

LETTERS

must it be done simultaneously? Anyone who is part of academia must know that academia doesn't change easily. Meanwhile millions of children are hostage to the low level of math and science teaching. If you influence one teacher, you affect thousands of children. Should we abandon our efforts until this, that and the other precondition, sensible as they are, are satisfied? The point of my column was to urge fellow physicists to go out and get involved in the schools—at any level, in any effort. Each effort is a ripple, and enough ripples can make a tidal wave.

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6/92

Can a Tokamak Breed Enough Tritium?

The article "Progress Toward a Tokamak Fusion Reactor," by J. Geoffrey Cordey, Robert J. Goldston and Ronald R. Parker (January 1992, page 22), left me puzzled. The breeding of tritium reminded me of the story of Baron von Münchhausen's pulling himself out of a swamp by his own hair. My reasoning, based on the descriptions in the article, is as follows: For one D + T reaction you get one neutron. One neutron can produce one tritium nucleus during breeding. Since according to the article a 1000-MW station requires on the order of 1.5 tons of tritium a year, and the inventory of tritium is a few kilograms, this tritium inventory would have to be recycled several hundred times a year. Even with a breeding efficiency of 90% you would run out of tritium well before the first year of operation was over. I know that the above calculation must be wrong, because too many scientists work on a reactor of this kind, but I can't see the error.

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1/92

CORDEY, GOLDSTON AND PARKER REPLY: Apparently our description of how tritium fuel is to be regenerated from fusion neutrons was not detailed enough. In fact the reactor blanket will include *neutron-multiplying* materials such as beryllium or lead so that the net "breeding ratio" can be greater than 1; typically one will be aiming at an adjustable ratio of up to 1.1. The yearly tritium burn-up in a 1-GW_e D-T reactor would be about 170 kilograms. (The 1 tonne per year of deuterium quoted in the article is for a 1-GW_e D-D reactor.) In contrast

to a fission breeder, in a fusion reactor the fuel inventory is very modest, so the time it takes to produce the extra tritium required to start up a new reactor can be made quite small.

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'Japan: Not an Energy Efficiency Model'—Not!

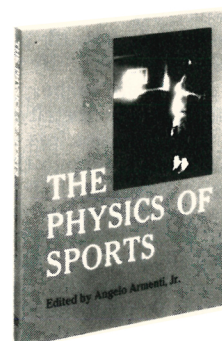
I suspect you will receive a flood of letters in response to the Opinion piece in February 1992's issue (page 95); still, "Japan: Not an Energy Efficiency Model," by Milton Searl and Chauncey Starr, proved too provocative for me to resist adding to that presumed deluge.

Searl and Starr attempt to convince the reader that although the US uses 2.4 times as much energy per capita as Japan, there is really no reason nor even a viable course of action to reduce this ratio substantially. The numbers quoted in their column actually make it worth reading; it is the interpretation—the "spin"—they give those numbers that makes it so objectionable. In short, the "reasons" they give for each form of massive energy waste in this country, and even more their attempts to reinterpret the data until they look agreeable, are worthy of a public relations team trying to whitewash an industry with a bad reputation (maybe a fair description of the goal of the column).

Let me give some examples: Searl and Starr first point out that the conversion from primary to secondary energy forms is the largest single sector of energy use in the US, and that this conversion is done more efficiently here than in Japan. That may be true, but is of course completely besides the point: This part of the energy budget is, after all, proportional to the sum of all other sectors and thus should be factored into them. (If we waste energy in transportation, we're also wasting a proportional amount in the conversion process needed to produce the fuels in the first place.)

From that perspective, the second-largest sector of energy use in the US cited by Searl and Starr, namely transportation, is really the largest one. And it is this sector where indeed most of the waste occurs: 3.6 times as much energy per capita is

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used for transportation here as in Japan. Searl and Starr simply "explain" this by the fact that the population density is 13 times smaller here than in Japan. If one were to follow their argument, it would be the eternal laws of geometry ($\sqrt{13} \approx 3.6$) that force every American to travel 3.6 as many miles every year as his or her Japanese counterpart. This kind of pseudoscientific argument completely misses more relevant explanations, such as the substantially higher average fuel efficiency of Japanese cars and the extensive network of public transportation in Japan. (By the way, just one paragraph earlier the authors state that the distribution of energy in the US is not less efficient than in Japan even though the same density factor should apply!) The fact that more people live in cities in Japan than in the US is, by itself, no valid reason for Japan's better energy efficiency either—on the contrary, my suspicion is that much of the surplus energy used in this country is wasted in endless daily traffic jams, predominantly a phenomenon of urban areas.

The second argument Searl and Starr give for why we shouldn't worry too much about the factor of 3.6 is that energy prices in Japan are 3.6 times higher than here, so the Japanese end up paying just as much for transportation as we do. It is this kind of argument that is really infuriating: If the price is the same, why worry about anything else! I agree with the authors that the price of energy plays a decisive role, but I also believe emphatically that if we could satisfy our true transportation needs at the same total cost as today (and do away with the unnecessary ones), but with three times less energy consumed, we all would be vastly better off. (Just think of the people killed each year on the highways, the increasing smog pollution, the dangers of an increase in greenhouse gases, the "necessity" to fight wars over oil.)

Searl and Starr then use this same energy price argument over and over to justify the substantial waste in every other sector of energy consumption. In the end, they buttress the argument by the predictable threat of economic doom if we were to seriously cut down on energy (ab)use. How they manage to come to this conclusion in a column that starts out with the observation that Japan uses 1.7 times less energy per dollar of gross domestic product completely eludes me (especially in view of the Japan's much publicized economic superiority). Quite contrary to Searl and Starr, I believe we *should* "feel

guilty" about the amount of energy being wasted in this country, and it is not at all a "misdirection of R&D" or "misallocation of resources" to do something about it.

SEBASTIAN KUHN
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2/92

Many of us would draw conclusions opposite to those drawn by Milton Searl and Chauncey Starr in their otherwise useful analysis of Japan's energy efficiency.

Searl and Starr recognize Japan's far lower energy use per capita and per dollar of GDP. Most of us would say that this amounts to higher "efficiency," especially for a country whose GNP per person (\$15 600 in 1988) is comparable to the US's (\$19 500 the same year). But Searl and Starr have a different definition. They argue that Japan's statistics are "primarily due to geography [because of the greater compactness of Japan's population], less floor space per person and energy prices," and that the US should maintain business as usual in all three areas. They conclude that the US is really as efficient as Japan, but in a different way—an American way that unfortunately requires us to use more energy per capita and per GDP than Japan (and, it should be added, Western Europe).

But the debate about energy efficiency concerns precisely those factors Searl and Starr identify as contributing to Japan's low energy consumption. Energy prices in particular are at the heart of the debate. Many of us argue that energy prices should reflect the full cost, to society, to the environment and to future generations, of each energy resource. By not including these costs, the US underprices and therefore overuses energy, and contributes to problems like automobile congestion, global warming and resource depletion. We are in effect asking society, other countries, the environment and future generations to pick up our energy costs.

Instead of showing that the US is as efficient as Japan, Searl and Starr identify the reasons for Japan's (and Western Europe's) greater efficiency. We could, with tax incentives, price energy to reflect its full cost. And contrary to their column's implication, we could alter our population density patterns, our "geography," by discouraging urban sprawl and rehabilitating our cities. In choosing to undervalue energy in order to cheaply support an expansive lifestyle, the US has opted for energy inefficiency. It is a misleading use of words to

argue that this is efficiency, only of a different kind.

ART HOBSON
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Milton Searl and Chauncey Starr claim that although Japanese per capita energy consumption is less than half that of the United States, this is not evidence of better energy efficiency. They reach this remarkable conclusion primarily by using an economic definition of efficiency instead of a physical definition, which makes *PHYSICS TODAY* a rather odd place to publish their column. Although the Japanese use less energy per task than Americans, they pay roughly the same amount of money. While this is a good example of macroeconomic principles, it does not offer any useful insights for future US energy policy.

Physical efficiency, the amount of useful energy obtained per unit of raw energy used, is determined by natural laws and by technology, and it is clear from the authors' own figures that Japanese industry is more energy efficient than its US counterpart. This is due in part to a high rate of recycling. The assumption that Japanese travel less distance than Americans is questionable, because commuting distances generally increase with population density due to expansion outward from city centers. The typical Japanese worker commutes roughly one hour each way to work (six days a week!). A comparison of mass transit utilization and automobile fuel efficiency would have been more relevant.

Economic efficiency, on the other hand, is directly dependent on energy prices, which can be highly volatile. Searl and Starr mention the "oil price shocks of the 1970s" but do not consider the possibility that energy prices will increase in the future. Also, they consider only the direct costs of energy consumption and ignore indirect costs caused by energy-related pollution and depletion of resources. Their claim that high energy prices "may adversely affect economic growth" seems to be at odds with Japan's incredible economic success. A more realistic threat to the economy is unstable energy prices.

Because of its inefficiency, the US has become economically dependent on a cheap energy supply that is rapidly diminishing. It is prudent to prepare for future energy price increases by investing in energy efficiency now. President Carter considered US energy problems to be the "moral equivalent of war," but even after a real war in the Persian Gulf, Americans still have not gotten the

message. Reduction of energy usage will in the long run result in improved competitiveness for US industry, lower cost of living, a better environment and greater national security. Searl and Starr also support such investment, but apparently only at a rate driven by short-term economic factors. Investment in improved efficiency will almost always pay off in the long term, but typical payback times are longer than acceptable to shortsighted American planners.

To give an example of one means of lowering energy usage, I was impressed to learn that modern Japanese homes do not waste heat by continuously storing hot water. The water is heated en route when needed. This type of system may be available in the US, but I had not seen it before.

Perhaps the most important lesson we can learn from the Japanese is the merit of adopting ideas from other people. I agree with the authors that we should not "feel guilty" about our current inefficiencies, which we inherited. However, neither should we excuse ourselves from the obligation to plan for a better future.

ROBERT CLOSE
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3/92

SEARL AND STARR REPLY: We are pleased with the attention that "Japan: Not an Energy Efficiency Model" has received. It was our intent to go beyond the simple, and we believe naive, per capita energy use figures commonly quoted in order to achieve some understanding of why energy consumption per capita is so much less in Japan than in the US, and in particular to see if the major cause of the difference was the use of more energy-efficient (that is, thermodynamically efficient) technology than in the US. We found that at the aggregate level much of the higher US per capita consumption in the transportation and residential sectors was due to demographic and geographic factors, not technology. We also concluded that the largest energy-using sector in the US, the energy conversion and distribution section, was more efficient than the Japanese sector. And as Sebastian Kuhn implies, the efficiency difference is even greater if geography is considered.

The letters exemplify the confusion that exists when one uses such terms as "efficiency," "conservation" and "waste." Are we talking about economic efficiency, thermodynamic efficiency or even some broader efficiency concept that includes social and environmental factors? We be-

lieve that comparisons solely on the basis of per capita energy use tend to obscure many of the economic, demographic and geographic factors. It would be useful to look in even more detail than we have at the reasons for the lower Japanese energy use per capita, and further at how we in the US would have to change our technology or end-use practices to achieve less energy use per capita, and then to disclose for public consideration the costs and benefits of a reduction in US per capita use.

In addition to geographic and demographic factors, it is obvious that energy prices may be a factor in the lower Japanese energy consumption. We agree that energy prices should theoretically include full economic, environmental and social costs. However, higher energy prices in other countries appear to be due to economic costs and revenue-raising taxes rather than to measures to cover environmental costs. Further, high energy costs appear to have serious short-run (and perhaps long-run) adverse effects on economic growth. One need only look at economic growth after the 1973 oil embargo and after the 1979-80 price increases to see such an effect. Increased energy prices do not provide a free lunch!

Turning to some of the specific comments, Kuhn speaks about "massive energy waste in this country." He provides no data and seems to be begging the question, since it was our contention that much of the higher level of energy use has explanations rooted in our geography and standard of living and is *not* evidence of technological inefficiency or large-scale negligence.

Kuhn suggests that the greater efficiency of the largest energy-using sector in the US, the conversion sector, is irrelevant, since other, end-use sectors determine the primary demand. Certainly that output of this sector is the integrated demand of other sectors, but the input is determined also by the losses incurred in conversion and distribution. The US energy conversion and distribution sector is even more efficient than we indicated, owing to the geographic factor of 3.6.

Regarding our explanation for the transportation sector difference, Kuhn says, "This kind of pseudoscientific argument completely misses more relevant explanations, such as the substantially higher average fuel efficiency of Japanese cars." There seems to be some difference in data here. According to "Fuel Efficiency of Passenger Cars" (International Energy Agency, 1991), in 1979 the Japa-

nese passenger car fleet used 72% as much fuel per mile as the US fleet. In 1986 the Japanese fleet used 83% as much as the US fleet. Japanese use for later years is not reported, but by 1988 US use was essentially the same as that of Japan in 1986. It does not appear that differences in fuel efficiency can come close to explaining the factor-of-3.6 difference in per capita transportation use. We agree with Kuhn's contention that we would all benefit from a more efficient transportation system.

Art Hobson's letter clearly recognizes differences in the definition of "efficiency." He appears basically to accept our identification of the reasons for differences in per capita energy use, but believes that the US could "alter our population density patterns, our 'geography,' by discouraging urban sprawl and rehabilitating our cities." He may be right, but that is a sociologic, demographic and economic matter, not chiefly an energy issue.

Robert Close makes several useful observations and seems to understand the implications of our discussion. We disagree with his statement that "investment in improved efficiency will almost always pay off in the long term." In general an investment in one area reduces the amount of investment available for some other area. For example, are all energy-efficiency investment options more valuable to society than, say, investments in medical care?

In summary, we still believe that per capita energy use comparisons are a simplistic and naive basis on which to make judgments about energy efficiency. We agree that more economically and technically efficient technologies should be used in the US, no matter where they are developed. It does not appear that the US is generally negligent in this respect.

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6/92

Where Did Pauli Make His 'Wrong' Remark?

Please: Can anyone quote a definitive source for the statement, attributed to Wolfgang Pauli after he listened to a boring seminar, "But it isn't even wrong"? This seems consistent with Pauli's acerbic European humor. Our excellent librarians can't trace its origin definitively.

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5/92