelling techniques to evaluate renewable energy system performance and express performance in terms of the standard derived parameters.	PE1.1, PE1.2, PE1.3, PE2.2, PE3.4, PE3.5
3.	Use statistical methods and modelling techniques to evaluate and understand system losses, degradation and diagnose system faults.	PE1.1, PE1.2, PE1.3, PE2.2, PE3.4
4.	Use modelling to undertake a resource assessment, predict short- and long-term renewable energy system performance and appropriately describe the uncertainty of the prediction.	PE1.1, PE1.2, PE1.3, PE2.2, PE2.4, PE3.2, PE3.4, PE3.5
5.	Use data analysis and modelling techniques to understand, describe, interrogate, and challenge assumptions and results of RE models.	PE1.1, PE1.2, PE1.3, PE2.2, PE3.4

4. Teaching strategies

The teaching strategy for this course comprises a series of lectures and tutorial sessions. The lectures will introduce concepts related to renewable energy system modelling and analysis, through the combined use of online resources, case studies, and worked examples. Tutorials will build on the theory presented in the lectures.

The tutorials are designed to engage students with the course material, and to help students successfully complete the course assignments. The tutorials provide students with the opportunity to develop, practice, and apply their knowledge and modelling and analysis skills to real world RE modelling and analysis tasks.

A variety of additional resources are available through Moodle, including non-assessable practice quizzes, bonus activities, links to webinars, and journal and magazine articles. Students can use these resources to self-assess their understanding of the course content, or to dive deeper into a topic area that sparked an interest.

Within the course, students are encouraged to actively participate in order to maximise their own learning.

5. Course schedule

The schedule for the online lectures and tutorials is provided below. The topics and the order are subject to change at any time.

Indicative Online Lecture Schedule

Week	Topic
1	0.1: Course Introduction 1.1: Weather Data 1.2: Data Visualisation
2	2.1: Statistical Metrics 2.2: Data Quality Assessment 2.3: Data Filling
3 & 4	3.1: Resource Assessments & Variability 3.2: Bankable Datasets
5 to 7	4.1: PV Modelling – Part 1: Modelling Irradiance 4.2: PV Modelling – Part 2: Shading, Soiling & Reflection Losses 4.3: PV Modelling – Part 3: POA to Cell Temperature; to DC and AC Output
8	5.1: PV System Monitoring 5.2: PV System Analysis
9	6.1: Wind Energy

10	7.1: Forecasting

Indicative Online Tutorial Schedule

Week	Tutorial Topic & Activity Description
1	Excel or Python Basics
2	Data Quality Assessment
3	Statistical Metrics
4	Creation of an Hourly Synthetic Weather File in PVsyst
5	Modelling PV Systems in PVsyst – I
6	Modelling Module Temperature
7	Catchup Week – Complete Assignment 2
8	Modelling PV Systems in PVsyst – II
9	Handling Real World Problems
10	Catchup Week – Complete Assignment 3 or Analysis of Wind Data *(optional)*

6. Assessment

Assessment overview

The assessment scheme in this course reflects the intention to assess your learning progress throughout the term.

Assessment	Group Project?	Length	Weight	Learning outcomes assessed	Assessment criteria	Due date and submission requirements	Deadline for absolute fail	Marks returned
Assignment 1	No	4 pages	10%	1 & 5	Topics assessed include: Data Exploration; Data Visualisation; and your assumed knowledge content.	Submission: 5pm, Friday Week 3 Peer Assessment: 5pm, Thursday Week 4	5pm, Friday Week 3; and 5pm Thursday Week 4	Target: 24 hours after the peer assessment deadline.
Assignment 2	No	15 pages (max)	30%	1, 4 & 5	Topics assessed include: Data Analysis; Data Visualisation; Data Quality Assessment; Resource Assessment; and PV System Modelling.	5pm, Friday Week 7	5pm, Saturday Week 8	Target: Two weeks after submission
Assignment 3	No	10 pages (max)	20%	1, 2, 3 & 5	Topics assessed include: Data Exploration; Data Visualisation; PV System Modelling, Monitoring, Analysis and Fault Diagnostics; and Report writing skills.	5pm, Friday Week 10	5pm, Saturday Week 11	Target: Two weeks after submission
Final exam	No	TBD	40%	1, 2, 3, 4 & 5	All course content.	Exam period, date TBC	N/A	Upon release of final results

Assignment 1 (Total 10%)

Submission Due: 5pm, Friday Week 3

Peer Assessment Due: 5pm, Thursday Week 4

This assignment will provide students with the opportunity to apply knowledge covered in the lectures and practice skills in the tutorials in relation to weather data, data analysis and data visualisation.

Students will undertake data exploration of an unspecified data sources in order to provide three key insights of the data for Renewable Energy modelling. Data will be provided.

This assessment is to be done individually, and will be peer assessed, with a report to be submitted via Moodle. Marks will be awarded based on the completeness and quality of your submission, and how well you complete the peer assessment process.

No late reports will be accepted for this assessment task and a grade of zero will be awarded if a student does not complete the peer assessment section of the assignment.

Assignment 2 (Total 30%)

Due: 5pm, Friday Week 7

This assignment will provide students with the opportunity to apply knowledge and practice skills related to weather data, data analysis and visualisation, bankable datasets, resource assessment, uncertainty, and PV system modelling.

Students will undertake a resource and energy production assessment for a proposed PV farm.

This assessment is to be done individually with a report to be submitted via Moodle. ***Late reports will attract a penalty of 30% on the due date, plus 10% per day thereafter.*** Reports submitted after the deadline for absolute fail or after the results have been released will incur the maximum penalty.

Assignment 3 (Total 20%)

Due: 5pm, Friday Week 10

This assignment will provide students with the opportunity to apply knowledge and practice skills related to data analysis and visualisation, data quality assessment, PV system modelling, monitoring and analysis.

Students will undertake a performance assessment of a designated PV system. Data will be provided.

This assessment is to be done individually with a report to be submitted via Moodle. ***Late reports will attract a penalty of 30% on the due date, plus 10% per day thereafter***. Reports submitted after the deadline for absolute fail or after the results have been released will incur the maximum penalty.

Final Exam (Total 40%)

Due: UNSW Exam Period, TBD

The exam in this course will be a 2 hour digital exam. The examination will test your analytical and critical thinking, the applied skills you've developed over the course, and your 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.

As more details about the final exam become available they will be posted on Moodle via the *Course Announcements* forum and on the Moodle *Assessment* page.

Presentation

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.

Submission

Work submitted late without an approved extension by the course coordinator or delegated authority is subject to a late penalty of 30 percent (30%) mark reduction on the first day and an additional 10% per day thereafter, consistent with other SPREE courses.

The late penalty is applied per calendar day (including weekends and public holidays) that the assessment is overdue. There is no pro-rata of the late penalty for submissions made part way through a day.

Work submitted after the ‘deadline for absolute fail’ is not accepted and a mark of zero will be awarded for that assessment item.

For some assessment items, a late penalty may not be appropriate. These are clearly indicated in the course outline, and such assessments receive a mark of zero if not completed by the specified date. Examples include:

a. Weekly online tests or laboratory work worth a small proportion of the subject mark, or
b. Online quizzes where answers are released to students on completion, or
c. Professional assessment tasks, where the intention is to create an authentic assessment that has an absolute submission date, or
d. Pass/Fail assessment tasks.

Marking

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.

Examinations

You must be available for all quizzes, tests and examinations.

Final examinations for each course are held during the University examination periods: February for Summer Term, May for T1, August for T2, and November/December for T3.

Please visit myUNSW for Provisional Examination timetable publish dates.

For further information on exams, please see the Exams webpage.

Special consideration and supplementary assessment

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.

Please note that UNSW now has a Fit to Sit / Submit rule, which means that if you sit 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.

7. Expected resources for students

Software

- PVsyst – Photovoltaic modelling software: https://www.pvsyst.com/
- Microsoft Excel – Students can download Microsoft Excel as part of Microsoft Office 365 available via UNSW IT: https://www.myit.unsw.edu.au/services/students
- Anaconda – A desktop platform to run Jupyter Notebooks and Python: https://www.anaconda.com/

Reference Books

- Solar Energy Forecasting and Resource Assessment by Jan Kleissel
- Modelling Solar Radiation at the Earth's Surface by Viorel Badescu

Online Resources

Links to additional online resources and research publications will be made available through Moodle.

- UNSW Library website: https://www.library.unsw.edu.au/
- UNSW IT website for students: https://www.myit.unsw.edu.au/services/students
- Moodle: https://moodle.telt.unsw.edu.au/login/index.php
- PV Performance Modelling Collaborative: https://pvpmc.sandia.gov/
- NREL's Solar Position Algorithm Calculator: http://www.nrel.gov/midc/solpos/spa.html
- Australian Bureau of Meteorology: http://www.bom.gov.au/
- NASA – The POWER Project: https://power.larc.nasa.gov/

- EnergyPlus Weather Data: https://energyplus.net/weather
- The Australian Renewable Energy Mapping Infrastructure (AREMI): https://nationalmap.gov.au/renewables/
- The World Bank Group Global Solar Atlas: https://globalsolaratlas.info/map
- The World Bank Group Global Wind Atlas: https://globalwindatlas.info/
- PV Education by C.B. Honsberg and S. Bowden https://www.pveducation.org/

8. 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.

In this course, recent improvements resulting from student feedback included the introduction of Python/Jupyter Notebook tutorial activities. 2020 was the first time that students were offered the choice between completing the tutorial activities in Microsoft Excel or via Python/Jupyter Notebooks. 2020 also saw the introduction of a set of Week 0 Assumed Knowledge lessons, including review lessons on basic statistics and solar resource basics.

Student feedback from the 2020 iteration of the course has led to further improvements of the tutorial resources for both the Microsoft Excel and Python learning streams; and the introduction of the online Course Book, available on Moodle.

9. Academic honesty and plagiarism

UNSW has an ongoing commitment to fostering a culture of learning informed by academic integrity. All UNSW students have a responsibility to adhere to this principle of academic integrity. Plagiarism undermines academic integrity and is not tolerated at UNSW. *Plagiarism at UNSW is defined as using the words or ideas of others and passing them off as your own.*

Plagiarism is a type of intellectual theft. It can take many forms, from deliberate cheating to accidentally copying from a source without acknowledgement. UNSW has produced a website with a wealth of resources to support students to understand and avoid plagiarism, visit: student.unsw.edu.au/plagiarism. The Learning Centre assists students with understanding academic integrity and how not to plagiarise. They also hold workshops and can help students one-on-one.

You are also reminded that careful time management is an important part of study and one of the identified causes of plagiarism is poor time management. Students should allow sufficient time for research, drafting and the proper referencing of sources in preparing all assessment tasks.

If plagiarism is found in your work when you are in first year, your lecturer will offer you assistance to improve your academic skills. They may ask you to look at some online resources, attend the Learning Centre, or sometimes resubmit your work with the problem fixed. However more serious instances in first year, such as stealing another student's work or paying someone to do your work, may be investigated under the Student Misconduct Procedures.

Repeated plagiarism (even in first year), plagiarism after first year, or serious instances, may also be investigated under the Student Misconduct Procedures. The penalties under the procedures can include a reduction in marks, failing a course or for the most serious matters (like plagiarism in an honours thesis) even suspension from the university. The Student Misconduct Procedures are available here:

www.gs.unsw.edu.au/policy/documents/studentmisconductprocedures.pdf

10. Administrative matters and links

All students are expected to read and be familiar with UNSW guidelines and polices. In particular, students should be familiar with the following:

- Attendance
- UNSW Email Address
- Special Consideration
- Exams
- Approved Calculators
- Academic Honesty and Plagiarism
- Equitable Learning Services

Appendix A: Engineers Australia (EA) Competencies

Stage 1 Competencies for Professional Engineers

	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