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Course Staff

Course Coordinator, Lecturer and Tutor: Mr Geoff Stapleton
He is only part-time and is only at the University on Fridays. He is available for consultations on Fridays by appointment.
Contact Details are:
e-mail: gses@bigpond.com
Phone: 02 4457 3057 or 0418 429 255
The best form of contact is via the gses@bigpond.com e-mail address.

Casual Academics;
Dong Lin  dong.lin@unsw.edu.au
Lingfeng Wu  lingfeng.wu@unsw.edu.au
Jian Chen  jian.chen@unsw.edu.au

Laboratory assistant/Demonstrator:
Dong Lin  dong.lin@unsw.edu.au

Course details
The course is a 6 Unit of Credit course.

Course aims
The main aims of the course are to learn to:
- Design a stand alone power system (including hybrids) in accordance with Australian standards- with photovoltaic (PV) modules as the main charging source to meet the energy requirements of the end-user (client)
- Understand the two configuration of systems- DC Bus Systems, AC Bus Systems
- Understand the principles of installing a stand alone power system.

Stand alone power systems (or off-grid systems) are still required throughout Australia. While throughout the world it is estimated that 1.4 billion people are not connected to grid electricity. In Australia there are many standards that have been developed by industry over the last 15 years. This course teaches how to design stand alone systems in accordance with those standards.

Student learning outcomes
After successful completion of this course the student should meet all the competencies listed in the Clean Energy Council (CEC) Skills:
- Know and understand the movement of the sun throughout the sky and therefore how to determine the most appropriate tilt angle for the PV array.
- Know how to undertake an energy assessment with a client to determine their actual daily and yearly energy requirements.
- Know how to advise a client on basic energy efficiency initiatives that could be undertaken to reduce their electrical energy demand.
- Know and understand the basic working of the key components within a stand-alone power system including:
  - PV Module (and array)
  - Battery
  - Charge controller (regulator)
  - Inverters
  - Generator
  - Battery Charger
Know how to design a stand alone power system for a specified daily (yearly) energy usage, which involves determining the correct number and rating of the following system components and ensure that they are matched

- PV Module (and array)
- Battery
- Charge controller (regulator)
- Inverter
- Generator
- Battery Charger

Calculate the required time a generator must operate monthly based on: daily energy usage, size (in watts) of PV array.

Understand the difference between a DC Bus system and an AC Bus System and the design principles

Understand the design principles of a hybrid power system.

Understand the basic function of wind generators and micro-hydro generators and their role in a stand-alone power system

The rationale behind the approach to learning and teaching

In 1993 the then industry association called Solar Energy Industry Association (SEIA) (now the Clean Energy Council or CEC) developed a correspondence course for the industry. Successful completion of this course led to the attendees obtaining their accreditation for design and installation of stand alone power systems. To achieve this qualification now, people must complete a number of modules at a TAFE college to obtain their accreditation.

The short course that was previously developed by SEIA has been upgraded to incorporate the standards released over the coming years. Students at UNSW who successfully complete this course and upon graduating with their engineering degree will be eligible to apply for their CEC accreditation in Design of Stand Alone Power Systems.

The development of the material for the course was overseen by a committee of experienced designers and installers. The course will allow students to appreciate what is required to successfully design and install a system. The lectures will also include real life examples from my experience in operating a company supplying and installing systems for over 10 years. The tutorials will provide the students the opportunity to gain the skills in designing a system. There is only one lab where the students will gain experience in installing a small system.

Course Delivery

Lectures: 2 hours per week
Friday 9.00AM to 11.00AM Webster Theatre A (F Hall A)

These will be based on the “Stand Alone Power Supply Systems- Design and Installation Training Manual”, Global Sustainable Energy Solutions (GSES). This publication will be available from the UNSW Bookstore.

Note: The lecture provides a summary of the manual however it is expected that each course attendee have access to a book because part of the assessment will include questions from material contained in the book.

The contents page of this manual is shown on page 4.

Labs: Mondays 11am to 3pm room TETB Room LG25 You only attend 1 lab session for this period.

Tutorials: You attend 1 2 hour tutorial each week.
Monday 9 am to 11 am   Webster Room 250
Tuesday 11 am to 1 pm   Webster Room 256
Friday 11 am to 1 pm   Webster Room 250

Labs and tutorials start in **Week 2.** There are **no** labs in **Week 5**

There is only 1 lab –this involves the installation of a system and it will take 4 hours.
The class will be divided into groups of 3. There will be 3 groups working on the system installation each week.
The roster is as follows:

<table>
<thead>
<tr>
<th>Week</th>
<th>Date</th>
<th>Lab Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>4\textsuperscript{th} August</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>11\textsuperscript{th} August</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>18\textsuperscript{th} August</td>
<td>7</td>
</tr>
<tr>
<td>5</td>
<td>25\textsuperscript{th} August</td>
<td>NO LAB</td>
</tr>
<tr>
<td>6</td>
<td>1\textsuperscript{st} September</td>
<td>10</td>
</tr>
<tr>
<td>7</td>
<td>8\textsuperscript{th} September</td>
<td>13</td>
</tr>
<tr>
<td>8</td>
<td>15\textsuperscript{th} September</td>
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<td>9</td>
<td>22\textsuperscript{nd} September</td>
<td>19</td>
</tr>
<tr>
<td>10</td>
<td>6\textsuperscript{th} October</td>
<td>22</td>
</tr>
<tr>
<td>11</td>
<td>13\textsuperscript{th} October</td>
<td>25</td>
</tr>
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<td>12</td>
<td>20\textsuperscript{th} October</td>
<td>28</td>
</tr>
<tr>
<td>13</td>
<td>27\textsuperscript{st} October</td>
<td>31</td>
</tr>
</tbody>
</table>

Each group will complete the installation on a single day; thus they will be required to be there for the tutorial sessions and lab on the week they have a lab allocated. So for one week during the session you will need to attend 11am-3pm on a Monday.

There are 11 tutorials (total of 22 hours) throughout the session- The tutorials will be available through Moodle prior to the Tutorial and the answers will be posted on Moodle in the week after the tutorial.

**Assessment**

System Installation- 5% - You hand in the laboratory assessment sheets at the Lecture on the Friday following the week you do the lab.

Major Project-System Design (25%). Due Week 11

Mid course test - Week 5 (10%)

Final exam (60%) to be conducted during the exam period.

**Supplementary Exam Date**

If a supplementary exam is required to be conducted then it will be held on:
Date to be announced.
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Major Assignment

Major Project Report – Due Week 11- Friday 17th October at 5PM
Assignments will be submitted online via Moodle. No hard copy submission will be required.

The assignment shall be presented in the form of a report that includes all the tasks listed below. The report must be TYPED not handwritten so it is recommended that it be completed as a MS Word document (or equivalent). You can submit both a PDF and word version. The word version will be used for marking with comments written on the side by markers.

Marking of the assignment will involve deducting 1 or 2 marks (out of 25) for each error. An error could include the following:

- mistakes in design calculations
- selecting incorrect size equipment
- incorrect sizing of cable or fuses
- errors in drawings
- or any other error that could lead to a poor system design or installation

Five (5) marks are directly allocated to presentation.

Note:
If assignment is late, you will lose 3 marks (out of 25) - if it is handed in after 5 PM on Friday 17th October or on the following Monday. You will then lose 1 mark for every day after that date. Meaning if it is handed in on:

- Before 5PM Monday 20th October—lose 3 marks;
- Before 5PM Tuesday 21st October- lose 4 marks
- Before 5PM Wednesday 22nd October-lose 5 marks
- Before 5PM Thursday 23rd October-lose 6 marks
- Before 5PM Friday 24th October-lose 7 marks
- Before 5PM Monday 27th October- lose 8 marks
- Continues with 1 mark lost every day after that as well

Work Individually
This assignment is to be done individually. If any evidence of people working together is identified all those involved will receive 0 marks for their assignment.

The main outcomes of this course are that:
1. You can complete a load assessment
2. You can complete a design of a standalone power system (SPS)
3. You can provide a system drawing
4. You can specify all the equipment needed to install a SPS.
5. You know all the relevant standards and appreciate the procedures to install a SPS that operates correctly and safely.

This assignment will test your competencies in the first four points and ensure you understand what is involved in installing a system. (Point 5)

Tables B1, B2 and B3 required for this assignment have been provided as separate word documents.

ALL CALCULATIONS MUST BE SHOWN.
THE TABLES SHOWN AT THE BACK OF AS/NZS4509.2 ARE NOT TO BE USED IN THE ASSIGNMENT SUBMISSION.

TASKS:
The following tasks are to be presented as two separate reports -

- Report A shall include Task 1,
- Report B shall include Tasks 2 through to Tasks 5.

Report A will include Table B1 and then B2 and B3 for what is currently in the house/unit; B2 and B3 revised (if required) are used to state what would be in the house/unit to be powered by the system.
Report B requires the complete design of a system and the preparation of a quotation. All design calculations shall be shown. The main body of the report includes:

- The load assessment forms
- System design. All calculations must be shown.
  - The report should include the number (quantity) and brand of each item to be used. State all the assumptions used in the calculations to determine the number of items required: e.g. Used Worst Month PSH of XXX; allowed oversize factor of XXX; used X days autonomy; max DOD of XXX% etc.
  - These assumptions should be stated for each product and should be a thorough explanation of your equipment choice.
  - Each piece of equipment should have a heading in the report.
- The System Quotation, showing equipment being recommended for system design
- Wiring Diagrams of system design.

REPORT A
1. For the house or unit where you currently live, conduct an energy and load assessment and complete Tables B1, B2 and B3 from AS4509.2 (supplied as word document). If you are living in a college, try to find a friend or relative who has a house or unit and complete the assessment and the forms.
   a. Having completed that energy assessment, now assume that the people living in that house/unit are going to move to the country where they will need to live on a stand-alone system and that they will use similar appliances and operating times. Using the initial load assessment (No. 1 above), complete a second load assessment form showing the energy usage at the new location.
   b. Please provide a report which includes: the initial load assessment form; the revised form (if there is one); and state what appliances initially included that have now been removed or changed to other sources of energy, in order to reduce your daily energy demand.

REPORT B
2. Please complete the load (electrical energy) assessments in Tables 1 (provided separately) for a building located at latitude 35 degrees south.

Assume the peak sunhours and ambient daytime temperature for the tilt angle and orientation for your PV array are as follows:

<table>
<thead>
<tr>
<th>Month</th>
<th>Temp °C</th>
<th>PSH</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>26.3</td>
<td>6.39</td>
</tr>
<tr>
<td>February</td>
<td>26.2</td>
<td>6.44</td>
</tr>
<tr>
<td>March</td>
<td>23.4</td>
<td>6.17</td>
</tr>
<tr>
<td>April</td>
<td>19.5</td>
<td>4.92</td>
</tr>
<tr>
<td>May</td>
<td>14.7</td>
<td>4.28</td>
</tr>
<tr>
<td>June</td>
<td>11.5</td>
<td>4.03</td>
</tr>
<tr>
<td>July</td>
<td>10.1</td>
<td>3.83</td>
</tr>
<tr>
<td>August</td>
<td>11.9</td>
<td>4.86</td>
</tr>
<tr>
<td>September</td>
<td>14.2</td>
<td>5.17</td>
</tr>
<tr>
<td>October</td>
<td>17.2</td>
<td>5.83</td>
</tr>
<tr>
<td>November</td>
<td>20.6</td>
<td>5.86</td>
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<tr>
<td>December</td>
<td>23.5</td>
<td>6.03</td>
</tr>
<tr>
<td>Average</td>
<td>18.26</td>
<td>5.32</td>
</tr>
</tbody>
</table>

3. Design a complete AC bus system to meet the loads as determined in task 2 based on the yearly average peak sunhours. The AC bus system will include all items as shown in the following diagram. That is one portion of the array will connect to Grid Connect inverter and the other portion will be connected to the battery bank via an MPPT.
Note: The above diagram is only a schematic the system you design might include clusters of inverters and battery banks. There will be one MPPT per cluster of batteries. Assume for design purposes that **70% of the daily energy will be provided via solar charging the battery bank and 30% of the load will be supplied directly via the grid connect inverters.** However the battery inverter must be sized such that all the solar PV connected to the system via the grid connected inverters is able to be used for charging the battery bank as per the design principles explained in the course.

The design as a minimum must include:
- The resource to load ratio for each month of the year.
- All your assumptions on design—e.g. inverter efficiency, battery efficiency etc.
- System voltage section
- Photovoltaic array sizing and selection including specifying the size of array connected to the MPPT (or MPPTS) and grid connect inverter (or inverters)
- Grid Connect Inverter (or inverters) Sizing and selection
- Specifying the minimum sized battery inverter required to meet the maximum and surge demand for the loads.
- The required Battery Inverter (or inverters) sizing and selection suitable for the system
- Battery Bank Sizing and selection (Note: could be more than one bank)
- MPPT sizing and selection
- Generator sizing and selection
- Size of required ventilation
- Generator run time for the month having the worst ‘resource to load’ ratio

The report must include headings for the equipment items being sized and selected, and show the actual formulas (note: formulas could just be in words, not symbols if that is what you prefer) and the calculations used.

The system will NOT include a wind generator or a micro-hydro generator.

4. Prepare a circuit diagram for the installation of the system designed:
   - Include distances between equipment and the size of cables selected.
   - Calculate the voltage drops for the following d.c. cables selected and show these calculations:
     i. Array to Grid Connect Inverter
     ii. Array to MPPT
     iii. MPPT to Battery Bank
   - Determine the size of the fuses and circuit breakers to be used and mark their location on the circuit diagram.
   - Do not determine the size of the a.c. cables, for example the cable between the inverter to switchboard or genset to inverter etc - this must be done in real life by an electrician.

5. Prepare a complete parts list and pricing for the major equipment (e.g. solar modules, batteries, array frame, controller, inverters etc.) chosen for your design. Provide the total cost of the major equipment for your system in task 3. List the type of installation equipment that you would require for undertaking the installation of the system designed. This list does not need to include the quantities nor pricing but should list all the installation items (e.g. cable, mounting screws etc.) that you would require. This list could be presented in table form.

The following equipment data sheets will be provided on Moodle and are to be used for the equipment selection:
- YINGLI YGE 60 Cell Range of Modules 240w to 260W
- TRINA Honey Range 245W to 260W
- SMA Range of Grid Connect Inverters
- SMA Sunny Island Inverters
- SMA MPPT Controller
- Sonnenschein 2V A600 range of Solar Batteries
Academic honesty and plagiarism

What is Plagiarism?
Plagiarism is the presentation of the thoughts or work of another as one’s own.* Examples include:

- direct duplication of the thoughts or work of another, including by copying material, ideas or concepts from a book, article, report or other written document (whether published or unpublished), composition, artwork, design, drawing, circuitry, computer program or software, web site, Internet, other electronic resource, or another person’s assignment without appropriate acknowledgement;
- paraphrasing another person’s work with very minor changes keeping the meaning, form and/or progression of ideas of the original;
- piecing together sections of the work of others into a new whole;
- presenting an assessment item as independent work when it has been produced in whole or part in collusion with other people, for example, another student or a tutor; and
- claiming credit for a proportion a work contributed to a group assessment item that is greater than that actually contributed.†

For the purposes of this policy, submitting an assessment item that has already been submitted for academic credit elsewhere may be considered plagiarism.

Knowingly permitting your work to be copied by another student may also be considered to be plagiarism.

Note that an assessment item produced in oral, not written, form, or involving live presentation, may similarly contain plagiarised material.

The inclusion of the thoughts or work of another with attribution appropriate to the academic discipline does not amount to plagiarism.

The Learning Centre website is main repository for resources for staff and students on plagiarism and academic honesty. These resources can be located via:

www.lc.unsw.edu.au/plagiarism

The Learning Centre also provides substantial educational written materials, workshops, and tutorials to aid students, for example, in:

- correct referencing practices;
- paraphrasing, summarising, essay writing, and time management;
- appropriate use of, and attribution for, a range of materials including text, images, formulae and concepts.

Individual assistance is available on request from The Learning Centre.

Students 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 items.

* Based on that proposed to the University of Newcastle by the St.James Ethics Centre. Used with kind permission from the University of Newcastle
† Adapted with kind permission from the University of Melbourne.
## Course schedule

<table>
<thead>
<tr>
<th>Week/Date</th>
<th>Week</th>
<th>Topic</th>
<th>Lecturer</th>
</tr>
</thead>
</table>
| **1** 1<sup>st</sup> August | Lecture 1 | - Introduction and course outline  
- System Overview: Basic Role of Each Component  
- Overview of Safety  
Explanation of How the lab and Tut will operate.  
Dividing into groups  
Discussing Assignments | Geoff Stapleton |
| **2** 8<sup>th</sup> August | Lecture 2 | - Solar Trackers.  
- Batteries | Guest lecturer- Susan Neill  
Tutorial 1 | Casual academics |  
Lab-4<sup>th</sup> August | Groups 1, 2 and 3 |
| **3** 15<sup>th</sup> Aug | Lecture 3 | - System Controllers  
- Inverters | Geoff Stapleton  
Tutorial 2 | Casual academics |  
Lab 11<sup>th</sup> August | Groups 4, 5 and 6 |
| **4** 22<sup>nd</sup> Aug | Lecture 4 | - Energy Efficiency  
- Load Assessment  
- System Design | Geoff Stapleton  
Tutorial 3 | Casual academics |  
Lab 18<sup>th</sup> August | Groups 7, 8 and 9 |
| **5** 29<sup>th</sup> Aug | Lecture Time 9:30-10:30 | - Mid Term Test (1hr) | ?? will supervise  
Tutorial 4 | Casual Academics |  
Lab | NO LAB |
| **6** 5<sup>th</sup> September | Lecture 5 | - System Sizing DC Bus Systems Part 1 | Geoff Stapleton  
Tutorial 5 | Casual academics |  
Lab 1<sup>st</sup> Sep | Groups 10, 11 and 12 |
<p>| <strong>7</strong> | Lecture 6 | System sizing DC Bus Systems Part 2 | Geoff |</p>
<table>
<thead>
<tr>
<th>Date</th>
<th>Events</th>
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</thead>
<tbody>
<tr>
<td>12th Sept</td>
<td>Lecture 7: System Sizing AC Bus Systems - Geoff Stapleton</td>
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<td>19th Sept</td>
<td>Lab 8: Group 13, 14 and 15</td>
</tr>
<tr>
<td>8th Sep</td>
<td>Lecture 8: System Wiring, System Installation - Geoff Stapleton</td>
</tr>
<tr>
<td>19th Sept</td>
<td>Tutorial 8</td>
</tr>
<tr>
<td>19th Sept</td>
<td>Lab 15: Group 16, 17 and 18</td>
</tr>
<tr>
<td>9th Sep</td>
<td>Lecture 9: Maintenance and Fault Finding, Drawings</td>
</tr>
<tr>
<td>26th Sept</td>
<td>Tutorial 9</td>
</tr>
<tr>
<td>26th Sept</td>
<td>Lab 22: Group 19, 20 and 21</td>
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<td>10th Oct</td>
<td>Lecture 10: Wind Generators, Micro-Hydro Generators</td>
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<td>10th Oct</td>
<td>Tutorial 10</td>
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<td><strong>MAJOR ASSIGNMENT DUE 17th October 5PM</strong></td>
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<td>Lecture 11: System Installation Slide Presentation</td>
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<td>Lab 27: Group 31, 32 and 33</td>
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Resources for students

Course Book:

Stand Alone Power Systems Design and Installation Resource Book, GSES. This will be available at the UNSW bookshop.

Other Reference Books

The first 4 resource books and learning guides are all developed and published by Brisbane Institute of TAFE-Renewable Energy Centre and TAFE Queensland with funding support by ACRE.

To Order: These books are available from the Queensland Textbook Warehouse. You will need to go to their website in order to place an order or make an enquiry about the price of this book. The Qld Textbook Warehouse has an order form for retailers and an order form for students.

Enquiries: Contact the Qld Textbook Warehouse:

Tel: (07) 3261 1300
Fax: (07) 3261 1966
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Email: info@qtw.com.au
Website: http://qtw.com.au
Post: PO Box 3220, Bracken Ridge 4017 Australia


Contents:

Unit 1: Energy- The Big Picture
Unit 2: Energy Basics, Energy Services and Demand
Unit 3: The Solar Energy Resource
Unit 4: Solar Thermal Systems
Unit 5: Energy Efficient Building Design
Unit 6: Photovoltaics
Unit 7: Wind Energy
Unit 8: Micro-Hydro Resource and Technology
Unit 9: Energy Storage  
Unit 10: Stand Alone Power Systems  
Unit 11: Biomass Resource and Technology

Informative book and Units 1, 2, 3, 6, 7, 8, 9 and 10 are useful for this course.


Contents:
Unit 1: Photovoltaic Device Physics and Manufacturing  
Unit 2: Module Operating Characteristics  
Unit 3: PV System Configurations and Applications  
Unit 4: Solar Radiation and Shading Assessment  
Unit 5: PV Water Pumping Systems  
Unit 6: Stand Alone PV System Design  
Unit 7: Grid Connected PV System Design  
Unit 8: System Installation and Commissioning  
Unit 9: Maintenance and Fault Finding

Informative book and Units 4, 6, 8 and 9 are useful for this course. Note Units 8 and 9 are very similar to the notes that will be provided with this course.


Resource Guide Contents:
Unit 1: PV System Installation and Commissioning  
Appendix A- Schematic and Wiring Diagrams  
Unit 2: Maintenance and Fault Finding  
Unit 3: Occupational Health and Safety


Contents:
Unit 1: ELV Wiring and Circuit Protection  
Unit 2: System Configurations and Electrical Drawings  
Unit 3: Batteries  
Unit 4: Inverters, Regulators, MPPTs, Battery Chargers and PV Array Trackers  
Unit 5: Basic Lighting Design  
Unit 6: Generating Sets

“Extra-low Voltage- Electrical Wiring and Practice” Learning Guide. The resource notes are part of the learning guide.

Contents:
Unit 1: Electrical Drawing and Drawing practice
   Appendix 1 Schedule of Equipment
   Appendix 2 Wiring & Architectural Diagram
Unit 2: Workplace Health and Safety
   Appendix 1 OH&S Risk Analysis
Unit 3: Cables, Connections and control boards
Unit 4: Circuit Protection, earthing and safety
   Appendix 1: RENEW Issue 78 Earthing article
Unit 5: Wiring Systems and lighting
Unit 6: Wiring Rules and Cable Sizing
   Appendix 1: Calculations of cable size required
   Appendix 2: House wiring design
   Appendix 3: Schedule of Equipment
   Appendix 4: D.C. Circuit Diagram
Unit 7: Installation and testing
Unit 8: Lighting Design

Relevant Standards
The following standards will be relevant to this course

AS/NZS3000-2007 Wiring Rules
AS/NZS4509 Stand Alone Power Systems
   Part 1: Safety and installation Requirements
   Part 2: System Design Guidelines
AS/NZS5033 Installation of PV Arrays
AS4086 Secondary batteries for use with stand-alone power systems
   Part 2: Installation and maintenance
AS3010 Electrical Installations- Supply by Generating Set
   Part 1: Internal combustion engine driven set

The following standards are also relevant for a system designer and installer
AS1170 Minimum Design loads on structure
   Part 2: Wind Loads
AS1768 Lightning Protection
AS2676 Guide to the installation, maintenance, testing and replacement of secondary batteries in buildings
AS1359 Rotating Electrical machines
   Part 109: Noise Limits
AS3011 Electrical Installations – Secondary batteries installed in buildings