(the one responsible for the radioactive decay of the neutron). In 1999, the Nobel committee recognized Veltman and t'Hooft's consistent quantization of that theory.

Individual tastes will largely determine the like or dislike of this book; however, the book suits my tastes perfectly. For this reason, I would strongly recommend it (may even require it) to theoretical physics graduate students, even though they may be familiar with much of the content. Like other points of a fine jewel not seen before, Veltman's engaging style of writing will remind students of the value of looking at physics through another's well-trained eye. His style will also pique the layman's interest in the most fundamental discoveries of physics in modern times.

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The Hype About Hydrogen: Fact and Fiction in the Race to Save the Climate by Joseph J. Romm. Island Press, 2004. 256 pp. $25.00 (hardcover). ISBN 1-55963-703-X.

There are numerous roadblocks for hydrogen fuel cells, a major element in New Energy. The one that is stressed in this most important book is relatively greater cost. However, in reaching this conclusion the author is comparing the cost of hydrogen fuel cells with the cost of petroleum-driven internal combustion engines, a mature technology and the cause of the greenhouse effect. This kind of market analysis was not foreseen by those who first wrote papers about a Hydrogen Economy in 1971. It was thought of as a replacement for the polluting oil-based economy when the realization of the dangers of letting CO_2 in the atmosphere sank into the public's mind.

The author is not always consistent. Thus, on page 16, he states that 2010 is the turning point for the rate of supply of oil against time. But in spite of this, his plans imply that fossil fuels will be available through 2040.

Romm admits that a Hydrogen Economy is inevitable. But the transfer to it is not to be worked out on the basis of a competition with fossil fuels, which will last hardly a decade more, but rather on the basis that *we must have environmentally acceptable, i.e., zero CO_2 emitting, energy,* and whatever this energy costs is going to be something we shall have to pay for.

The book is very strong in terms of showing the consequences of allowing more CO_2 to be admitted into the atmosphere. He shows—and I found this riveting—the danger of a *sudden* change in the climate, which these emissions would eventually cause. But then he compares the cost of hydrogen with the present cost of fossil fuels. Of course, the fossil fuel way is much cheaper right now, but such comparisons omit the cost of pollution associated with the present

fuels and the likely increase in their costs as Hubbert's Peak—or maximum oil production—is approached. A rational approach would be to add the cost of pollution to the cost of using gasoline and natural gas and to make a guesstimate of the price of oil in, say, 2015 ($5–$10 per gallon?). Compared with these probable costs, hydrogen in 2015 should be relatively cheap.

There is a commonly committed error in Chapter 4, namely, to call the method of obtaining hydrogen by electrolysis "inefficient." Where does this myth come from? It arises because the electricity which drives the electrolysis is obtained by the use of heat engines, processes subject to Carnot's efficiency limitation, which shows that these processes involve, typically, a 70 percent loss in the form of waste heat (Carnot losses do not occur with fuel cells). In fact, electrolytically splitting water to form hydrogen is the most efficient of the processes known at the present time! But the electricity used to carry out the electrolysis is made with an efficiency of 30 to 40 percent. That is the problem.

Another rather general piece of unreasonableness is to portray horror at the cost of the new infrastructure needed to build a dependence on hydrogen. Of course, these costs will be large, although they are one-time costs. The methods of creating energy we now use are making the world uninhabitable. The future must involve nuclear reactors or renewables (wind, solar, etc.). But either approach will require hydrogen as the clean medium, and either approach will need a whole new infrastructure.'

The author rejects the various methods of producing hydrogen, saying, "but this is too expensive." Too expensive compared with the present price of gasoline? But that is not the relevant comparison if oil begins to decline in rate of production in only six years' time. What will its price be then?

The author's attitude, and I think it is Washington's attitude, too, is illustrated on page 108 where Romm says "for a new fuel (hydrogen) *trying to break into the marketplace."* No one who suggested the Hydrogen Economy ever envisaged that hydrogen would break through (in terms of price) the present supply of polluting energy made cheap by neglecting the fact that it is these fuels which are causing us to approach *sudden* environmental disaster. Hydrogen, yes, will be more expensive, but it offers a solution to our energy woes. No other is suggested.

I could not understand the neglect of the ideas coming from Amory Lovens in the Rocky Mountain Institute. Lovens has suggested how automobiles could be made to run economically on hydrogen. They could be produced right now with the lightweight material of plastic. The hydrogen would come from natural gas. Surely, Lovens is one man who has an interesting proposition. Why not feature his ideas?

The author gives, later in the book, his own schedule for the conversion to a Hydrogen Economy. But his plans rely on fossil fuels well past Hubbert's Peak. On page 116 the author reports that the California Fuel Cell Partnership stated in 2003 "at the end of the day, hydrogen and other alternate fuels will be *three to four times as expensive as the oil-based product and if no one wants to pay for that, we can't make these fuels."* This is like the ship's captain who saw

two routes for his journey. Route A is only 1000 miles in length but filled with icebergs. The other route is 3000 miles in length but is safe and secure. What degree of sanity would one give to the captain who said Route A was the only one his passengers could afford?

A good example of the limited logic in Washington's energy policy is the quotation on page 119 from a report from a government organization: In 2003, "several fleet managers and representatives of the automobile industry acknowledge that it is unlikely that usage of alternative fuel vehicles by these fleets will convince the general public to buy them." Again, the attitude is that we must depend upon the market, which leads to people buying things which are cheaper. What the public is being offered in the case of the Hydrogen Economy, however, is something more expensive. Well, obviously it will not work within the market system, but *something* has to work or we shall be left with no oil and no alternative either.

An example lies in the seldom mentioned economics of our military forces. *They* are not run according to a market principle. Military expenditures are supposed to be made according to what is needed to make the country safe. There is no party that says "this military expenditure is too expensive."

It should be the same for the new energy supply. There is no alternative other than the nuclear or renewables option, and thus, we have to find out what is the cheaper way to have one of them even though they will be more expensive than the earlier available (environmentally harmful) fossil fuels, which will be exhausted within decades. (And decades is the time scale for restructuring the new source.)

I was glad to see that by page 124, Romm puts forward the notion that the only way to introduce hydrogen is by "Government intervention in the market." Indeed, you cannot persuade people to buy into something more expensive than the alternative which they think will always be available.

One thing Romm brings out excellently is the acceptance by the Academy of Sciences of the idea of sudden and irreversible climate change. The Academy's meteorologists maintain that if continuous injection of CO_2 into the atmosphere continues, we shall be threatened not simply by gradually increasing temperatures, but by 30-foot rises in sea levels and a deflection of the Gulf Stream, which would have life-threatening effects on parts of Europe.

Romm says (p. 133) that the evidence that the change may be far worse than expected should be motivation enough to drastically rethink the sense of urgency required. In the strongest statement of all, Romm points out (p. 134) "in a business as usual scenario of expanded global reliance on the combustion of fossil fuels, global annual *greenhouse gas* emissions would approximately *triple* by the end of the century, (what of 2010 for Hubbert's Peak?), *and the atmospheric concentrations of CO_2 would increase by three times pre-industrial levels to more than 800 ppm (parts per million)."* But at 600 ppm, the sudden, catastrophic climate change may come.

Disappointingly, in Chapter 8, Romm presents only unsuccessful alternatives to compete with hydrogen. The primary alternative is the hybrid car, which has

electric motors with batteries charged by onboard gasoline engines. But these cars still produce CO_2 and there is no consideration of what will happen to it or of the availability of natural gas and gasoline past the Hubbert maximum. One of the more frightening things which Romm quotes is a Lawrence Livermore National Laboratory report of 2003 that explains that in order to stop global temperature from rising more than two times as a result of gas emissions, we should be building at least two nuclear reactors per week for 50 years!

In spite of all his price-based objections, Romm *is* an advocate of the Hydrogen Economy. Romm foresees no government action until 2035, but oil will fail to meet our needs by 2010. At this point, he sees government intervention and the change to the Hydrogen Economy as just beginning—a change that could take 50 years!

In fact, Romm says "enabling a shift to a Hydrogen Economy may be one of the central tasks of the United States as we cope with the 21st Century and the major energy and environmental problems which it gives us." He says on page 189, "Only government action can reverse the growth of carbon dioxide emissions until hydrogen and other new technologies can help to reduce emissions sharply."

This book should be read and understood by every citizen, for it makes clear that environmental terror is much nearer than we thought and that the (essential) Hydrogen Solution will be more expensive than we feared.

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Notes

[1] There's no way to avoid this. Suppose, even, that some vast store of oil or natural gas should be discovered in 2009. Its use, whilst emitting CO_2 into the environment, would lead to the disaster of sudden climate change. Its satisfactory sequestration, e.g., burial in the deep sea, would mean an infrastructure of pipelines hardly less than those demanded by the renewables.

Copies in Seconds: Chester Carlson and the Birth of the Xerox Machine by David Owen. Simon and Schuster, 2004. 306 pp. $24.00 (cloth). ISBN 0-7432-5117-2.

We have had to wait too long for a biography of Chester Carlson, who was the sole inventor of xerographic copying. Carlson was not just a remarkable person; he was remarkable in unusual ways. Experts had declared impossible his idea for a machine that would make copies on ordinary paper. Carlson, however, had the requisite qualities for success. David Owen correctly identified these as "his