Renewables Can’t Save the Planet—but Uranium Can

By Michael Shellenberger

Around the world, the transition from fossil fuels to renewable sources of energy appears to finally be under way. Renewables were first promoted in the 1960s and 1970s as a way for people to get closer to nature and for countries to achieve energy independence. Only recently have people come to see adopting them as crucial to preventing global warming. And only in the last ten years has the proliferation of solar and wind farms persuaded much of the public that such a transition is possible. In December 2014, 78 percent of respondents to a large global survey by Ipsos agreed with the statement “In the future, renewable energy sources will be able to fully replace fossil fuels.”

Toward the end of his sweeping new history, *Energy and Civilization*, Vaclav Smil appears to agree. But Smil, one of the world’s foremost experts on energy, stresses that any transition to renewables would take far longer than its most ardent proponents acknowledge. Humankind, Smil recounts, has experienced three major energy transitions: from wood and dung to coal, then to oil, and then to natural gas. Each took an extremely long time, and none is yet complete. Nearly two billion people still rely on wood and dung for heating and cooking. “Although the sequence of the three substitutions does not mean that the fourth transition, now in its earliest stage (with fossil fuels being replaced by new conversions of renewable energy flows), will proceed at a similar pace,” Smil writes, “the odds are highly in favor of another protracted process.”

In 2015, even after decades of heavy government subsidies, solar and wind power provided only 1.8 percent of global energy. To complete the transition, renewables would need to both supply the world’s electricity and replace fossil fuels used in transportation and in the manufacture of common materials, such as cement, plastics, and ammonia. Smil expresses his exasperation at “techno-optimists [who] see a future of unlimited energy, whether from superefficient [photovoltaic] cells or from nuclear fusion.” Such a vision, he says, is “nothing but a fairy tale.” On that point, the public is closer to Smil than to the techno-optimists. In the same 2014 Ipsos survey, 66 percent agreed that “renewable sources of energy such as hydroelectricity, solar and wind cannot on [their] own meet the rising global demand for energy.”

Smil is right about the slow pace of energy transitions, but his skepticism of renewables does not go far enough. Solar and wind power are unlikely to ever provide more than a small fraction of the world’s energy; they are too diffuse and unreliable. Nor can hydroelectric power, which currently produces just 2.4 percent of global energy, replace fossil fuels, as most of the world’s rivers have already been dammed. Yet if humanity is to avoid ecological catastrophe, it must find a way to wean itself off fossil fuels.

Smil suggests that the world should achieve this by sharply cutting energy consumption per capita, something environmental groups have advocated for the last 40 years. But over that period, per capita energy consumption has risen in developed and developing countries alike. And for good reason: greater energy consumption allows vastly improved standards of living. Attempting to reverse that trend would guarantee misery for much of the world. The solution lies in nuclear power, which Smil addresses only briefly and inadequately. Nuclear power is far more efficient than renewable sources of energy and far safer and cleaner than burning fossil fuels. As a result, it offers the only way for humanity to both significantly reduce its environmental impact and lift every country out of poverty.

ENERGY’S HISTORY

Few scholars dominate a field of interdisciplinary study the way Smil does that of energy, on which he has published over 20 books. *Energy and Civilization* synthesizes his canon, offering a broad picture of the evolution of *Homo sapiens*, the rise of agriculture, and the very recent emergence of a high-energy industrial civilization.

The core of Smil’s argument is that the history of human evolution and development is one of converting ever-larger amounts of energy into ever more wealth and power, allowing human societies to grow ever more complex. “To generalize, across millennia, that higher socioeconomic complexity requires higher and more efficiently used inputs of energy is to describe indisputable reality," Smil writes. That striving for more energy began with prehuman foragers, who craved energy-dense foods, such as oils and animal fats, which contain two to five times as much energy by mass as protein and ten to 40 times as much as fruits and vegetables. The harnessing of fire let prehumans consume more animal fats and proteins, allowing their intestinal tracts to shrink (since cooked food requires less digestion) and their brains to grow. The final outcome was the human brain, which demands twice as much energy by mass as the brains of other primates.

Around 10,000 years ago, humans gradually started to shift from foraging for food to farming and began to tap new forms of energy, including domesticated animals for plowing, wind for powering mills, and human and animal waste for fertilization. Permanent farms allowed human societies to grow in size and power. "Even an ordinary staple grain harvest could feed, on the average, ten times as many people as the same area used by shifting farmers," Smil notes. Yet those societies' individual members saw little benefit. Smil records the remarkable fact that "there is no clear upward trend in per capita food supply across the millennia of traditional farming." A Chinese peasant ate about as much in 1950, before the arrival of synthetic fertilizers and pumped irrigation, as his fourth-century ancestor.

That's in part because for most of human history, societies increased their food and energy production only when they were forced to, by factors such as rising population or worsening soils. Even in the face of recurrent famines, farmers consistently postponed attempts to increase production, because doing so would have required greater exertion and longer hours.

Then, as farming became more productive in England in the seventeenth and eighteenth centuries, farmers were freed up to move to the city and work in manufacturing. Urbanization and industrialization required a far larger leap in energy consumption than the one involved in moving from foraging to agriculture. The shift was made possible by a rapid increase in coal mining. Coal offered roughly twice as much energy by weight as wood and by the mid- to late nineteenth century provided half of all the fuel consumed in Europe and the United States. Despite the obvious benefits, the transition from biomass to fossil fuels is not yet complete. In India, 75 percent of the rural population still relies on dung for cooking, despite a push by the Indian government and international agencies to replace it with liquefied petroleum gas. And as Smil points out, thanks to population growth, humans today use more wood for fuel that at any other time in history.

The transition from a low-energy, biomass-dependent agricultural life to a high-energy, fossil-fuel-dependent industrial one came at a high human and environmental cost but also delivered significant progress. As terrible as industrial capitalism, particularly in its early forms, could be for factory workers, it was usually an improvement over what came before it, as Smil documents in a series of delightful boxes peppered throughout the book that feature obscure old texts reminding the reader of the brutality of daily life before and during the Industrial Revolution. “Ye gods, what a set of men I saw!” wrote the second-century Roman scholar Lucius Apuleius, describing Roman mill slaves. “Their skins were seamed all over with marks of the lash, their scarred backs were shaded rather than covered with tattered frocks.”

The shift from wood to coal was, especially in its early years, painful for many workers. In another box, Smil quotes from “An Inquiry Into the Condition of the Women Who Carry Coals Under Ground in Scotland,” published in 1812. “The mother sets out first, carrying a lighted candle in her teeth; the girls follow . . . with weary steps and slow, ascend the stairs, halting occasionally to draw breath. . . . It is no uncommon thing to see them . . . weeping most bitterly, from the excessive severity of labor.” Yet as cruel as coal mining could be, over time it helped liberate humans from agricultural drudgery, increase productivity, raise living standards, and, at least in developed nations, reduce reliance on wood for fuel, allowing reforestation and the return of wildlife.

WHY RENEWABLES CAN’T WORK

Smil argues that moving to renewable sources of energy will likely be a slow process, but he never addresses just how different such a move would be from past energy transitions. Almost every time a society has replaced one source of energy with another, it has shifted to a more reliable and energy-dense fuel. (The one exception, natural gas, has a larger volume than coal, but extracting it does far less environmental damage.) Replacing fossil fuels with renewables would mean moving to fuels that are less reliable and more diffuse.

Many advocates of renewables argue that hydroelectric power can solve this problem. They suggest that upgraded dams could supplement the unreliable electricity from solar and wind power, yet there are not nearly enough dams in the world to hold the necessary energy. In a study published in June in the *Proceedings of the National Academy of Sciences*, a team of energy and climate researchers found that the most prominent proposal for shifting the United States to completely renewable energy had inflated estimates of U.S. hydroelectric capacity tenfold. Without the exaggerated numbers, there is no renewable energy source to replace the power generated from the sun and the wind during the long stretches of time when the sun doesn't shine and the wind doesn't blow.

Moreover, all three previous energy transitions resulted in what's known as "dematerialization": the new fuels produced the same amount of energy using far fewer natural resources. By contrast, a transition from fossil fuels to solar or wind power, biomass, or hydroelectricity would require rematerialization—the use of more natural resources—since sunlight, wind, organic matter, and water are all far less energy dense than oil and gas.

Basic physics predicts that that rematerialization would significantly increase the environmental effects of generating energy. Although these would not be uniformly negative, many would harm the environment. Defunct solar panels, for example, are often shipped to poor countries without adequate environmental safeguards, where the toxic heavy metals they contain can leach into water supplies.

Given that Smil has done more than anyone to explain the relationship between energy density and environmental impact, it's surprising that he spends so little time on this problem as it relates to renewables. In 2015, Smil published an entire book, *Power Density*, on the general subject, showing how large cities depend on dense fuels and electricity. Renewables, he concluded, are too diffuse and unreliable to meet the vast material demands of skyscrapers, subways, and millions of people living and working close together. Yet he fails to mention this obstacle when discussing the fourth energy transition in his new book.

THE POWER OF THE ATOM

In both *Energy and Civilization* and *Power Density*, Smil introduces the concept of "energy return on energy investment" (EROEI), the ratio of energy produced to the energy needed to generate it. But Smil again fails to explain the concept's implications for renewable energy. In *Power Density*, Smil points to a study of EROEI published in 2013 by a team of German scientists who calculated that solar power and biomass have EROEIs of just 3.9 and 3.5, respectively, compared with 30 for coal and 75 for nuclear power. The researchers also concluded that for high-energy societies, such as Germany and the United States, energy sources with EROEIs of less than seven are not economically viable. Nuclear power is thus the only plausible clean option for developed economies.

Taking the rest of the world into account strengthens the case for nuclear power even further. Since two billion humans still depend on wood and dung to cook their supper, Smil notes that "much more energy will be needed during the coming generations to extend decent life to the majority of a still growing global population." But he goes on to claim that the environmental consequences of dramatically increasing global energy consumption are "unacceptable." He might be right if the increase were achieved with fossil fuels. But if every country moved up the energy ladder—from wood and dung to fossil fuels and from fossil fuels to uranium—all humans could achieve, or even surpass, Western levels of energy consumption while reducing global environmental damage below today's levels.

That's because far more energy is trapped in uranium atoms than in the chemical bonds within wood, coal, oil, or natural gas. Less than half an oil barrel full of uranium can provide the average amount of energy used by an American over his or her entire life. By contrast, it takes many train cars of coal to produce the same energy—with correspondingly larger environmental effects.

Renewables also require far more land and materials than nuclear power. California's Diablo Canyon nuclear power plant produces 14 times as much electricity annually as the state's massive Topaz Solar Farm and yet requires just 15 percent as much land. Since those vast fields of panels and mirrors eventually turn into waste products, solar power creates 300 times as much toxic waste per unit of energy produced as does nuclear power. For example, imagine that each year for the next 25 years (the average life span of a solar panel), solar and nuclear power both produced the same amount of electricity that nuclear power produced in 2016. If you then stacked their respective waste products on two football fields, the nuclear waste would reach some 170 feet, a little less than the height of the Leaning Tower of Pisa, whereas the solar waste would reach over 52,000 feet, nearly twice the height of Mount Everest.

Nuclear power is also by far the safest way to generate reliable energy, according to every major study published over the last 50 years. Even the worst nuclear accidents result in far fewer deaths than the normal operation of fossil fuel power plants. That’s because of the toxic smoke released by burning fossil fuels. According to the World Health Organization, the resulting air pollution from this and burning biomass kills seven million people every year. Nuclear power plants, by contrast, produce significant pollutants only when radioactive particles escape as a result of accidents. These are exceedingly rare, and when they do occur, so little radioactive material is released that vanishingly few people are exposed to it. In 1986, an unshielded reactor burned for over a week at the Chernobyl nuclear power plant, the world’s worst-ever nuclear accident. Yet the WHO has estimated that among the emergency workers at the scene, only about 50 died, and over the course of 75 years after the disaster, the radiation will cause only around 4,000 premature deaths.

The real threat to the public comes from irrational fears of nuclear power. The Fukushima nuclear accident in Japan in 2011, for example, did not lead to any deaths from direct radiation exposure. Yet public fear led Japan’s prime minister to intervene unnecessarily, prompting a panicked and needlessly large evacuation, which led to the deaths of over 1,500 people.

To his credit, Smil acknowledges nuclear power’s environmental and health benefits, but he goes on to suggest that for nuclear power to be economically viable, engineers will need to make a “breakthrough” in reducing the construction times of new nuclear power plants. But a comprehensive study of nuclear power plant construction costs published in *Energy Policy* last year found that water-cooled nuclear reactors (which are far less expensive than non-water-cooled designs) are already cheap enough to quickly replace fossil fuel power plants. And where nuclear power plant builders have shortened construction times, such as in France in the 1980s and South Korea more recently, they did so not by switching to different designs—a sure-fire recipe for delays—but rather by having the same experienced managers and workers build the same kinds of units on each site.

Despite his skepticism, Smil does leave the door open to nuclear power playing a role in the future. But he overlooks the fact that an entirely nuclear-powered society would be far preferable to a partially nuclear-powered one, as it would have no need for fossil fuels or large, wasteful, and unreliable solar or wind farms.

In the 1960s and 1970s, some of nuclear power's opponents regarded the technology as dangerous because it would provide humanity with too much energy. In 1975, the biologist Paul Ehrlich wrote in the Federation of American Scientists' *Public Interest Report* that "In fact, giving society cheap, abundant energy at this point would be the moral equivalent of giving an idiot child a machine gun." "It'd be little short of disastrous for us to discover a source of cheap, clean, and abundant energy because of what we would do with it," the energy guru Amory Lovins told *Mother Earth News* in 1977.

Smil does not share those extreme views, but he is concerned about the effects of excessive energy use. In *Energy and Civilization*, as in his other books, he skewers hyperconsumerism with relish, lambasting, for example, the "tens of millions of people [who] annually take inter-continental flights to generic beaches in order to acquire skin cancer faster" and the existence of "more than 500 varieties of breakfast cereals and more than 700 models of passenger cars." "Do we really need a piece of ephemeral junk made in China delivered within a few hours after an order was placed on a computer?" he asks.

As entertaining as Smil's outbursts are, restricting high-energy activities would do more harm than good. Cutting down on jet travel would crimp trade, investment, and international political cooperation, all of which would slow global economic growth and prevent poor nations from catching up to rich ones. And although consumer culture does generate a rather ridiculous array of breakfast cereals, it also delivers life-saving drugs and medical devices.

A high-energy society also allows continuing technological advances that often reduce humanity's environmental impact. Fertilizers and tractors, for example, have dramatically increased agricultural yields and allowed poorer soils to return to grasslands, wetlands, and forests and wildlife to return to their former habitats. For that reason, a growing number of conservationists support helping small farmers in poor nations replace wood with liquid fuels and improve their access to modern fertilizers and irrigation techniques in order to both feed the world's growing population and reverse deforestation.

Breakthroughs in information and communications technology are leading to forms of dematerialization unimaginable just a decade ago. Consider smartphones. They require more energy to manufacture and operate than older cell phones. But by obviating the need for separate, physical newspapers, books, magazines, cameras, watches, alarm clocks, GPS systems, maps, letters, calendars, address books, and stereos, they will likely significantly reduce humanity's use of energy and materials over the next century. Such examples suggest that holding technological progress back could do far more environmental damage than accelerating it.

Despite Smil's omissions and oversights, *Energy and Civilization* is a wise, compassionate, and valuable book. Smil helps readers understand the relationships among the energy density of fuels, the shape of human civilization, and humanity's environmental impact. The lesson Smil does not draw, but that flows inevitably from his work, is that for modern societies to do less environmental damage, every country must move toward more reliable and denser energy sources. In recent decades, governments have spent billions of dollars subsidizing renewables, with predictably underwhelming results. It's high time for countries to turn to the safer, cheaper, and cleaner alternative.