ENERGY

Can Civilization (at Least the U.K.) Run Sustainably?

Marty Hoffert

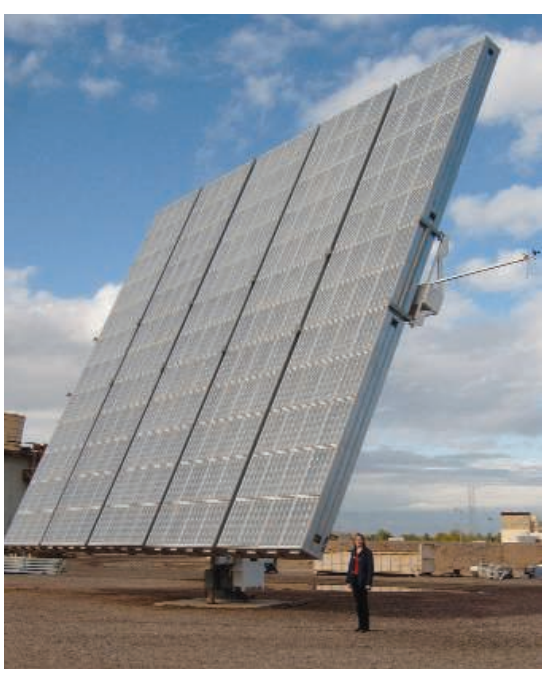
Sustainable Energy
Without the Hot Air
by David J. C. MacKay
UIT Cambridge, Cambridge, 2009. 384 pp. £45. ISBN 9781906860011. Paper, £19.99. ISBN 9780954452933. (*1*)

Much that passes for serious discussion of energy and climate policy in legislative halls is "hot air." It is hard to understand the scale of effort needed to transition by midcentury from fossil fuel combustion with CO_2 up the stack or out the tailpipe to "something else" (what some call the terawatt challenge) or what energy "sustainability" or "self-sufficiency" even mean, if one is unwilling to think about actual numbers.

Cambridge physics professor David MacKay doesn't assume fear and loathing of arithmetic: His *Sustainable Energy: Without the Hot Air* is a cold blast of reality that hits hard with numerical estimates, data, and logic. He offers a must-read analysis of cars, jet flights, heating and cooling, food, and manufactured "stuff" on the consumption side, and of energy-generation technologies that might replace fossil fuels on the supply side, in the United Kingdom. For that island country, he delves into the specifics for solar thermal (using sunlight for direct heating), photovoltaics (on rooftops and in "farms"), wind (on land and offshore), biofuels, and tides as well as coal with carbon capture and storage (CCS) and nuclear power. He also covers the critical role of storage in limiting large-scale solar and wind power sources.

McKay holds it instructive to express power in kilowatt-hours per day, and he patiently explains to general readers that we don't say watts (or kilowatts) "per" anything. Fine. In my experience, units for energy and power are endless sources of confusion for students. But the author's use of kilowatt-hour/day doesn't distinguish between electrical and thermal energy. All kilowatt-hours may be equal, but some are more equal than others—with due credit to Sadi Carnot and George Orwell. A rule of thumb is that generating an electrical kilowatt-hour takes about three thermal kilowatt-hours, which might have been worth taking into account.

One challenge in preparing these back-of-the-envelope analyses is deciding what principles limit a given technology. We know, for example, that we may need some 30 terawatts from carbon-neutral sources by midcentury to meet the world's business-as-usual economic targets while staying below the 2°C global warming limit adopted by most nations. Let's say we target a third from renewables, a third from coal with CCS, and a third from fission. MacKay correctly estimates the nuclear fuel extractable from oceans (from the parts per billion concentration of dissolved uranium and ocean volumes) as huge compared with reactor-grade ores. But to provide fuel rods to run ^{235}U thermal reactors at 10 terawatts, the flow through hypothetical collectors in the sea would have to be an order of magnitude greater than the outflow of all the world's rivers (*2*). Nuclear reactors have been proposed as the only serious contender to avoid carbon emissions (*3*), so it is important to understand that the insufficiency of known uranium supplies for "once through" reactors argues for uranium and thorium breeders.



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Scope of the problem. This concentrator photovoltaic collector can generate 138 kilowatt-hours per day, half the energy consumption of an average American.

I found MacKay's book by turns exhilarating and terrifying. His calculations are always thought-provoking even when his assumptions had me banging the table in disagreement. My objections often faded as his analysis unfolded. The author dug out a lot of hard-to-find data, and his intelligence, wit, and excellent British humor are in evidence throughout. Some readers—but not Al Gore, who employs offsets to maintain carbon neutrality as he trots the globe—may be surprised that taking even a few jet flights uses as much energy as an average year of car driving.

The author doesn't consider cost or socioeconomic factors, just physics and engineering. With this caveat, MacKay finds there's barely enough "green" power to meet demand in the United Kingdom. But he doesn't believe Britain can live on its own renewables because there is too much opposition due to the costs and not-in-my-backyard arguments. Sustainability is achievable, he concludes, with sun power imported from the Sahara. For the United States, others have independently proposed using high-voltage direct current lines to transmit solar-generated power from Southwestern deserts to the coasts, a "grand plan" that raises well-known issues of transmission and storage (*4*). Continuous solar electricity from space beamed to Earth offers another possibility—and another story (*5*).

Shifting primary power production away from fossil fuels will require substantial investments in energy research, development, demonstration, and deployment. We now have in the United States an administration that understands both the science and the urgency. But I share McKay's concern that for the public at large this is no done deal:

> Given the general tendency of the public to say "no" to wind farms, "no" to nuclear power, "no" to tidal barrages—"no" to anything other than fossil fuel power systems—I am worried that we won't actually get off fossil fuels when we need to. Instead, we'll settle for half-measures: slightly-more-efficient fossil-fuel power stations, cars, and home heating systems; a fig-leaf of a carbon trading system; a sprinkling of wind turbines; an inadequate number of nuclear power stations.…
>
> We need to stop saying no and start saying yes. We need to stop the Punch and Judy show and get building."

Amen. Meanwhile, read *Sustainable Energy*.

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ARCHAEOLOGY

Arguments over Early Arrivals

Tim Flannery

First Peoples in a New World
Colonizing Ice Age America
by David J. Meltzer
University of California Press, Berkeley, 2009. 480 pp. $29.95, £20.95. ISBN 9780520250529.

David Meltzer's *First Peoples in a New World* is a double history: an investigation into the initial colonization of the Americas as well as a chronicle of the controversy some finds have engendered. The skeleton of "Kennewick Man," collected in Washington state in 1996 by local archaeologist James Chatters, was particularly fraught. Chatters concluded the remains were those of a middle-aged European. But when dating revealed them to be over 8400 years old, local Indians accused Chatters of forging the European identity to dodge the Native American Graves Protection and Repatriation Act, and an ongoing court case ensued. The idea that Kennewick Man had anything to do with Europe was long ago dismissed in academic circles, but the claim that the Americas were first populated by Caucasians has, according to Meltzer, "seeped into ... the poisonous corners of the Internet where white supremacists continue to claim Kennewick as one of their own."

Meltzer (an anthropologist at Southern Methodist University) argues that America was discovered long before the arrival of the Clovis big-game hunters around 11,200 radiocarbon years ago. (All dates in the book are given in uncalibrated radiocarbon years, although a table allows conversion to calendar years.) This is a contentious position, and the author confesses a partisan stance. Because archaeologists can devote entire careers to excavating a single site, their funding, academic status, and egos can become inextricably tied up with it. James Adovasio claims that Meadowcroft Rockshelter in Pennsylvania had humans living in it by 14,250 radiocarbon years ago, making it the oldest (and only pre-Clovis) site on the continent. A colleague said that he would accept the finding if Adovasio would date a single seed from the critical layer, a request that caused Adovasio to "burst out in derisive laughter" before saying that he would never "accede to any request [his colleague] made for further testing."

The linchpin in Meltzer's argument for a pre-Clovis presence in the Americas is Monte Verde in southern Chile. One of the most extraordinary archaeological sites ever discovered, it has yielded wooden artifacts, human footprints and feces, and pieces of skin and meat from large mammals, all preserved in a bog that radiocarbon dating suggests is around 12,500 years old. In 1997, senior American archaeologists conducted a site visit, which was not entirely satisfactory because excavations had removed almost everything, forcing a shift to collections in museums and labs. Drinks at a tavern afterward saw Monte Verde excavator Tom Dillehay become "short-tempered, even insulting." A row broke out, but not before a show of hands unanimously confirmed Monte Verde as a pre-Clovis site. Although that unanimity has since crumbled, Meltzer continues to argue that Monte Verde is where "the standards of proof" for a pre-Clovis presence "were finally met." However, only radiocarbon dating was done at Monte Verde. Because every dating technique has its own imbedded assumptions (which can lead to error), it's preferable to use multiple methods at such important sites. Optically stimulated luminescence dating and electron spin resonance dating of relevant materials would arguably have shed more light on the age of Monte Verde than a show of hands.

Meltzer devotes much space to explaining why archaeologists have not discovered undisputed pre-Clovis sites north of Chile. Perhaps the people stuck to a coastline now submerged by rising seas or archaeologists are looking in the wrong places. Yet it's striking that excavators have retrieved over 13,000 Clovis points from across North America, yet have been unable to conclusively identify a single site dating to even a few centuries earlier. Archaeologists in Australia and Europe have no such difficulty.

Meltzer discounts Paul Martin's theory that hunting by the Clovis people led to the swift extinction of America's megafauna, but his analysis is based on a selective reading of the evidence. It takes no account of the global pattern of large animal extinction following on the heels of human arrival, nor of the survival until after 8000 years ago of megafauna on islands—including dwarf mammoths on St. Paul Island off Alaska and the sloths and giant rodents on Caribbean islands, all of which go extinct only when humans arrive. And Meltzer never articulates a convincing alternative hypothesis capable of explaining how climate or some other factor could have caused the extinctions. The spores of a fungus that grows on the dung of large herbivores provide a new method with the potential to shed light here. Studies suggest that the spores declined abruptly 10,800 years ago in North America (indicating a collapse of mammalian biomass); a few decades later, there is evidence for an increase in fire. This is the kind of fine resolution required to help untangle the causes of megafaunal extinction.

The questions Meltzer raises in *First Peoples in a New World* are, from a technological perspective, eminently answerable. But doing so will require a broader array of analytical tools than seem, judging from this book, to be currently in use in American archaeology. A more global perspective on the problem would also be helpful.

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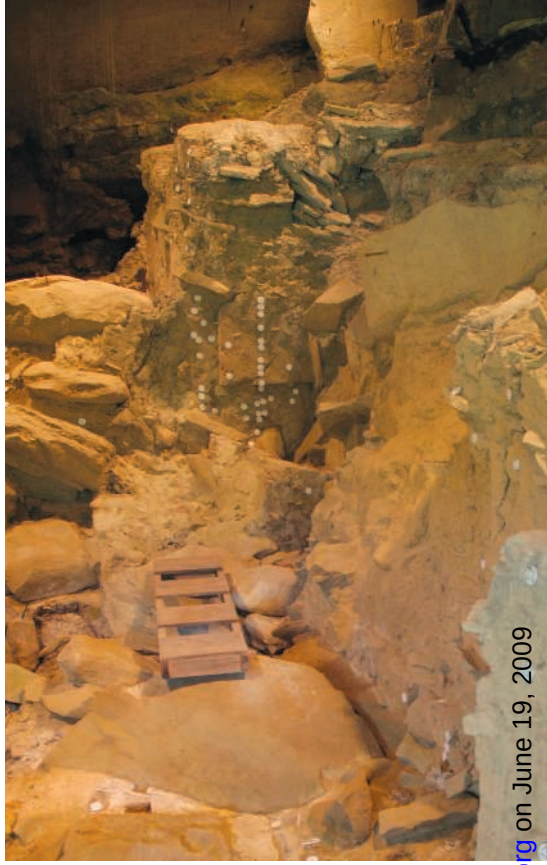

"In archaeological limbo." The Meadowcroft Rockshelter, western Pennsylvania.

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