THE ENERGY SPECTATOR

Unscientific American

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Scientific American used to be a great magazine but like any publishing venture headquartered in New York, it has gradually drifted into liberal never-never-land. .

Over the years the magazine has run several lead stories encouraging complete nuclear disarmament. At one point it had O.J. Simpson's attorney explaining why DNA technology would never be accurate. Now it's become a shameless, uncritical cheerleader for a world run on renewable energy.

This month's cover story, "A Plan for a Sustainable Future: How to get all energy from wind, water and solar power by 2030," is a prime example. Authors Mark Z. Jacobsen and Mark A. Delucchi are respectively, a professor of civil and environmental engineering at Stanford and a research scientist at UC Davis -- which makes you wonder what's going on in academia these days. The article is so full of half-truths, absurd omissions and blue-sky fantasy that it is hard to know where to begin.

The authors premise is this: In order to free ourselves from fossil fuels and nuclear power, the authors postulate, all we need to do over the next 20 years is build the following:

> • 490,000 tidal turbines of 1 megawatt apiece (<1 percent of which are now in place).
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> • 5,350 geothermal plants of 100 MW (< 2 percent in place).
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> • 900 hydroelectric dams of 1300 MW (70 percent in place),
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> • 3,800,000 windmills of 5 MW (1 percent in place).
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> • 720,000 wave converters (ocean turbines driven by waves rather than the tide), 0.75 MW (< 1 percent in place).

> • 1,700,000,000 rooftop solar voltaic systems, 0.003 MW (< 1 percent in place).
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> • 49,000 solar thermal plants (mirror arrays that heat a fluid), 300 MW (< 1 percent in place).
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> • 40,000 photovoltaic power plants (sunlight directly into electricity), 300 MW (<1 percent in place).

That would make a nice stimulus package, wouldn't it? Let's hope Congress doesn't take this too seriously. Offhand, I would say that if we undertook one-tenth of these tasks over the next twenty years we would be very ambitious. Even then, the authors have had to do a lot of fudging. For example:

• *900 hydroelectric dams, 1300 MW, 70 percent in place*. There are only 94 dams in the whole world that produce more than 1300 MW, eleven of them in the United States. Even Glen Canyon (1296 MW) does not quite qualify. Around the world there are few dam sites left untamed. Even building 70 more dams of this size – let alone 800 -- is unlikely.

• *3,800,000 windmills, 5 MW, <1 percent in place*. The largest windmills now designed generate 3 MW. These are "the length of a football field," as President Obama recently mentioned. A windmill generating 5 MW would probably be the length two football fields and stand 80 stories high. Imagine the landscape covered with 3 million these.

• *1.7 billion solar rooftop systems*. With only 6 billion people in the world, there may not be enough rooftops to house all these. We'll have to put up some more buildings just to accommodate them.

• *89,000 solar thermal and voltaic plants, 300 MW apiece*. It takes about 15 square miles to generate 1000 MW with either system. There is little room for improvement, since the limits are set by the sun's energy. That amounts 450,000 square miles, about the size of Texas and California combined. Solar mirrors and panels must be washed once a week or they collect too much dust and lose their efficiency. That's a lot of water.

Oh well, this isn't really a serious exercise, is it? The authors are just doing some creative thinking so the U.S. delegation at Copenhagen in December can have something to wave in front of the cameras. The lead editorial praises the authors' "hard-headed pragmatism," saying they show "step by step... that more than enough sustainable energy exists [and] the needed technologies are available now."

What is truly remarkable is that the authors' inventory of knowledge seems to include nothing about nuclear power, the one technology that can truly provide "green energy." To begin with, they barely make any distinction between nuclear and fossil fuels, lumping together as the old way of doing things:

> Most recently, a 2009 Stanford University study ranked energy systems according to their impacts on global warming, pollution, water supply, land use, wildlife and other concerns. The very best options were

> wind, solar, geothermal, tidal and hydroelectric power -- all of which are driven by wind, water or sunlight (referred to as WWS). [This statement is incorrect. Geothermal energy is driven by the radioactive heat of the earth due to the breakdown of uranium and thorium. That's why I called my book "Terrestrial Energy."] Nuclear power, coal with carbon capture, and ethanol were all poorer options, as were oil and natural gas.... Nuclear power results in up to 25 times more carbon emissions than wind energy, when reactor construction and uranium refining and transport are considered. Carbon capture and sequestration technology can reduce carbon dioxide emission from coal-fired power plants but will increase air pollutants and will extend all the other deleterious effects of coal mining, transport and processing, because more coal must be burned to power the capture and storage steps. Similarly, we consider only technologies that do not present significant waste disposal or terrorism risks.

Where the authors get the notion that nuclear will emit 25 times as much carbon as wind is anybody's guess. A reactor contains about 500,000 cubic yards of concrete and 120 million pounds of steel. Yet a single 45-story windmill stands on a base of 500 cubic yards of concrete and contains as much metal as 120 automobiles. Since you need 2000 of these to equal one nuclear reactor (a very generous estimate), that adds up to twice as much concrete and steel.

Then there's the business of uranium enrichment. Environmentalists love to argue that nuclear is actually ***more*** carbon-intensive because uranium enrichment requires such huge amount of electricity. This is true in one respect. The country's only operating uranium enrichment plant in Paducah, Kentucky requires 2,000 MW of electricity -- supplied by two full-fledged coal plants. But the plant employs World War II gas-diffusion technology. The United States Enrichment Corporation's new laser enrichment plant in Ohio would consume only 5 percent as much electricity- except that the Obama Administration has mysteriously rejected its application for a $2 billion loan guarantee and work has been temporarily suspended. In any case, uranium enrichment produces carbon emissions ***only if the electricity is supplied by coal.*** If enrichment were powered by nuclear power, carbon emissions would be zero.

Then there's the business of "transporting uranium fuel." It's hard to tell what the authors are talking about here. A nuclear reactor requires a new shipment of fuel rods ***once every 18 months.*** They are delivered by about six tractor trailers. There is probably more energy expended in hauling a single giant windmill to a remote farm location than is spent in refueling an entire 1000-MW reactor.

Where the authors lose all contact with reality, however, is in talking about "reliability." Here is what they have to say:

> *W*WS [wind, water, solar] technologies generally suffer less downtime than traditional sources. The average U.S. coal plant is offline 12.5 percent of the year for scheduled and unscheduled maintenance. Modern wind turbines have a down time of less than 2 percent on land and less than 5 percent at sea. Photovoltaic systems are also at less than 2 percent. Moreover, when an individual wind, solar or save device is down, only a small fraction of production is affected; when a coal, nuclear or natural gas plant goes offline, a large chunk of generation is lost.

Here are the facts. Every form of electrical generation is rated by what is called its "capacity factor," meaning the percentage of time, on average, it is up and running. Plants go on- or off-line for many reasons – maintenance, refueling, high costs, or simple unavailability. Coal plants are generally shut down once every two weeks to perform routine maintenance and "give the boiler a rest." Natural gas is often taken off-line because the fuel is so expensive. Hydroelectric dams shut down because of fish migrations or seasonal variations in reservoir capacity.

The generally accepted capacity factors for the various forms of generation are as follows:

• Nuclear -- >90 percent

• Coal -- ~80 percent

• Geothermal -- 75 percent

• Natural gas -- 50 percent

• Hydroelectricity -- 45 percent

• Wind -- 30 percent

• Solar -- 20 percent

In order to fabricate their argument, the authors have:

1. Considered only ***maintenance*** shut-downs and not general ***availability,*** and

2. Completely ignored the capacity factor of nuclear.

Windmills may only offline for maintenance 2 percent of the time but ***the wind only blows about 30 percent of the time.*** Solar power is available even less. Neither is "dispatchable," as the electrical engineers say, and therefore require constant back-up from other sources. Storage techniques may eventually solve this problem but the storage facilities will take up as much room as the generators themselves.

What Jacobson and Delucchi have managed to leave entirely out of the picture is the concept of ***energy density.*** Nuclear power's overwhelming advantage is its tremendous energy yield per pounds of resource employed. A pound of uranium contains ***2000 times*** as much energy as a pound of coal. In real life, this translates into a 110-car coal train arriving every 30 hours versus six tractor trailers arriving once every 18 months.

Yet while nuclear has a tremendous advantage over the fossil fuels, ***so the fossil fuels have about 20 times the density of wind, water and solar.*** That is we adopted fossil fuels in the first place. We no longer use the wind to power grist mills or waterwheels to run factories because it takes too much effort to gather too little energy. What renewable enthusiasts are asking us to do is move ***backwards*** in history.

Even more significant, the world of Jacobson and Delucchi would be the most colossal human intrusion into the natural world the history of the planet. It would dwarf any previous effort of civilization. We would live in a forest of 80-story windmills interrupted by rolling prairies of solar collectors. Every inch of coastline would be girdled with tidal generators while every square mile of ocean was dotted with wind and wave collectors. There would be no place on the planet not dedicated to gathering energy.

Could we do it? Sure, we probably could, although not on the time scale Jacobsen and Delucchi propose. Would we ***want*** to do it? You can answer that question yourself.

William Tucker *is most recently the author of the new book* Terrestrial Energy: How Nuclear Power Will Lead the Green Revolution *and* End America's Long Energy Odyssey (Bartleby Press).