**SOLA 4012**

**Photovoltaic (PV) Systems DesignContents**

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# Staff contact details

## Contact details and consultation times for course convener

Name: Dr Baran Yildiz

Office location: Level 3 -1 CB 22, Tyree Energy Technologies Building (TETB)

Tel: (02) 9385 4284

Email: baran.yildiz@unsw.edu.au

Microsoft Teams Video Chat Hours: Mondays from 16:00 to 18:00

For all enquiries about the course please contact the course convener. For all other questions or enquiries, you are encouraged to ask the lecturer or demonstrators during the lectures and studios, and you are encouraged to post your question on the dedicated Microsoft Teams channel.

## Contact details for demonstrators

Demonstrators: Dr Jinyi Guo, [jin.guo@unsw.edu.au](mailto:jin.guo@unsw.edu.au)

Dr Tracey Yeung, [tracey.yeung@unsw.edu.au](mailto:tracey.yeung@unsw.edu.au)

Lamees Al Kiyumi [l.alkiyumi@unsw.edu.au](mailto:l.alkiyumi@unsw.edu.au)

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# Important links

* [Microsoft Teams](https://student.unsw.edu.au/teams-students)
* [Moodle](https://moodle.telt.unsw.edu.au/login/index.php)
* [Health and Safety](https://www.engineering.unsw.edu.au/energy-engineering/student-resources/workplace-health-and-safety)
* [Student Resources](https://www.engineering.unsw.edu.au/energy-engineering/student-resources)
* [UNSW Timetable](http://timetable.unsw.edu.au/current/subjectSearch.html)
* [UNSW Handbook](https://www.handbook.unsw.edu.au/)
* [Engineering Student Support Services Centre](https://www.engineering.unsw.edu.au/study-with-us/current-students/student-resources/engineering-student-support-services)
* [UNSW Photovoltaic and Renewable Energy Engineering](https://www.engineering.unsw.edu.au/energy-engineering)

# Course details

## Credit points

This is a 6 unit-of-credit (UoC) course and involves five 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 a total of about 15 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.

## Contact hours

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Day** | **Time** | **Delivery Mode** |
| **Online Lecture** | Monday | 09:00 - 11:00 | Microsoft Teams |
| **Online Studio** | Tuesdays | 15:00 - 18:00 | Microsoft Teams |

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

## Summary and Aims of the course

There is increasing need in generating electricity from renewable energy sources and reducing greenhouse gas emissions. Photovoltaic (PV) systems are one of the few distributed renewable electricity generation options that can be readily used in urban areas (as grid connected systems) and in remote areas (as stand-alone systems), with little environmental impact at the site and potential economic benefits for the user and the network operator.

The aim of the course is to provide students with tools and information on the technical and economic issues with respect to the design, installation, and operation of photovoltaic energy systems. In particular, the course aims to develop students’ design, problem solving, and communication skills to implement PV systems in accordance to Australian Standards.

## 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:

|  |  |  |
| --- | --- | --- |
| **Core Learning Outcomes (CLO - hurdle requirements[[1]](#footnote-1))** | | **EA Stage 1 Competencies** |
| 1. | Recommend and justify the most adequate PV system architecture based on the specific requirements of the application and location. | PE1.3, PE1.5, PE1.6 |
| 2. | Calculate the impact of PV systems on the local electricity network and how they can influence the power factor via reactive and active power. | PE1.3, PE2.1, PE2.2 |
| 3. | Design and document a PV system fully compliant with all relevant Australian Standards for a safe and optimal operation. | PE1.6, PE2.2 PE2.3, PE3.2 |
| **Advance Learning Outcomes (ALO)** | | **EA Stage 1 Competencies** |
| 4. | Optimise PV designs based on technoeconomic principles using software tools | PE1.6, PE2.1, PE2.2, PE2.3 |
| 5. | Develop proposals for utility scale PV projects and its associated business model | PE2.3, PE3.2 |

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# Teaching strategies

The teaching strategy for this course comprises online lectures and a series of online studio sessions in Microsoft Teams. The online lessons will present most of the theory related to understanding PV systems and will be available in Microsoft OneNote. Each week you’ll have to answer an online quiz in Moodle about the theory presented in the online lessons before the online studios.

Studio sessions will involve a combination of individual work, team work, and computer based activities (using PV system design programs such as PVsyst and SAM, general software like Excel and design and drafting software like AutoCAD). The course lecturer and demonstrators will be present during the online studio to facilitate your learning process.

# Course schedule

|  |  |  |  |
| --- | --- | --- | --- |
| **Week** | **Topic** | **Delivery Mode** | **Suggested Readings** |
| 1 | Course introduction, PV basics, design thinking and team creation | Online | OneNote online lesson |
| 2 | PV site specific design and modelling, component matching, cables, and protections | Online | OneNote online lesson |
| 3 | Array circuit protection, AC power, waves, phasors, and power factor | Online | OneNote online lesson |
| 4 | PV architecture, inverters, and grid connection, earthing and faults | Online | OneNote online lesson |
| 5 | Tendering for PV projects, installation of PV systems, wind loads and mounting | Online | OneNote online lesson |
| 6 | Flexibility week |  |  |
| 7 | Large scale PV systems, the grid, islanding and inverter safety | Online | OneNote online lesson |
| 8 | Solar farm virtual site visit, quality of supply, voltage and frequency regulation | Online | OneNote online lesson |
| 9 | PV financing & business models, three phase systems | Online | OneNote online lesson |
| 10 | HV grid connection, operation and maintenance of power plants | Online | OneNote online lesson |

# Assessment

## Assessment overview

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Assessment** | **Group Project?** (group size) | **Length** | **Weight** | **Learning outcomes assessed** | **Assessment criteria** | **Due date and submission requirements** | **Deadline for absolute fail** | **Marks returned** |
| Online quizzes (x7) and video interviews (x1) (CLO) | No | Quizzes: 10 questions  Interviews: 10 minutes | 15% (Pass/Fail) | 1 to 3 | Lecture material from weeks 2 to 9. | Quizzes: Fridays 12pm  Interview: week 9 | N/A | Quizzes: One hour after the quiz due date |
| Commercial PV project (CLO) – Compliance submission | No | 6-page report, plus attachments | 30%  (Pass/Fail) | 1 and 3 | Lecture material and studio activities from weeks 1 to 5 | End of week 5 | One week after due date | Two weeks after submission deadline |
| Commercial PV project (ALO) – Tender submission | No | 8-page report, plus attachments | 15% | 4 | Lecture material and studio activities from weeks 1 to 5 | Monday week 7 | One week after due date | Two weeks after submission deadline |
| Utility scale PV project (ALO) | Yes (5) | 10-page report and 5 min video | 40% | 4 and 5 | All course content from weeks 1-10 inclusive. | Video: Week 10  Report: Week 11 | One week after due date | Upon release of final results |

This course will include the following hurdle requirements that are closely linked to a set of learning outcomes which demonstrate that you have acquired the required skills and competencies within this discipline. These requirements are closely linked Clean Energy Council (CEC) design accredication1.

* Students must demonstrate understanding of all key content of the course in the online quizzes and interviews. A minimum mark of 80% must be obtained in each quiz in order to pass this subject. The interviews will be used as check points with questions based in the online quizzes. Failure to achieve this minimum mark will result in an unsatisfactory fail (UF) grade, regardless of the performance in the rest of the course.
* Students must demonstrate they can design a full PV system for optimum performance and in conformance to all the relevant Australian Standards. A minimum mark of 80% must be obtained in the Commercial PV Project – Compliance report to pass this subject. Failure to achieve this minimum mark will result in an unsatisfactory fail (UF) grade, regardless of the performance in the rest of the course.

## Assignments

*Online quizzes (Total 15%)*

You will have to complete eight online quizzes, from weeks 2 to 5 and weeks 7 to 10. The quizzes will test your learning from the content in the online lessons. The quizzes are strictly individual and can be done online at any time after you have completed the online lessons. You will have multiple attempts to complete each quiz. The online quiz of a respective week will be open until Friday 12 pm (i.e., one hour before the studio start) **after this time the quiz cannot be attempted**.

In addition, a video interview will be carried out during the term in week 10. The interviews are strictly individual between the student and the course coordinator or demonstrator. The interviews will check that you have learned the content of the course as demonstrated by the results in the online quizzes.

*Commercial PV Project (Total 40%)*

In this assessment task you will apply your knowledge to a real-world design challenge of a commercial grid connected PV system (core) with storage option (advanced). As a part of this project, you and your team member will play the roles of ‘junior engineers’ in a PV company. Although this is an individual assessment, you are encouraged to collaborate with your team during this process. However, the work submitted must be solely yours.

The project involves the use of the modelling software System Advisory Model (SAM) to design the PV system and of AutoCAD to deliver professional level single line diagrams and array layout. SAM will be used to carry out a techno-economic optimisation of the system performance and cost. The aim is to produce a comprehensive design of a grid connected PV system for a location and load to be selected. The project report will be prepared as a ‘Tender submission’, i.e., you are preparing a full tender submission in order to ‘win’ a contract for the installation of a new PV system.

The report will have two clear sections:

- Core learning outcomes: must include drawings and the results and performance estimation of the commercial PV design using first principles

- Advanced learning outcomes: must include an optimised PV design using SAM with a storage alternative

*Utility scale PV project (Total 45%)*

This project is based on utility scale PV systems, meaning that your team will be working on a solar farm. As part of this project, your team will play the role of a ‘PV developer’ trying to setup a new solar farm project in Australia. The project will run through the last half of the term aiming at producing a comprehensive project that can be presented to investors for funding in week 11. The team will have to select the location of the solar farm taking into consideration aspects like irradiance and grid connection. The final submission will be prepared as an investment brochure (video poster with commercial information plus drawings and marketing material) so your company can obtain funding for your project. This project will allow you to implement all the knowledge gained through the course involving the use of Australian standards, modelling software, together with engineering and economic principles to design a solar farm.

### 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 immediately subject to a late penalty of 30 percent (30%) of the maximum mark possible for the assessment item submitted after the due date. There is additional 10 percent (10%) late penalty of the maximum mark possible per 24 hour period after the due date. The 10% 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’ (one week after the due-date) 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:

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

### Marking

Marking guidelines (i.e., rubrics) 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. There will be no final examination for this course.

## 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](https://student.unsw.edu.au/sites/all/files/uploads/group271/fit-to-sit-guide.pdf), 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](https://student.unsw.edu.au/special-consideration).

## Workload

It is recommended you design a study plan for the term, based on the learning activities and assignments of each of your courses, detailing the number of hours you will spend on each learning task. A simple example of a study plan for SOLA4012 is shown in the table below (e.g., the work related to the Commercial PV project should take you around 26 hours, while the Utility Scale project is around 20 hours for each team member or 100 hours in total).

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Period** | **Self-directed**  **Study** | **Online Activities** | **Online Quizzes** | **Commercial PV Project** | **Utility Scale PV Project** | **Total**  **Hours** |
| Week 01 | 4 | 5 | 1 | 2 |  | 12 |
| Week 02 | 4 | 5 | 2 | 4 |  | 15 |
| Week 03 | 4 | 5 | 2 | 4 |  | 15 |
| Week 04 | 4 | 5 | 2 | 4 |  | 15 |
| Week 05 | 4 | 5 | 2 | 4 |  | 15 |
| Week 06 | 6 |  |  | 8 |  | 14 |
| Week 07 | 4 | 5 | 2 |  | 4 | 15 |
| Week 08 | 4 | 5 | 2 |  | 4 | 15 |
| Week 09 | 4 | 5 | 2 |  | 4 | 15 |
| Week 10 | 4 | 5 | 2 |  | 4 | 15 |
| Week 11 |  |  |  |  | 4 | 4 |
| **Total** | **42** | **45** | **17** | **26** | **20** | **150** |

# Expected resources for students

*Reference Books*

* Stand Alone Power Systems, Design and Installation - GSES
* Grid-Connected PV Systems, Design and Installation - GSES
* Grid-Connected PV Systems with Battery Storage - GSES

*Online resources*

* UNSW Library website - <https://www.library.unsw.edu.au/>
* Australian Bureau of Meteorology - <http://www.bom.gov.au/climate/>
* NASA (weather data) - <https://eosweb.larc.nasa.gov/>
* NREL National Solar Radiation Database (weather data) - <https://nsrdb.nrel.gov/>
* Renewables Ninja - <https://www.renewables.ninja/>
* 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>

*Design Tools*

* PVSYST - Software for photovoltaic Systems
* SAM - System Advisory Model
* RETScreen - Clean Energy Management Software system for energy efficiency

*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

# 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 include changes in the assessment tasks and the online content.

# 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](https://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](http://www.gs.unsw.edu.au/policy/documents/studentmisconductprocedures.pdf)

# 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](https://student.unsw.edu.au/attendance)
* [UNSW Email Address](https://www.myit.unsw.edu.au/services/students/email-students-and-staff)
* [Special Consideration](https://student.unsw.edu.au/special-consideration)
* [Exams](https://student.unsw.edu.au/exams)
* [Academic Honesty and Plagiarism](https://student.unsw.edu.au/plagiarism)
* [Equitable Learning Services](https://student.unsw.edu.au/els)

# 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 |

1. You must obtain at least 80% mark on all core learning outcomes to pass the course. These learning outcomes allow you to apply for provisional Clean Energy Council (CEC) design accreditation. [↑](#footnote-ref-1)