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Climate teaching tidbits[a)] FREE

Special Collection: Teaching about the environment, sustainability, and climate change

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Climate teaching tidbits[a)]

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The *AJP* editors have assembled some short teaching tips for your use.

ASSESSING HOME SOLAR ENERGY

Solar photovoltaics have reached break-even cost in many parts of the U.S., making it interesting—and possibly even useful—for students to assess the cost of photovoltaics for their own homes as a project. A calculator provided by the National Renewable Energy Laboratory allows students to draw a photovoltaic installation on a satellite image of their own roofs and determine the size of the installation and the expected output.[1] (If you want to ask students to do more work, they can instead start with solar insolation data from weather records, but the calculations for tilt and orientation angles are tricky.) Then students can get information on the cost of system installation, either records from a state energy agency or from a commercial site such as Ref. 2. Be careful to distinguish between costs before or after subsidies. Many sites offer to calculate tax credits and other incentives, but they get out of date quickly, so I ask students to find the local, state, and federal websites describing the incentives. It's also important to check the terms for net billing from the utility, since some states have limitations.

Based on these costs, students can calculate a cost per kWh of electricity produced and compare it to the current costs. It would be possible to include financing costs, but it's also reasonable to guess that the increase in electricity costs over time balances the financing costs. You may also want to ask students to calculate the cost without subsidies and discuss the reasons for subsidies, including kickstarting an industry and accounting for the true costs of electricity,[3] as well as the argument against subsidies that they only benefit the wealthy.

EUNICE NEWTON FOOTE

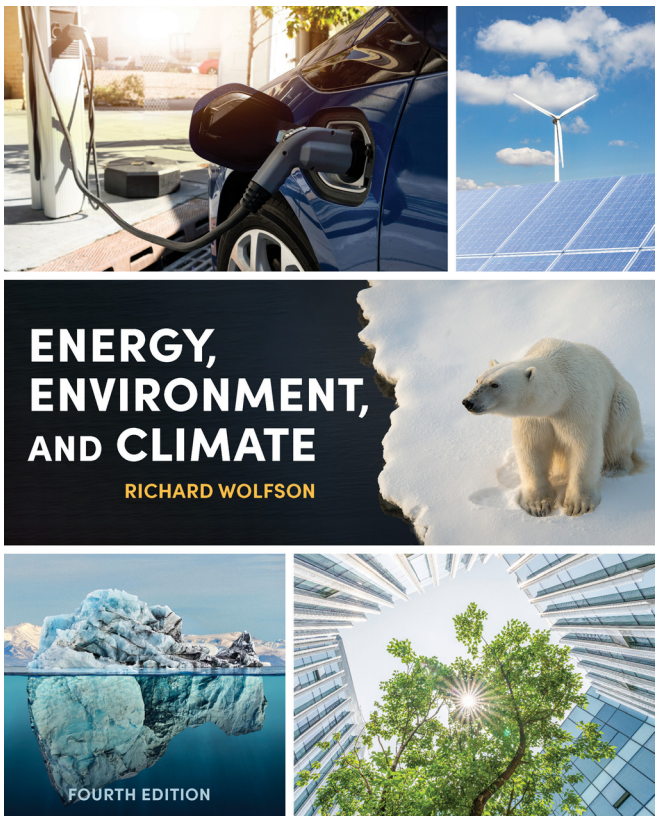
An interesting example of the way science has often ignored or forgotten women scientists is the case of the climate scientist Eunice Newton Foote. Although she published the results of her experiments on the heat absorption of various gasses (including carbon dioxide and water vapor) in 1856 and was praised in an early issue of *Scientific American* for her work, John Tyndall was given credit for the discovery of what later became known as the "greenhouse effect." Foote's work, which was also reported at a meeting of the American Association for the Advancement of Science, was published three years earlier than Tyndall's. As this podcast describes, Foote's investigations were rediscovered in 2011, and she now is receiving credit for showing that Earth's surface is heated by atmospheric gasses that absorb radiant energy from the sun.[4]

THE ARGONNE GREET MODEL

Developed by scientists at Argonne National Laboratory and sponsored by the U.S. Department of Energy, the GREET (Greenhouse gasses, Regulated Emissions, and Energy use in Technologies) model is a tool for analyzing emissions and the total well-to-wheel energy use of various combinations of fuel, fuel source, and engine technology.[5] The spreadsheet requires registration to download but is otherwise free and can be used by students to compare, for example, a hypothetical hybrid diesel car with a fuel cell car powered by hydrogen from renewable energy. The spreadsheet is somewhat complicated but not beyond the abilities of junior level physics majors as an extended homework exercise or semester project.

ENERGY, ENVIRONMENT, AND CLIMATE

The fourth edition of Richard Wolfson's *Energy, Environment, and Climate* has just been published by W. W. Norton.[6] The new edition is a major update to this textbook, which is aimed at beginning to mid-level undergraduates in science and nonscience majors alike. The book starts with a grounding in Earth's history and the planet's fundamental energy resources, a survey of human energy use, and two chapters on the physics of energy, including the all-important second law of thermodynamics. Subsequent chapters detail the energy sources and technologies available to humankind and include an expanded chapter on the energy



carriers electricity and hydrogen and especially their roles in transportation. The last five chapters cover the science of climate, including the greenhouse effect, human alteration of climate, climate modeling and attribution, and future climates. The final chapter brings together energy and climate and spells out the urgent need to break the link between them. The fourth edition includes a discussion of the IPCC's Sixth Assessment Report.

Each chapter features end-of-chapter questions, quantitative exercises, and research problems. New to this fourth edition is a "Science Meets Policy" box in every chapter, relating the science content to contemporary policy issues.

A GLOBAL WARMING PRIMER: ANSWERING YOUR QUESTIONS ABOUT THE SCIENCE, THE CONSEQUENCES, AND THE SOLUTIONS

Jeffrey Bennett's *A Global Warming Primer* is just that—a simple description of the facts and consequences of global warming.[7] It was published in 2015 but is not particularly dated. The dearth of equations and problems limits its usefulness in the classroom, but the focus on data (including many clearly explained graphs) makes it valuable in its arguments.

There are four chapters. The first is a clear and simple description of global warming, and why there is no scientific doubt about its existence. The second is a description of the skeptics' debate. Bennett tries to be fair and refrains from cheap shots and name calling, though there is no doubt about his position. This section might help those who are not certain about global warming understand the issues, but it won't change the minds of any skeptics. The third chapter describes phenomena related to global warming and their consequences—ocean acidification, increased forest fires, and so on. This chapter depends heavily on climate models and will be even less convincing to confirmed skeptics. In the fourth chapter, Bennett presents his own ideas for a solution. Many will disagree with his determined optimism and his positive ideas about nuclear fission and fusion. Finally, the last chapter asks readers to write a letter to their grandchildren, explaining their own decision.

This is not a book for scientists—the arguments presented are familiar. The very clear explanations might be useful in helping us develop our own explanations to others, or it might be a book you would give to a relative to help them understand and respond to the climate crisis.

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[1]<https://pvwatts.nrel.gov>.
[2]<https://www.energysage.com>.
[3]Erica Gies, "The real cost of energy," Nature 551, S145–S147 (2017).
[4]<https://www.aip.org/initialconditions/eunice-foote-once-forgotten-climate-science-pioneer>.
[5]Energy Systems and Infrastructure Analysis, Argonne National Laboratory, <https://greet.es.anl.gov>.
[6]Richard Wolfson, *Energy, Environment, and Climate*, 4th ed. (W.W. Norton, New York, 2023).
[7]Jeffrey Bennett, *A Global Warming Primer: Answering Your Questions about the Science, the Consequences, and the Solutions* (Big Kid Science, 2016).