1 Course Overview

Title: EE 492 Renewable Energy Resources
Credits: Three credit hours; technical elective
Semester: Spring 2018
Instructor: Prof. Ali Mehrizi-Sani
Email: mehrizi@eecs.wsu.edu
Office: EME 35
Phone: (509) 335-6249
Fax: (509) 335-3818
Lecture Room: SLOA 5
Lecture Hours: MWF 11:10–12:00
Course Website: http://eecs.wsu.edu/~mehrizi/ee492/2018S
Office Hours:
- MF 12:00-12:30; or
- Email me for an appointment with “EE 492” in the subject line.

TA Name: Rabayet Sadnan
TA Email: rabayet.sadnan@wsu.edu
TA Office Hours: Tuesday 2–3pm in SLOA 338

Catalog Description: Renewable energy resources, wind energy, fuel cells, solar cells and modules, stand alone and grid connected PV system design.

Longer Description: This course introduces different types of renewable energy, including solar cells, wind turbines, and fuel cells, and discusses the challenges brought about by their integration in the power system. Based on the technology, design considerations, examples, and policies will also be discussed.

Please note: This course will use AMS recording facilities to capture videos of each lecture. Your voice and/or picture may also be captured. The recordings may be used for future offerings of this or similar courses. Any concerns about this should be communicated to the course instructor in writing, that is, WSU email, by the end of the first week of classes. You can find the videos in Blackboard (learn.wsu.edu) under Tools and then Panopto content. (If needed, the server address is wsu.hosted.panopto.com.)

2 Required Background by Topic

You need to have taken the following courses. For each prerequisite, some of the topics that will be used in this course are listed. A general knowledge of other topics typically covered in the respective course is preferred.

Certified in major: Electrical Engineering, Computer Science, or Computer Engineering.

EE 361 Electrical Power Systems (with C or better) Three-phase circuits; transformers; phasors; electric machines.
3 Learning Outcomes

At the end of this course, you are expected to be able to

- Calculate cost of electricity generation;
- Analyze a PV, wind, or fuel cell system;
- Analyze and solve problems related to a renewable energy generation system;
- Compare different renewable energy generation technologies;

4 Course Topics

The course topics include

- Energy resources, electric power generation, energy usage and sustainability [h, j]
- Nonrenewable energy sources: Reserves, environmental impacts, and economic cost [f, h, j]
- Renewable energy resources: Energy density, economics, environmental and social costs [f, h, j]
- Solar modules: Operation principles, IV characteristics, effects of temperature and shading [a, e]
- Photovoltaic system components [a]
- Photovoltaic system design: Sizing, stand-alone vs. grid-connected systems [a, c, k]
- Wind Energy: Components and operation principles, output power estimation and regulation [a]
- Fuel cells: Analysis and sizing [a]

Below is the approximate course schedule (the text in crimson and green are hyperlinked). Important dates are also marked. Because of the necessary travel to showcase research/teaching efforts at WSU, we may have a few make-up classes in the evenings.

To download PSCAD simulation cases, click on the green link and then press Ctrl-S (Save) in your browser. Make sure the file is saved with an extension of .pscx, and not .pscx.txt.

<table>
<thead>
<tr>
<th>Week</th>
<th>Topic</th>
<th>Reading and Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>W1 Jan. 8</td>
<td>M Overview of the course and policies</td>
<td>M Slides</td>
</tr>
<tr>
<td></td>
<td>W Electric power industry and renewable generation in the US</td>
<td>W LaTeX resources (Gettig something out of LaTeX; LaTeX Wikibook; The Art of LaTeX; A (not so) Short Introduction to LaTeX; TeX StackExchange; TikZ graphics in LaTeX)</td>
</tr>
<tr>
<td></td>
<td>F Diagnostic Exam</td>
<td>F Sample Diagnostic Exam</td>
</tr>
<tr>
<td>W2 Jan. 15</td>
<td>M No class—MLK Day (Holiday)</td>
<td>M Homework 1</td>
</tr>
<tr>
<td></td>
<td>W Electric energy in the US</td>
<td>W Slides for this and the next few lectures</td>
</tr>
<tr>
<td></td>
<td>F Environmental impacts</td>
<td>F EIA's Electric Generator Inventory</td>
</tr>
<tr>
<td></td>
<td>O Diagnostic Exam</td>
<td>O Extra; Fri 1/19, 3:10pm–4:00pm</td>
</tr>
<tr>
<td></td>
<td>Conventional generation: Rankine cycle</td>
<td></td>
</tr>
<tr>
<td>W3 Jan. 22</td>
<td>M Brayton cycle; gas generation</td>
<td>M Homework 2</td>
</tr>
<tr>
<td></td>
<td>W LCOE</td>
<td>W Homework 1 due</td>
</tr>
<tr>
<td></td>
<td>F LCOE examples</td>
<td>Homework 1 Solution</td>
</tr>
<tr>
<td></td>
<td>O History of utilities in the US</td>
<td>F Project Title Due</td>
</tr>
<tr>
<td></td>
<td>O Extra; Fri 1/26, 3:10pm–4:00pm</td>
<td></td>
</tr>
<tr>
<td>Week</td>
<td>Monday</td>
<td>Tuesday</td>
</tr>
<tr>
<td>------</td>
<td>-------------------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>W4</td>
<td>Jan. 29</td>
<td>M History of utilities and regulation; FERC, NERC, and other aspects</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W5</td>
<td>Feb. 5</td>
<td>M PV effect in semiconductors</td>
</tr>
<tr>
<td>W6</td>
<td>Feb. 12</td>
<td>M Sample problems</td>
</tr>
<tr>
<td>W7</td>
<td>Feb. 19</td>
<td>M No class—Presidents’ Day (Holiday)</td>
</tr>
<tr>
<td>W8</td>
<td>Feb. 26</td>
<td>M Solution to shading</td>
</tr>
<tr>
<td>W9</td>
<td>Mar. 5</td>
<td>M No class—APEC</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W10</td>
<td>Mar. 19</td>
<td>M Inverters</td>
</tr>
<tr>
<td>W11</td>
<td>Mar. 26</td>
<td>M Simulation of a full-bridge inverter</td>
</tr>
<tr>
<td>W12</td>
<td>Apr. 2</td>
<td>M Midterm Exam 2</td>
</tr>
<tr>
<td>W13</td>
<td>Apr. 9</td>
<td>M Batteries</td>
</tr>
<tr>
<td>W14</td>
<td>Apr. 16</td>
<td>M</td>
</tr>
<tr>
<td>W15</td>
<td>Apr. 23</td>
<td>M</td>
</tr>
</tbody>
</table>

- **Feb. 5**: M PV effect in semiconductors
  - W P-N junction and intrinsic field
  - F Exam coverage
- **Feb. 12**: M Sample problems
  - W Midterm Exam 1
  - F PV model
- **Feb. 19**: M No class—Presidents’ Day (Holiday)
  - W PV model with resistances; Effect of shading and temperature
  - F Shading issue; example
- **Feb. 26**: M Solution to shading
  - W MPPT
  - F MPPT; converters
- **Mar. 5**: M No class—APEC
  - W LIPE tour
  - F DC converters: buck boost
- **Mar. 12**: Spring Break

**Notes:**
- **Feb. 26**: SunPower 20% • FirstSolar Series 6 • Panasonic 19% • Mitsubishi
- **Mar. 12**: Spring Break
- **Apr. 2**: M Midterm Exam 2
  - W Examples
  - F Examples
- **Apr. 9**: M Batteries
  - W
  - F
- **Apr. 16**: M
  - W
  - F
- **Apr. 23**: M
  - W
  - F
5 Textbook

The required textbook is


6 Evaluation

Your performance in this course will be assessed based on the components shown below. Failure to complete assigned work or to take a test results in a zero for that portion of your grade, unless you have a compelling reason because of an emergency, which has to be discussed with me and approved by me in advance. I will not consider ANY request at the end of the semester to convert a failing grade to a passing grade or to otherwise change a grade. The grading scheme is subject to change. Grades will not be curved; you are assessed on what you know, not what others know.

1https://registrar.wsu.edu/media/758551/spring_2018_final_exam.pdf
Diagnostic Exam (5%; required) Scoring 100% on the diagnostic exam (DE) is paramount to passing this course. DE is designed to test your basic math and electrical engineering skills (examples include phasor notation, complex math, KVL/KCL, real and reactive power, and circuit concepts). The DE will be administered twice (in class). Only if you take the first DE, but you think you can do better, can you take the DE again. If you miss the first DE, you will not be allowed to take the second DE. Anyone who does not pass the diagnostic test can withdraw from the course without it showing on their transcript if done by the appropriate deadline (please see WSU academic calendar).

Assignments/Quizzes (20%) Nine to 12 (depending on the course schedule) assignments. Each assignment is usually assigned on a Monday and is due at the beginning of the Wednesday class of the following week. You can discuss assignments with your fellow students, but you must learn how to solve the assignment on your own. Instead, there will be a quiz at the beginning of the Wednesday class with a question from the assignment due that week. Since you are expected to have solved the assignment beforehand, the quiz will be very short—just enough time for you to write down the solution. Occasionally I will ask you to hand in the full solution to the assignment, e.g., when an exam is scheduled for the same time. In such cases, the assignment is due in class. Assignments not submitted in class can be submitted before 12:00 pm in my office only if you receive my approval in advance. Assignments submitted between 12:00 pm and midnight are subject to a 50% grade reduction. No assignment after the due date will be accepted as I usually post solutions as soon as possible. Assignments will significantly help you in preparing for tests and final exam. Please take this point seriously.

Midterm Exams (40%) Two fifty-minute midterm exams during lecture.

Final Project (15%) See Subsection 6.1 below.

Final Exam (20%) Two-hour comprehensive exam.

Class Participation (0%) But class attendance is required. Class participation may help you when in the boundary of letter grades.

6.1 Final Project

The final project is an important part of this course. The project is where you apply the analysis methods covered in class to a design problem, and you will make a prototype. Some topics/ideas are provided below, but you are welcome to come up with your ideas as well.

- **Energy efficient flashlight.** An output of 9000 lumen or higher; design of the converter(s).
- **Solar oven.** Heat water to generate electricity. You can do a “pizza box solar oven.” Measure and characterize the sun’s irradiation (make a pyranometer). You may want to make some popcorn on the side too.
- **Wind system to power lights and a motor load.** Regulate the voltage of the motor. Show the effect of obstruction of wind on generation output.
- **Operational standalone power system (microgrid).** Include solar, wind, and hydro power with some loads. Aesthetic aspects will be important.
- **Methane Digester.** See [http://www.morrisville.edu/alternativeenergy/methanедigester.aspx](http://www.morrisville.edu/alternativeenergy/methanедigester.aspx)
• **Mini wind farm.** See http://www2.ivcc.edu/mimic/nsf/renewable_energy/Building%20Wind%20Farm-Handbook.pdf. You need to do more elaborate than this, but it gives you a very good starting point.

• **Environmental impacts.** Measurements of GHG and demonstration of their impact in visible and general public-understandable ways, e.g., how temperature changes the amount of dissolved oxygen in water.

Projects should be done in teams of two or three, or in rare and well-justified circumstances, four. In carrying out the project, you can use facilities in the Renewables lab; I will also subsidize the justifiable costs of the project up to a certain maximum. The expenses are auditable so I or WSU may not approve all expenses. The projects will be assessed in comparison to each other as a competition. The project deliverables are as follows.

**Project Title and Team Members.**

**Project Proposal.** The project proposal (maximum one page) includes the title, plan (what you want to build, demonstrate, or report on), and team members of your selected project. It should include a timeline as well.

**Project Progress Report.** A one-page report or bullet list of what you have accomplished.

**Project Presentation and Demo (Last Week of Classes).** It will be important how interesting/creative your project looks to an outsider.

**Project Report.** The project results should be included in a final report in no more than 5 pages. Similar to a standard paper, the report should include title, abstract, introduction, methodology, simulation and results, discussion, future work and conclusion, and references. The project report will be graded according to the following rubric:

40% Presentation and demo

30% Technical correctness Your method and results should be technically sound. Your report should be clear and reader-friendly.

30% English and format Use standard American (not British) English. Specifically, you will be graded according to the handout “Writing in Academia” that is posted on the course website (see http://eecs.wsu.edu/~mehrizi/LIPE_WritingInAcademia.pdf). I encourage you to use the IEEE double-column style. Both \LaTeX{} and Word templates are available on IEEE Author Digital Toolbox at http://www.ieee.org/publications_standards/publications/authors/authors_journals.html. You can choose between Word and \LaTeX{} (or other tools), but to encourage producing beautiful technical documents, submissions that use \LaTeX{} will receive 5% bonus (mark+ = 5%).

7 Academic Integrity

I encourage you to work with classmates on assignments. However, each student must turn in original work. No copying will be accepted. Students who violate WSU’s Standards of Conduct for Students will receive an F as a final grade in this course, will not have the option to withdraw from the course and will be reported to the Office Student Standards and Accountability. Cheating is defined in the Standards for Student Conduct WAC 504-26-010 (3). It is strongly suggested that you read and understand these definitions. Please also see http://academicintegrity.wsu.edu.

8 Students with Disabilities

Reasonable accommodations are available for students with a documented disability. If you have a disability and need accommodations to fully participate in this class, please either visit or call the Access Center (Washington Building 217; (509) 335-3417; Access.Center@wsu.edu) to schedule an appointment with an Access Advisor. All accommodations MUST be approved through the Access Center. For more information, see http://accesscenter.wsu.edu.
9 Safety and Emergency Notification

Washington State University is committed to enhancing the safety of the students, faculty, staff, and visitors. It is highly recommended that you review the Campus Safety Plan (http://safetyplan.wsu.edu) and visit the Office of Emergency Management web site (http://oem.wsu.edu) for a comprehensive listing of university policies, procedures, statistics, and information related to campus safety, emergency management, and the health and welfare of the campus community.

10 Disclaimer

Information contained in this document may and will change as required during the semester. Such changes will be communicated to you via email, in class, and/or on the website. Please make sure you attend all lectures to stay up-to-date. Most course material, e.g., assignments, grades, and extra readings, will be communicated through the website. I encourage you to discuss any difficulties you may have in this course with me or with your TA.