Sustainable Energy Technologies: Do They Fit Into Undergraduate Electrical Engineering Education?

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Outline

- Case study: starting a new course in photovoltaics at SDSU
- The leading arguments against the course, and how they were defeated ***in this case***
- Sources of student interest in PV
- Are there sufficient resources to teach this subject at the undergraduate level?
- Conclusion: does the course work?

Case study: a PV course at South Dakota State University

The course:

EE492: Photovoltaics as a Practical Power Source

Course objectives:

- ☑ to introduce sustainability concepts--***efficiency***
- ☑ to provide students familiarity with PV technology
- ☑ to introduce system engineering concepts
- ☑ to provide a hands-on design project (students will design and install a PV system as the final course project)

Case study: a PV course at South Dakota State University

A secondary ("hidden") objective:

to promote student interest in the area of electric power

A problem in the field of power engineering education[1]:

- Student interest in the power area is waning
- University offerings in power are declining
- Simultaneously, the industry is rapidly changing, and new power engineers are needed

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One solution: capitalizing on student interest in photovoltaics

- ☑ Student interest in photovoltaics is relatively high
- ☑ PV can be used to teach power electronics, system design, control concepts, utility interface issues, codes and standards, etc….

Arguments against sustainable energy technology at the undergraduate level

The main counterargument:

The curriculum is already too full, and sustainable energy technologies should not take precedence over any part of the existing curriculum because they are "not industrially relevant".

The question: What should we displace?

- ☒ Fiber optics?
- ☒ VLSI design?
- ☒ Communications engineering?
- ☒ Networking?

Also… the "voice of dissent"

A more troubling counterargument:

Our current progress is sustainable; technology will always come to the rescue to solve the ills caused by technology.

- ☒ Why this point is hard to refute:
  the historical evidence generally supports it.
  - ☐ Example: Oil exhaustion times have increased since 1970[5]

Proven world oil reserves in 1970: **600 billion barrels**

Proven world oil reserves in 2000: **1000 billion barrels**

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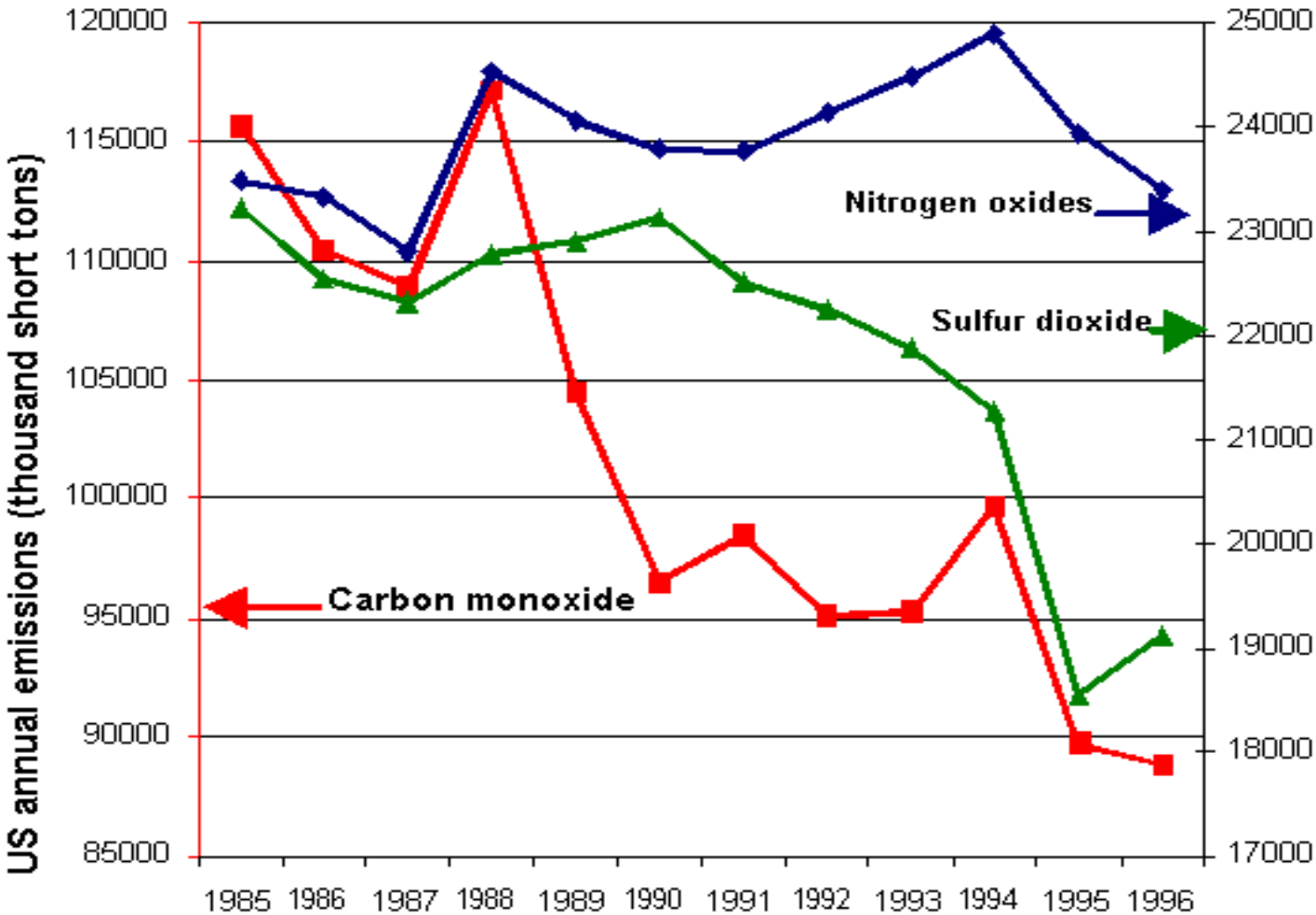
- ☒ Also, conservationists' and sustainability advocates' predictions are notoriously bad[7].
  - ☐ Human race extinct by 1930--predicted in 1830
  - ☐ No oil by 2000--predicted in 1975
  - ☐ Widespread famine in 1980s--predicted in 1978
  - ☐ Predictions about the universal use of PV and "free solar power" have been made since the demonstration of the selenium cell in 1954

But what about the environment?

- The environment is actually getting ***cleaner***[6].



Source: Environmental Protection Agency

Seeking a trend: looking at the Top Ten

Rank/School name (State) as ranked by U.S. News and World Report 2000	Academic reputation score (highest = 5.0)	Course on sustainable energy technology in EE?
1. Massachusetts Inst. of Technology	4.9	No
2. Stanford University (CA)	4.7	Yes[1]
2. University of California–Berkeley*	4.7	No
4. California Institute of Technology	4.6	No
5. U. of Illinois–Urbana-Champaign*	4.5	No[2]
5. University of Michigan–Ann Arbor*	4.5	No
7. Cornell University (NY)	4.4	Yes[3]
7. Georgia Institute of Technology*	4.4	
9. Carnegie Mellon University (PA)	4.3	No
9. Purdue Univ.–West Lafayette (IN)*	4.3	No
9. University of Texas–Austin*	4.3	No[4]

*Public school.

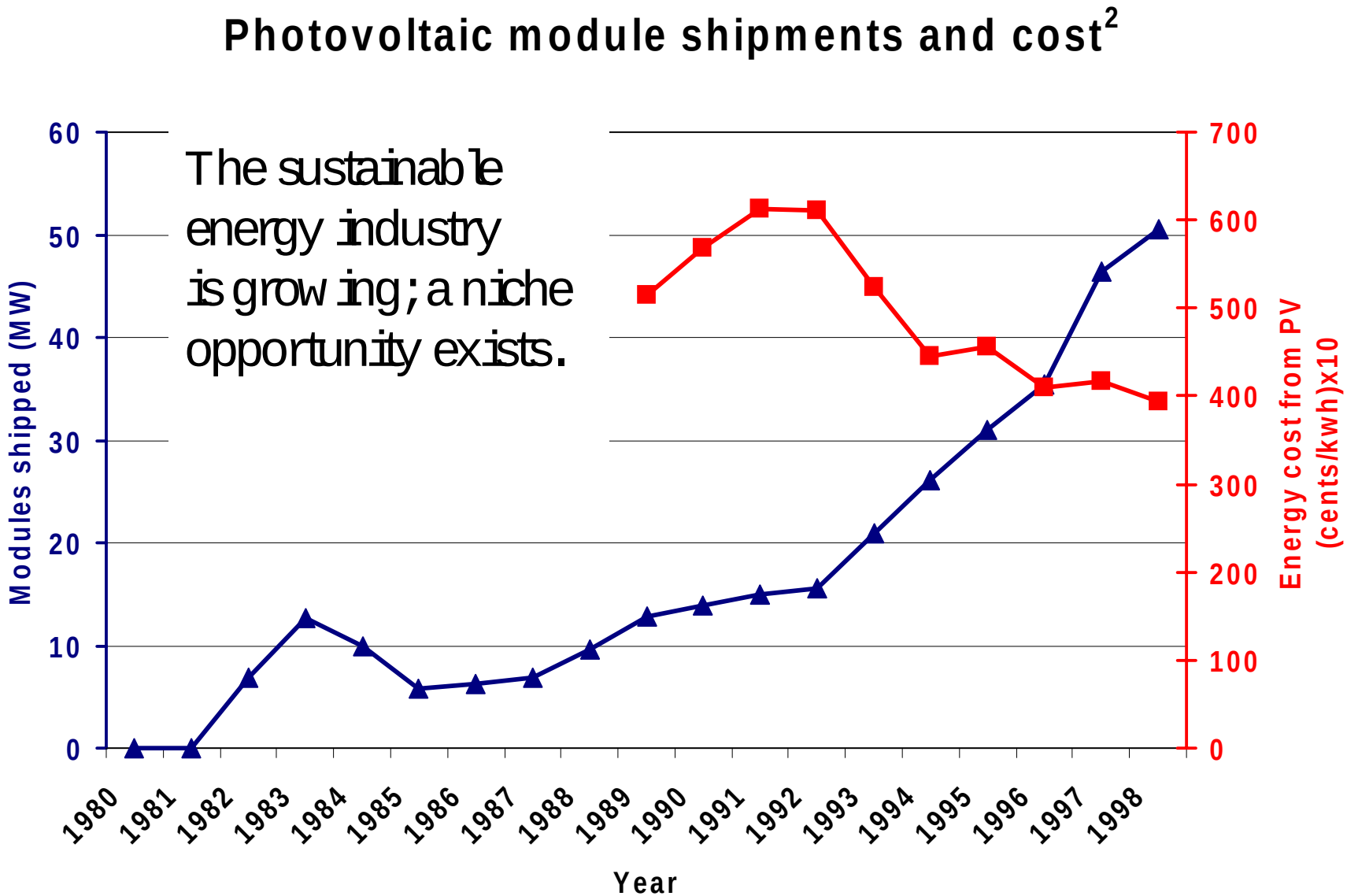
[1]Stanford offers EE293A/B, “Energy Conversion Fundamentals”, that can include fuel cells, windpower and PV.

[2]UIUC offers courses on nuclear fission and fusion technology.

[3]Cornell’s Energy Seminar, ELE E 587, *can* include sustainable energy technologies.

[4]UT-Austin offers EE367L, “Nuclear Medicine/Energy/Wastes: Ethical Issues”.

The key to getting the course offered



What the heck is sustainability, anyway?

My favorite definition:

"Sustainable development is development that meets the needs of the present generation without compromising the ability of future generations to meet their needs."

J. Peet, Energy and the Ecological Economics of Sustainability, Island Press 1992

Most definitions rely on determining things like "needs" and on predictions of future events and "needs"; very hard to actually *use*.

Defining sustainable energy technologies

Basis for selection:

Sustainable energy conversion technologies are defined to be *those technologies that convert an ambient energy source* to a desired form. Thus, the eligible sustainable energy conversion technologies:

- ☑ photovoltaics
- ☑ windpower
- ☑ fuelcells
- ☑ hydropower
- ☑ geothermalpower

Conspicuous omissions:

- 💣 nuclear power
- 💣 naturalgas

Why the student interest?

A great deal is being done to energize K-12 students coming into college programs. Photovoltaics:

- ☑ Educational materials and experiments
  - ✓ EnergySmart Schools (DOE)
  - ✓ CREST
  - ✓ Solar Now

- ☑ Support for school building PV systems
  - ✓ Schools Going Solar (UPVG)

- ☑ Contests
  - ✓ DOE Junior Solar Sprint
  - ✓ International Solar Car Race
  - ✓ IEEE PVSC High School Design Competition

Why the student interest?

A great deal is being done to energize K-12 students coming into college programs. Windpower:

Elementary and high schools in the Northern Plains States are installing wind turbines to feed energy back into the school building.

No net energy to the utility; all consumed on-site. Schools receive tax credits and energy savings; educational programs center on the turbines and associated systems.

Why the student interest?

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Sunrayce

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SolarSplash

Are there sufficient resources?

For PV and windpower, yes--these technologies *could* be taught at the undergrad level.

- ☑ Both are mature technologies.

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☑ They are based on principles that that undergrad students know.

- ✓ Photovoltaic effect is taught in most undergrad materials and semiconductor devices classes.
- ✓ Electromechanical energy conversion is still a required course in most (?) undergrad curricula.

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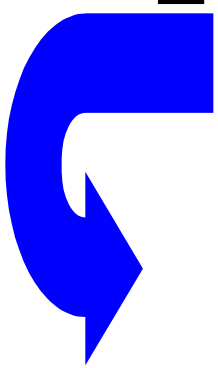
- ☑ They are based on principles that that undergrad students know.
- ☑ Good textbooks are available that cover them.



- ✓ Green, Solar Cells; Messenger, Photovoltaic Systems Engineering; Markvart, Solar Electricity
- ✓ Heier, Grid Interconnection of Wind Energy Conversion Systems

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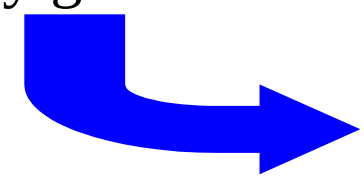
- ☑ Both are mature technologies.
- ☑ They are based on principles that that undergrad students know.
- ☑ Good textbooks are available that cover them.
- ☑ Their support technologies are also relatively mature and covered by good books.



- ✓ Power electronics
- ✓ Battery storage
- ✓ Codes and standards

Conclusion: does it work?

So far, so good...

- ☑ Sustainable energy courses at Stanford fill up each semester[8] (and, as we've heard, so does the grad-level one at MIT)
- ☑ The PV course at SDSU will have well above the minimum enrollment in its first offering
- ☑ Bottom line: student interest can sustain a sustainability course
- ☑ Does it encourage power-related studies? Don't know yet.

References

[1] B. Chowdhury, “Power Engineering Education at the Crossroads”, *IEEE Spectrum* October 2000, p. 68.

[2] USDOE Energy Information Administration WWWeb site, http://www.eia.doe.gov.

[3] J.B. Peatman, Design with PIC Microcontrollers, Prentice-Hall 1998, and assuming an average of $10/microcontroller.

[4] Georgia Institute of Technology Center for Image and Signal Processing, private communication.

[5] J. H. Ausubel, D. G. Victor, I. K. Wernik, “The Environment Since 1970”, *Consequences* **1**(3) 1995.

[6] U.S. Environmental Protection Agency.

[7] J. McCarthy, “Progress and Its Sustainability”, http://www-formal.stanford.edu/jmc/progress/index.html.

[8] Stanford University Department of Electrical Engineering, private communication.

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