San José State University
Department of Environmental Studies
ENVS 116 Solar Energy Analysis, Spring 2024

Course and Contact Information

Instructor:	Dr. Dustin Mulvaney
Office Location:	Washington Square Hall 115A
Email:	Dustin.mulvaney@sjsu.edu
Office Hour:	12-1:30pm Tuesdays
Class Days/Time:	Tuesday/Thursday 1:30–2:45 pm
Classroom:	Clark Hall
Prerequisites:	ENVS 119, CHEM 001A, PHYS 002A (or equivalent).

Faculty Web Page and MYSJSU Messaging

You are responsible for regularly checking with the messaging system through MySJSU. Course materials such as the syllabus, assignments, readings, and handouts will be found on canvas: https://sjsu.instructure.com

Course Description

This course will provide students with a comprehensive overview of sustainable solar energy resources, economics, and policy. Part one of the course will review the basic knowledge about solar energy physics needed to understand how solar energy technologies work, the biophysical and resource limitations, and sustainable deployment strategies for a solar powered civilization. Part two focuses on the key economic and policy concepts for solar deployment. Part three looks at ecological and environmental justice considerations for sustainable solar energy deployment, while part 4 looks at the potential opportunities and challenges for distributed solar power generation.

Course Learning Outcomes (CLO)

Upon successful completion of this course, students will be able to:

1. *Understand the opportunities and challenges for sustainable solar energy development.*
2. *Understand the principles and fundamentals of solar energy physics.*
3. *Understand and assess the natural resource limitations of solar energy including land and raw materials.*
4. *Describe basic economic and policy principles to solar energy deployment strategies.*
5. *Assess current sustainability trends in the solar energy industry, etc.*

Required Texts/Readings

Textbook

Solar Power: Innovation, Sustainability, and Environmental Justice. University of California Press.

by Dustin Mulvaney, 2019

https://www.ucpress.edu/book/9780520288171/solar-power
https://www.indiebound.org/book/9780520288171
https://www.amazon.com/Solar-Power-Innovation-Sustainability-Environmental/dp/0520288173

Podcast

Energy Transition Show.
https://xenetwork.org/ets/
This is a subscription-based podcast, you can see the pricing options here. Subscribe for four months if you choose that option. There is a 50% student discount. These are incredibly valuable podcasts.
https://xenetwork.org/become-a-member-ets/

Other Readings

Reports, research articles, and book chapters are in pdf format on the canvas site: https://sjsu.instructure.com

Library Liaison

Peggy Cabrera, peggy.cabrera@sjsu.edu

https://libguides.sjsu.edu/environmental_studies

Course Requirements and Assignments

- Assignment #1 Keywords and Concepts from Semiconductor Physics CLO #2
- Assignment #2 Semiconductor and photon physics CLO #2
- Assignment #3 Bringing Solar PV to grid parity CLO #1, 4
- Assignment #4 Solar Energy Farms and Sustainability CLO # 1, 3, 5
- Assignment #5 Solar Trade War policy memo CLO #1, 2
- Final Group Project CLO # 1, 2, 3, 4, 5

Final Examination or Evaluation

The final exam will be a combination of short answers, multiple choice, true/false, and essay questions.

Grading Information

20% Participation. Share your thoughts about the readings, ask thoughtful questions, answer discussion prompts. Keeping good notes about the main points or views taken by authors is a good means a facilitating a sustained discussion. You will also be asked to work in small groups now and then in class, and you will be expected to be a contributing member to your group. Prepare for class and keep a **notebook**. You can use the one you may have started in ENVS 119. Come to class having completed the readings and note something important in your notebooks. Students will be called upon in class, and marked for preparations. Keep an organized notebook and maintain short annotations on the readings. You should have this in all of your information in one place when you come to class. Make sure to bring the assigned readings each class or have the pdf readily available. You will you write a short summary of every article and keep notes on conversions, statistics, and other information on energy. If you take notes in the margins of your readings make sure to transfer important ones to your notebook. These notebooks may be evaluated to gauge your engagement with the readings and lectures.

30% Assignments: There will be five assignments that must be completed.

15% Midterm: The midterm and the final exams will be open notebook. The tests will include short answer, multiple choice, problem sets, and essay questions. However, you will not have access to any electronic devices (other than a calculator) and you will not have access to the canvas site. You must bring a calculator to the examinations. To study for the tests, you should review the readings, course lecture notes, homework, and learning objectives well in advance of the test date. The midterm will include material covered during the first portion of the class. We will include both multiple choice and problems related to the scientific principles of energy, heat, and work. You are encouraged to review the problems sets before the midterm.

20% Final Research Project: Students will develop a group research project related to solar energy technologies. More details on this assignment will be available on the course website.

How to Give a Bad Talk.docx

Wired 11.09: PowerPoint Is Evil.pdf

15% Comprehensive Final Exam: There will be a comprehensive final exam covering the entire course.

Determination of Grades

The course grade will be determined based on a total 100 possible points. Accumulated points that fall within the grade scale below determine your semester grade. +/- letter grades are used. Extra credit opportunities will be announced and described in class and over email. Late work will lose 10 points per day late.

A+ 97–100	A 92–96	A- 89–91	B+ 86–88	B 81–85	B- 79–80	C+ 76–78
C 72–75	C- 69–71	D+ 67–68	D 64–66	D- 60–63	F < 60	

Classroom Protocol

You are expected to come to every class on time as class will begin promptly. Classroom participation via conversation or online discussion will be reflected in your final grade.

University Policies

Per University Policy S16-9, university-wide policy information relevant to all courses, such as academic integrity, accommodations, etc. will be available on Office of Graduate and Undergraduate Programs' Syllabus Information web page at http://www.sjsu.edu/gup/syllabusinfo

ENVS 116 Solar Energy Analysis

Course Schedule

Module	Topics, Readings, Assignments, Deadlines
1	**Course introduction and history of solar energy**
2	**Solar Energy & Sustainability Science** • Mulvaney, D., 2014. Solar's green dilemma. *IEEE Spectrum*, 51(9), pp.30–33. • Hernandez, R. et al. 2019. Techno–ecological synergies of solar energy for global sustainability. Nature Sustainability 2: 560-568. https://www.nature.com/articles/s41893-019-0309-z.epdf?shared_access_token=q5fbWdnZc7SSrhak43MzndRgN0jAjWel9jnR3ZoTv0O7y_9FhGL6X3hdTiSabzptkEZ30NN85gDVSn-sEYgbSuZ1tQQm2hXAq-Bcicysi_58WdCsQYbzYqw0t4jQJE5bQGRsLOMhW4b1dXGavcy3ng%3D%3D *Keywords: industrial ecology, industrial ecology, thin films, crystalline silicon, green chemistry, trichlorosilanes, polysilicon, principles of sustainable design.*
3	**Solar Physics I: nature of electromagnetic radiations and interactions with matter** Nelson 2003. Physics of solar cells. *Keywords: photons, electrons, electron holes, absorption, conductive band, solar radiation, absorption, thermal utilization, array, modules, n-type, p-type, pn-junction, open circuit voltage, simple circuit, short circuit current density.*
4	**Solar Physics II: pn-junctions & photovoltaic semiconductors** PV Education. Chapter 3. https://www.pveducation.org/pvcdrom/pn-junctions/semiconductor-materials *Keywords: absorption, conductive band, valance band, band gap, quantum efficiency, Shockley Quiesser limit, Fill factor, Rated Power, IV curves, direct/indirect semiconductors,*
5	**Solar Energy Physics III: Color, band gap, PV technologies** *More on PN junctions , band gaps, & Fermi energy* *Semiconductors- Band Gaps, Colors, Conductivity and Doping* **Assignment 1 due.** *Keywords: Extrinsic v. intrinsic semiconductors, absorbed light versus colors, CIGS, CdTe, perovskite, dye-sensitized/polymer solar cells, Czochralski method, mono- & poly-crystalline.*
6	**PV Economics I** • Branker, Pathak, & Pearce, 2011. A Review of Solar Photovoltaic Levelized Cost of Electricity, *Renewable and Sustainable Energy Reviews*, 15: 4470–82. http://dx.doi.org/10.1016/j.rser.2011.07.104 • NREL LCOE calculator

Module	Topics, Readings, Assignments, Deadlines
	• Podcast: The future of solar - interview with Adam Browning • Timilsina. 2012. Renewable and Sustainable Energy Reviews.pdf • Podcast [Episode #72] – The Future of Solar - interview with Adam Browning Alternate link *Keywords: LCOE, grid parity, break-even point*
7	**PV Economics II** • Manage Podcast [Episode #87] – The Value of Flexible Solar • Confronting the Duck Curve: How to Address Over-Generation of Solar Energy • A Primer on Wind and Solar Value Deflation • California Solar Energy Statistics and Data *Keywords: LCOE, grid parity, break-even point*
8	**Solar Policy I** • Mulvaney, D. 2019. Solar Power, Chapter 1 & 2 • Everything you need to know about California Net Metering 2.0 in 2020 • DSIRE USA Policy Database *Keywords: EPBT, EROI*
9	**Solar Policy II** **Assignment 2** • Mulvaney, D. 2019. Solar Power, Chapter 3 • Everything You Need to Know About California's New Solar Roof Mandate *Keywords: FIT, net metering, pigouvian taxes*
10	**Solar Policy III** • Net Energy Metering (NEM) is a Critical Policy for Enabling Distributed Solar • Listen podcast: [Episode #58] – Solar with Storage *Keywords: TOU pricing, solar investment tax credit, PACE*
11	**Natural Resources I: Material requirements for PV** • Science-2010-Zweibel-699-701.pdf • [Episode #132] – The Future of Solar
12	**Natural Resources II: PV recycling, product stewardship, and green design** • Mulvaney, D. 2019. Solar Power, Chapter 4 • Listen [Episode #99] – Metals Supply in Energy Transition • Larsen, K. 2009. End-of-life PV then what? *Renewable Energy Focus.* *Keywords: Circular economy, industrial ecology*
13	**Land Use I: Energy sprawl & ecological impacts of solar farms** • Mulvaney, Solar Power, Chapter 5 • Lovich, J. E. and J. R. Ennen. 2011. "Wildlife Conservation and Solar Energy Development in the Desert Southwest, United States." *BioScience* 61(12): 982–92 • Hernandez et al. 2014 RSER.pdf

Module	Topics, Readings, Assignments, Deadlines
	• Explore (optional): USGS • Podcast: Solar Power *Keywords: Land-energy-ecology nexus, wildlife and land use impacts.*
14	**Land Use II: Energy sprawl & ecological impacts of solar farms** • Read: Grodsky and Hernandez-Reduced ES of desert plants from ground-mounted solar-NatureSustainabilityJuly2020.pdf • Mulvaney, D. (2017). Identifying the roots of Green Civil War over utility-scale solar energy projects on public lands across the American Southwest. *Journal of Land Use Science*, *12*(6), 493-515. *Keywords: social gap in renewable energy, energy siting policy*
15	**Land Use III: Public Acceptance of Solar Farms; cultural & agricultural resources** • Elkind, E. et al. 2016. A Path Forward: Identifying Least-Conflict Solar PV Development in California's San Joaquin Valley. Berkeley, UC Berkeley School of Law's Center for Law, Energy & the Environment (CLEE). https://www.law.berkeley.edu/wp-content/uploads/2016/05/A-PATH-FORWARD-May-2016.pdf • Hoffaker et al. 2017. *Keywords: Public participation, techno-ecological synergies, low conflict solar land*
16	**Land Use IV: Western Solar Plan and National Environmental Policy Act** • Mulvaney, D. 2019. Solar Power, Chapter 6 • Green Light Study Economic and Conservation Benefits of Low-Impact Solar Siting in California • Western Solar Plan • DRECP • Nevada_SNDO_Renewable_Energy_Application_Process_Presentation.pdf
17	**Solar Policy IV Procurement, Standards, Corporate Social Responsibility, Environmental Justice.** • PVSEC-IEEE PV Specialists.pdf • FirstSolar Sustainability Report.pdf • Luke & Heynen, Community Solar as Energy Reparations: Abolishing Petro-Racial Capitalism in New Orleans.pdf • Lennon 2017.pdf • OPTIONAL: Biello, D. (2010). "Explosive Silicon Gas Casts Shadow on Solar Power Industry." *Scientific American* Retrieved April 4, 2010, from http://www.scientificamerican.com/article.cfm?id=explosive-gas-silane-used-to-make-photovoltaics • SolarWorld: GRI Reporting. http://www.solarworld.de/index.php?id=360&L=1 • First Solar: Carbon Disclosure Project Report; http://www.firstsolar.com/Sustainability/Environmental • SunPower: Sustainability Report http://us.sunpowercorp.com/about/sustainability/

Module	Topics, Readings, Assignments, Deadlines
	• SEIA: http://www.seia.org/policy/environment/sustainability/solar-industry-environment-social-responsibility-committment SVTC. Scorecard. Life Cycle of PV http://svtc.org/solarlifecycle/ www.solarscorecard.org
	Midterm
18	**Solar Industry Trade Disputes and Global Commodity Chains** • Gunther, M. 2017. Could a Trade Dispute with China Bring an End to U.S. Solar Boom? Yale Environment 360 https://e360.yale.edu/features/could-trade-dispute-with-china-bring-an-end-to-u-s-solar-boom • Mulvaney, D. 2019. Solar Power, Chapter 7 OPTIONAL: • China Says U.S. Solar Ruling Will Hurt Clean Energy Development. http://www.bloomberg.com/news/articles/2015-01-21/u-s-trade-panel-triggers-penalties-on-china-taiwan-solar-gear • A Trade War Over Cheap Chinese Solar Panels: Protecting American Ingenuity or Needlessly Raising Prices? http://greenenergyinstitute.blogspot.com/2015/01/a-trade-war-over-cheap-chinese-solar.html
19	**Life Cycle Assessment I & 2** • Fthenakis & Kim. 2010. PV Life Cycle Analyses. Solar Energy. • Fthenakis 2008
20	**Solar Power & Wildfire** • California To Fight Wildfires With Microgrids And Batteries • RMI Grid Defection.pdf • Wildfires and blackouts mean Californians need solar panels and microgrids Distributed energy is the path to resilience • Some Wonder if Electric Microgrids Could Light the Way in California • What We Could Be Doing to Avoid Blackouts • Podcast Transition show: [Episode #102] – Transition as Wildfire Adaptation in California
21	**Solar Power and the Just Transition** • Mulvaney Solar Power. 2019. Chapter 8.