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Future energy

Paul Grant's article "Energy for the City of the Future," in the February/March 2002 issue of *The Industrial Physicist*, was great. It should win a prize for maximizing information per page. Even if someone wanted to disagree with the author on a point here or there (which is, after all, what makes a horse race), the article clearly defines issues that might be debated.

When I teach physics majors, I usually have the honors students do an informal energy study of the Washington, DC, metropolitan area, starting with Fermi estimates of supply and demand, then finding the actual numbers, and finally asking them questions about alternatives—what would it take to get all of the energy from hydro, solar, geothermal, and so on? Grant's article is now on the top of the reading list.

Chris Lobb
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I read "Energy for the City of the Future" with great interest. I have always been concerned about energy sources, their impact on the environment, and their long-term potentials. If the writer's assumptions are met, then he may well have a technically plausible solution for energy production and consumption. But what I do not see in his solution is any allowance for the "human factor" in a SuperCity world.

Is this city just for wage earners who can afford the energy? Where are the slums? Does industry not compete in SuperCity? Where do new office buildings and manufacturing sites go? What happens to the old ones? If people go bankrupt, are they still responsible for maintaining the thermal collectors on their rooftops, or does the energy department own and maintain those? If those are owned and maintained by the government, how does one go about expanding an existing structure? Humans and, in particular, capitalistic humans, don't fit very well into this scheme.

But the most difficult obstacle (to which the author does allude) requires us to answer yes to the famous question, "Can't we all just get along?" Unfortunately, the answer is no. So, I'm back to wondering what we are going to do about energy.

Kurt Erickson
Pendleton, South Carolina

[*Author replies*: Contrary to Mr. Erickson's view, I maintain that SuperCity is all about the "human factor." The "emerging societal boundaries and constraints" I refer to in the introduction are directly related to the human desire for sufficient energy, a protected environment, and an uncluttered ecology. Let me address a few of his points more directly.

Slums. I'm not aware of any city planner who sets aside urban plots for "slum development." In the past, such areas have resulted from a combination of social inequities and less than cost-of-living income, situations we are smart enough to eliminate with continued economic development and growth.

"Where do new office buildings and manufacturing sites go?" Where they go at present, and when local resources become saturated and further growth uneconomic, to other, new developing urban areas or SuperCities.

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T's Studio

"Ownership of rooftop energy production." Let the voters of SuperCity decide between public and private ownership. I suspect that most people would choose the latter, with the energy so produced partially offsetting the cost of grid-supplied electricity, and the capital plant being part of the structure itself (like house plumbing and wiring and many appliances), and thus transferable under conditions of sale…or bankruptcy.

"Can't we all just get along?" In a world possessing enormous numbers of weapons of mass destruction, threatened by their proliferation, with terrorism yet to be contained, the answer is simple. We'd better.

Paul Grant]

While I agree with Paul Grant's utopian concept of a future world with a nuclear–solar–wind–hydrogen energy base, I wish to make a few comments.

First, the change from fossil fuels by the United States should be based on the fight against terrorism, since current payments for oil fund terrorists who are dedicated to the destruction of the United States. Furthermore, our huge foreign trade imbalance and the increasing percentage of national debt owed to foreign interests may well constitute a greater danger to the stability of the United States than terrorists' bombs.

In the area of technology, I see that fusion energy is too far off for current planning, but we should consider the use of decentralized, but still large-sized, nuclear reactors accompanied by fuel recycling. Based on France's approach of having 85% of electricity from nuclear power, this should be the first line of energy production, supplemented by solar and wind energy. Facilities for producing the latter should be located not where usage is highest but where efficiency is greatest, that is, in deserts for solar and in the Midwest for wind—to provide hydrogen for mobile requirements and electricity to supplement the power grids.

Finally, I do not share one of the author's concerns—the "diversion" of nuclear fuel for terrorist uses. New fuel rods contain very long lived isotopes of uranium and/or plutonium that produce little radioactivity and which are chemically relatively inert. Thus, misuse of new fuel rods represents little threat unless there are facilites to remove the ^{238}U and increase the ^{235}U to more than 90%, which is difficult without very high cost and sophisticated facilities.

Spent fuel rods, which contain less of the uranium and/or plutonium, are so highly radioactive when first removed that they would be difficult to steal, transport, and work with to create the so-called dirty nuclear bomb (a chemical explosion that spreads radioactivity over broad areas).

A major concern that is often mentioned is the threat that recycling fuel would create ^{239}Pu, which could be accumulated to make a nuclear weapon. However, numerous scientists claim that recycling produces a slight amount of ^{240}Pu, which has little effect on the use of the ^{239}Pu in a nuclear reactor but is sufficient to "poison" the mixure so that it cannot be used as a nuclear bomb unless the terrorists have a highly sophisticated isotope separation facility to remove the ^{240}Pu and concentrate the ^{239}Pu.

One point with which I disagree with Dr. Grant is on the possible use of superconductivity for long, more-efficient transmission lines. I believe that the efficiency is already high, and I would be concerned about the total amount of coolant (liquid hydrogen, helium, or nitrogen) required and, even more, the risk of severe destruction from a sudden loss of high-temperature superconductivity (HTS) somewhere along the line. Thus, I suggest restriction of HTS use to generators, transformers, and other localized mechanisms.

Fred Schaff
Spring Grove, Pennsylvania
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[*Author replies*: I agree that terrorism today is likely significantly funded by Middle East oil revenues, which is another cogent reason for reducing oil consumption.

On fusion and renewables, I agree… mostly. Fusion is way off and would probably not be based on deuterium–tritium or deuterium–deuterium, because of the huge scale necessary to boil water with 14-MeV neutrons. Exploitation of lunar ^{3}He reserves, whose fusion reaction produces charged alpha particles for direct electricity generation, may be possible.

On wind and solar power, I think that many environmentalists and conservationists (including me) would have some difficulty with obliterating "useless" desert and Midwest land areas.

On diversion of nuclear fuel: Although difficult technological challenges do keep repro-

cessing out of the hands of the bad guys, we need international control of the actinide cycle for electric power production from mine to grave, as I allude to in my article.

On redundancy of superconducting lines: All power delivery infrastructure requires redundancy and security, and superconductivity presents no special problem. Undergrounding is the best approach, but nothing is bulletproof against a prepared and determined aggressor. At present, the thousands of miles of conventional aboveground pipeline and overhead electrical transmission networks are overwhelmingly vulnerable to attack. I invite Mr. Schaff to invent his own scenarios for their straightforward destruction, as I have done. Since September 11th, preventing such attacks is, in my opinion, the most pressing home security challenge.

Paul Grant]

It's a little deceptive of Paul Grant to describe a passive cooled nuclear reactor, then state that we have nuclear fuel for 300 to 800 years. The relatively safe reactors he describes have enough fuel for only 25 years of world energy production. The only way to extend the available fuel would be to use much more dangerous and commercially unproven breeder reactors.

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[*Author replies*: I'm somewhat at a loss as to where Mr. Donovan obtains his number, "…enough fuel for only 25 years of world energy production." The most pessimistic figure I've seen is 35 years—if the entire present electricity production of the United States were suddenly converted to nuclear energy, fueled only by domestic uranium reserves, without any reprocessing (this does not include the huge net amount of uranium salts in seawater, albeit recoverable at higher cost than land ore deposits). Should we continue at present levels (20% of U.S. electricity supplied by nuclear), known domestic reserves would suffice for about 170 years, again without reprocessing. With reprocessing, we obtain my worldwide figure of 300 to 800 years, depending on the mix of nuclear with other generation methods.

These numbers, which can be found in several textbooks and reviews of nuclear power, do not include the considerable amount of energy that can and will be recovered from the dismantling of the nuclear arsenals of the U.S. and Russia, perhaps tripling "reserves" worldwide. With respect to fast breeder technology, which is neither unsafe nor unproven—simply undeveloped at present because of the low price and availability of uranium ore—some people have estimated that we have planetary capability for 15,000 years.

Paul Grant] Ω

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