

Nuclear Now!

How clean, green atomic energy can stop global warming

By Peter Schwartz and Spencer Reiss

On a cool spring morning a quarter century ago, a place in Pennsylvania called Three Mile Island exploded into the headlines and stopped the US nuclear power industry in its tracks. What had been billed as the clean, cheap, limitless energy source for a shining future was suddenly too hot to handle.

In the years since, we've searched for alternatives, pouring billions of dollars into windmills, solar panels, and biofuels. We've designed fantastically efficient lightbulbs, air conditioners, and refrigerators. We've built enough gas-fired generators to bankrupt California. But mainly, each year we hack 400 million more tons of coal out of Earth's crust than we did a quarter century before, light it on fire, and shoot the proceeds into the atmosphere.

The consequences aren't pretty. Burning coal and other fossil fuels is driving climate change, which is blamed for everything from western forest fires and Florida hurricanes to melting polar ice sheets and flooded Himalayan hamlets. On top of that, coal-burning electric power plants have fouled the air with enough heavy metals and other noxious pollutants to cause 15,000 premature deaths annually in the US alone,

according to a Harvard School of Public Health study. Believe it or not, a coal-fired plant releases 100 times more radioactive material than an equivalent nuclear reactor - right into the air, too, not into some carefully guarded storage site. (And, by the way, more than 5,200 Chinese coal miners perished in accidents last year.)

Burning hydrocarbons is a luxury that a planet with 6 billion energy-hungry souls can't afford. There's only one sane, practical alternative: nuclear power.

We now know that the risks of splitting atoms pale beside the dreadful toll exacted by fossil fuels. Radiation containment, waste disposal, and nuclear weapons proliferation are manageable problems in a way that global warming is not. Unlike the usual green alternatives - water, wind, solar, and biomass - nuclear energy is here, now, in industrial quantities. Sure, nuke plants are expensive to build - upward of \$2 billion apiece - but they start to look cheap when you factor in the true cost to people and the planet of burning fossil fuels. And nuclear is our best hope for cleanly and efficiently generating hydrogen, which would end our other ugly hydrocarbon addiction-dependence on gasoline and diesel for transport.

Some of the world's most thoughtful greens have discovered the logic of nuclear power, including Gaia theorist James Lovelock, Greenpeace cofounder Patrick Moore, and Britain's Bishop Hugh Montefiore, a longtime board member of Friends of the Earth (see "Green vs. Green,"

page 82). Western Europe is quietly backing away from planned nuclear phaseouts. Finland has ordered a big reactor specifically to meet the terms of the Kyoto Protocol on climate change. China's new nuke plants - 26 by 2025 - are part of a desperate effort at smog control.

Even the shell-shocked US nuclear industry is coming out of its stupor. The 2001 report of Vice President Cheney's energy task force was only the most high profile in a series of pro-nuke developments. Nuke boosters are especially buoyed by more efficient plant designs, streamlined licensing procedures, and the prospect of federal subsidies.

In fact, new plants are on the way, however tentatively. Three groups of generating companies have entered a bureaucratic maze expected to lead to formal applications for plants by 2008. If everything breaks right, the first new reactors in decades will be online by 2014. If this seems ambitious, it's not; the industry hopes merely to hold on to nuclear's current 20 percent of the rapidly growing US electric power market.

That's not nearly enough. We should be shooting to match France, which gets 77 percent of its electricity from nukes. It's past time for a decisive leap out of the hydrocarbon era, time to send King Coal and, soon after, Big Oil shambling off to their well-deserved final resting places-maybe on a nostalgic old steam locomotive.

Besides, wouldn't it be a blast to barrel down the freeway in a hydrogen Hummer with a clean conscience as your copilot? Or not to feel like a planet killer every time you flick on the A/C? That's how the future could be, if only we would get over our fear of the nuclear bogeyman and forge ahead-for real this time - into the atomic age.

The granola crowd likes to talk about conservation and efficiency, and surely substantial gains can be made in those areas. But energy is not a luxury people can do without, like a gym membership or hair gel. The developed world built its wealth on cheap power - burning firewood, coal, petroleum, and natural gas, with carbon emissions the inevitable byproduct.

Indeed, material progress can be tracked in what gets pumped out of smokestacks. An hour of coal-generated 100-watt electric light creates 0.05 pounds of atmospheric carbon, a bucket of ice makes 0.3 pounds, an hour's car ride 5. The average American sends nearly half a ton of carbon spewing into the atmosphere every month. Europe and Japan are a little more economical, but even the most remote forest-burning peasants happily do their part.

And the worst - by far - is yet to come. An MIT study forecasts that worldwide energy demand could triple by 2050. China could build a Three Gorges Dam every year forever and still not meet its growing demand for electricity. Even the carbon reductions required by the Kyoto

Protocol - which pointedly exempts developing countries like China - will be a drop in the atmospheric sewer.

What is a rapidly carbonizing world to do? The high-minded answer, of course, is renewables. But the notion that wind, water, solar, or biomass will save the day is at least as fanciful as the once-popular idea that nuclear energy would be too cheap to meter. Jesse Ausubel, director of the human environment program at New York's Rockefeller University, calls renewable energy sources "false gods" - attractive but powerless. They're capital- and land-intensive, and solar is not yet remotely cost-competitive. Despite all the hype, tax breaks, and incentives, the proportion of US electricity production from renewables has actually fallen in the past 15 years, from 11.0 percent to 9.1 percent.

The decline would be even worse without hydropower, which accounts for 92 percent of the world's renewable electricity. While dams in the US are under attack from environmentalists trying to protect wild fish populations, the Chinese are building them on an ever grander scale. But even China's autocrats can't get past Nimby. Stung by criticism of the monumental Three Gorges project - which required the forcible relocation of 1 million people - officials have suspended an even bigger project on the Nu Jiang River in the country's remote southwest. Or maybe someone in Beijing questioned the wisdom of reacting to climate change with a multibillion-dollar bet on rainfall.

Solar power doesn't look much better. Its number-one problem is cost: While the price of photovoltaic cells has been slowly dropping, solar-generated electricity is still four times more expensive than nuclear (and more than five times the cost of coal). Maybe someday we'll all live in houses with photovoltaic roof tiles, but in the real world, a run-of-the-mill 1,000-megawatt photovoltaic plant will require about 60 square miles of panes alone. In other words, the largest industrial structure ever built.

Wind is more promising, which is one reason it's the lone renewable attracting serious interest from big-time equipment manufacturers like General Electric. But even though price and performance are expected to improve, wind, like solar, is inherently fickle, hard to capture, and widely dispersed. And wind turbines take up a lot of space; Ausubel points out that the wind equivalent of a typical utility plant would require 300 square miles of turbines plus costly transmission lines from the wind-scoured fields of, say, North Dakota. Alternatively, there's California's Altamont Pass, where 5,400 windmills slice and dice some 1,300 birds of prey annually.

What about biomass? Ethanol is clean, but growing the amount of cellulose required to shift US electricity production to biomass would require farming - no wilting organics, please - an area the size of 10 Iowas.

Among fossil fuels, natural gas holds some allure; it emits a third as much carbon as coal. That's an improvement but not enough if you're

serious about rolling back carbon levels. Washington's favorite solution is so-called clean coal, ballyhooed in stump speeches by both President Bush (who offered a \$2 billion research program) and challenger John Kerry (who upped the ante to \$10 billion). But most of the work so far has been aimed at reducing acid rain by cutting sulphur dioxide and nitrogen oxide emissions, and more recently gasifying coal to make it burn cleaner. Actual zero-emissions coal is still a lab experiment that even fans say could double or triple generating costs. It would also leave the question of what to do with 1 million tons of extracted carbon each year.

By contrast, nuclear power is thriving around the world despite decades of obituaries. Belgium derives 58 percent of its electricity from nukes, Sweden 45 percent, South Korea 40, Switzerland 37 percent, Japan 31 percent, Spain 27 percent, and the UK 23 percent. Turkey plans to build three plants over the next several years. South Korea has eight more reactors coming, Japan 13, China at least 20. France, where nukes generate more than three-quarters of the country's electricity, is privatizing a third of its state-owned nuclear energy group, Areva, to deal with the rush of new business.

The last US nuke plant to be built was ordered in 1973, yet nuclear power is growing here as well. With clever engineering and smart management, nukes have steadily increased their share of generating capacity in the US. The 103 reactors operating in the US pump out electricity at more than 90 percent of capacity, up from 60 percent when

Three Mile Island made headlines. That increase is the equivalent of adding 40 new reactors, without bothering anyone's backyard or spewing any more carbon into the air.

So atomic power is less expensive than it used to be - but could it possibly be cost-effective? Even before Three Mile Island sank, the US nuclear industry was foundering on the shoals of economics. Regulatory delays and billion-dollar construction-cost overruns turned the business into a financial nightmare. But increasing experience and efficiency gains have changed all that. Current operating costs are the lowest ever - 1.82 cents per kilowatt-hour versus 2.13 cents for coal-fired plants and 3.69 cents for natural gas. The ultimate vindication of nuclear economics is playing out in the stock market: Over the past five years, the stocks of leading nuclear generating companies such as Exelon and Entergy have more than doubled. Indeed, Exelon is feeling so flush that it bought New Jersey's Public Service Enterprise Group in December, adding four reactors to its former roster of 17.

This remarkable success suggests that nuclear energy realistically could replace coal in the US without a cost increase and ultimately lead the way to a clean, green future. The trick is to start building nuke plants and keep building them at a furious pace. Anything less leaves carbon in the climatic driver's seat.

A decade ago, anyone thinking about constructing nuclear plants in the US would have been dismissed as out of touch with reality. But today, for the first time since the building of Three Mile Island, new nukes in the US seem possible. Thanks to improvements in reactor design and increasing encouragement from Washington, DC, the nuclear industry is poised for unlikely revival. “All the planets seem to be coming into alignment,” says David Brown, VP for congressional affairs at Exelon.

The original US nuclear plants, built during the 1950s and ‘60s, were descended from propulsion units in 1950s-vintage nuclear submarines, now known as generation I. During the ‘80s and ‘90s, when new construction halted in the US, the major reactor makers - GE Power Systems, British-owned Westinghouse, France’s Framatome (part of Areva), and Canada’s AECL - went after customers in Europe. This new round of business led to system improvements that could eventually, after some prototyping, be deployed back in the US.

By all accounts, the latest reactors, generation III+, are a big improvement. They’re fuel-efficient. They employ passive safety technologies, such as gravity-fed emergency cooling rather than pumps. Thanks to standardized construction, they may even be cost-competitive to build - \$1,200 per kilowatt-hour of generating capacity versus more than \$1,300 for the latest low-emission (which is not to say low-carbon) coal plants. But there’s no way to know for sure until someone actually builds one. And even then, the first few will almost certainly cost more.

Prodded by the Cheney report, the US Department of Energy agreed in 2002 to pick up the tab of the first hurdle - getting from engineering design to working blueprints. Three groups of utility companies and reactor makers have stepped up for the program, optimistically dubbed Nuclear Power 2010. The government's bill to taxpayers for this stage of development could top \$500 million, but at least we'll get working reactors rather than "promising technologies."

But newer, better designs don't free the industry from the intense public oversight that has been nuclear power's special burden from the start. Believe it or not, Three Mile Island wasn't the ultimate nightmare; that would be Shoreham, the Long Island power plant shuttered in 1994 after a nine-year legal battle, without ever having sold a single electron. Construction was already complete when opponents challenged the plant's application for an operating license. Wall Street won't invest billions in new plants (\$5.5 billion in Shoreham's case) without a clear path through the maze of judges and regulators.

Shoreham didn't die completely in vain. The 1992 Energy Policy Act aims to forestall such debacles by authorizing the Nuclear Regulatory Commission to issue combined construction and operating licenses. It also allows the NRC to pre-certify specific reactor models and the energy companies to bank preapproved sites. Utility executives fret that no one has ever road-tested the new process, which still requires public hearings

and shelves of supporting documents. An idle reactor site at Browns Ferry, Alabama, could be an early test case; the Tennessee Valley Authority is exploring options to refurbish it rather than start from scratch.

Meanwhile, Congress looks ready to provide a boost to the nuclear energy industry. Pete Domenici (R-New Mexico), chair of the Senate's energy committee and the patron saint of nuclear power in Washington, has vowed to revive last year's energy bill, which died in the Senate. Earlier versions included a 1.85 cent per-kilowatt-hour production tax credit for the first half-dozen nuke plants to come online. That could add up to as much as \$8 billion in federal outlays and should go a long way toward luring Wall Street back into the fray. As pork goes, the provision is easy to defend. Nuclear power's extraordinary startup costs and safety risks make it a special case for government intervention. And the amount is precisely the same bounty Washington spends annually in tax credits for wind, biomass, and other zero-emission kilowattage.

Safer plants, more sensible regulation, and even a helping hand from Congress - all are on the way. What's still missing is a place to put radioactive waste. By law, US companies that generate nuclear power pay the Feds a tenth of a cent per kilowatt-hour to dispose of their spent fuel. The fund - currently \$24 billion and counting - is supposed to finance a permanent waste repository, the ill-fated Yucca Mountain in Nevada. Two decades ago when the payments started, opening day was scheduled

for January 31, 1998. But the Nevada facility remains embroiled in hearings, debates, and studies, and waste is piling up at 30-odd sites around the country. Nobody will build a nuke plant until Washington offers a better answer than “keep piling.”

At Yucca Mountain, perfection has been the enemy of adequacy. It's fun to discuss what the design life of an underground nuclear waste facility ought to be. One hundred years? Two hundred years? How about 100,000? A quarter of a million? Science fiction meets the US government budgeting process. In court!

But throwing waste into a black hole at Yucca Mountain isn't such a great idea anyway. For one thing, in coming decades we might devise better disposal methods, such as corrosion-proof containers that can withstand millennia of heat and moisture. For another, used nuclear fuel can be recycled as a source for the production of more energy. Either way, it's clear that the whole waste disposal problem has been misconstrued. We don't need a million-year solution. A hundred years will do just fine - long enough to let the stuff cool down and allow us to decide what to do with it.

The name for this approach is interim storage: Find a few patches of isolated real estate - we're not talking about taking it over for eternity - and pour nice big concrete pads; add floodlights, motion detectors, and razor wire; truck in nuclear waste in bombproof 20-foot-high concrete

casks. Void?safe storage while you wait for either Yucca Mountain or plan B.

Two dozen reactor sites around the country already have their own interim facilities; a private company has applied with the NRC to open one on the Goshute Indian reservation in Skull Valley, Utah. Establishing a half- dozen federally managed sites is closer to the right idea. Domenici says he'll introduce legislation this year for a national interim storage system.

A handful of new US plants will be a fine start, but the real goal has to be dethroning King Coal and - until something better comes along - pushing nuclear power out front as the world's default energy source. Kicking carbon cold turkey won't be easy, but it can be done. Four crucial steps can help increase the momentum: Regulate carbon emissions, revamp the fuel cycle, rekindle innovation in nuclear technology, and, finally, replace gasoline with hydrogen.

Regulate carbon emissions.

Nuclear plants have to account for every radioactive atom of waste. Meanwhile, coal-fired plants dump tons of deadly refuse into the atmosphere at zero cost. It's time for that free ride to end, but only the government can make it happen.

The industry seems ready to pay up. Andy White, CEO of GE Energy's nuclear division, recently asked a roomful of US utility executives what they thought about the possibility of regulating carbon emissions. The idea didn't faze them. "The only question any of them had," he says, "was when and how much."

A flat-out carbon tax is almost certainly a nonstarter in Washington. But an arrangement in which all energy producers are allowed a limited number of carbon pollution credits to use or sell could pass muster; after all, this kind of cap-and-trade scheme is already a fact of life for US utilities with a variety of other pollutants. Senators John McCain and Joe Lieberman have been pushing legislation such a system. This would send a clear message to utility executives that fossil energy's free pass is over.

Recycle nuclear fuel

Here's a fun fact: Spent nuclear fuel - the stuff intended for permanent disposal at Yucca Mountain - retains 95 percent of its energy content. Imagine what Toyota could do for fuel efficiency if 95 percent of the average car's gasoline passed through the engine and out the tailpipe. In France, Japan, and Britain, nuclear engineers do the sensible thing: recycle. Alone among the nuclear powers, the US doesn't, for reasons that have nothing to do with nuclear power.

Recycling spent fuel - the technical word is reprocessing - is one way to make the key ingredient of a nuclear bomb, enriched uranium. In 1977, Jimmy Carter, the only nuclear engineer ever to occupy the White House, banned reprocessing in the US in favor of a so-called once-through fuel cycle. Four decades later, more than a dozen countries reprocess or enrich uranium, including North Korea and Iran. At this point, hanging onto spent fuel from US reactors does little good abroad and real mischief at home.

The Bush administration has reopened the door with modest funding to resume research into the nuclear fuel cycle. The president himself has floated a proposal to provide all comers with a guaranteed supply of reactor fuel in exchange for a promise not to reprocess spent fuel themselves. Other proposals would create a global nuclear fuel company, possibly under the auspices of the International Atomic Energy Agency. This company would collect, reprocess, and distribute fuel to every nation in the world, thus keeping potential bomb fixings out of circulation.

In the short term, reprocessing would maximize resources and minimize the problem of how to dispose of radioactive waste. In fact, it would eliminate most of the waste from nuclear power production. Over decades, it could also ease pressure on uranium supplies. The world's existing reserves are generally reckoned sufficient to withstand 50 years of rapid nuclear expansion without a significant price increase. In a pinch,

there's always the ocean, whose 4.5 billion tons of dissolved uranium can be extracted today at 5 to 10 times the cost of conventional mining.

Uranium is so cheap today that reprocessing is more about reducing waste than stretching the fuel supply. But advanced breeder reactors, which create more fuel as they generate power, could well be the economically competitive choice - and renewable as well.

Rekindle innovation.

Although nuclear technology has come a long way since Three Mile Island, the field is hardly a hotbed of innovation. Government-funded research - such as the DOE's Next Generation Nuclear Plant program - is aimed at designing advanced reactors, including high temperature, gas-cooled plants of the kind being built in China and South Africa and fast-breeder reactors that will use uranium 60 times more efficiently than today's reactors. Still, the nuclear industry suffers from its legacy of having been born under a mushroom cloud and raised by your local electric company. A tight leash on nuclear R&D may be good, even necessary. But there's nothing like a little competition to spur creativity. That's reason enough to want to see US companies squarely back on the nuclear power field - research is great, but more and smarter buyers ultimately drive quality up and prices down.

In fact, the possibility of a nuclear gold rush - not just a modest rebirth - depends on economics as much as technology. The generation IV pebble-bed reactors being developed in China and South Africa get attention for their meltdown-proof designs. (See “Let a Thousand Reactors Bloom,” issue 12.09.) But it’s their low capital cost and potential for fast, modular construction that could blow the game open, as surely as the PC did for computing. As long as investments come in \$2 billion increments, purchase orders will be few and far between. At \$300 million a pop for safe, clean energy, watch the floodgates open around the world.

Replace gasoline with hydrogen.

If a single change could truly ignite nuclear power, it’s the grab bag of technologies and wishful schemes traveling under the rubric of the hydrogen economy. Leaving behind petroleum is as important to the planet’s future as eliminating coal. The hitch is that it takes energy to extract hydrogen from substances like methane and water. Where will it come from?

Today, the most common energy source for producing hydrogen is natural gas, followed by oil. It’s conceivable that renewables could do it in limited quantities. By the luck of physics, though, two things nuclear reactors do best - generate both electricity and very high temperatures-are exactly what it takes to produce hydrogen most efficiently. Last November, the DOE’s Idaho National Engineering and Environmental

Laboratory showed how a single next-gen nuke could produce the hydrogen equivalent of 400,000 gallons of gasoline every day. Nuclear energy's potential for freeing us not only from coal but also oil holds the promise of a bright green future for the US and the world at large.

The more seriously you take the idea of global warming, the more seriously you have to take nuclear power. Clean coal, solar-powered roof tiles, wind farms in North Dakota - they're all pie in the emissions-free sky. Sure, give them a shot. But zero-carbon reactors are here and now. We know we can build them. Their price tag is no mystery. They fit into the existing electric grid without a hitch. Flannel-shirted environmentalists who fight these realities run the risk of ending up with as much soot on their hands as the slickest coal-mining CEO.

America's voracious energy appetite doesn't have to be a bug - it can be a feature. Shanghai, Seoul, and S?Paolo are more likely to look to Los Angeles or Houston as a model than to some solar-powered idyll. Energy technology is no different than any other; innovation can change all the rules. But if the best we can offer the developing world is bromides about energy independence, we'll deserve the carbon-choked nightmare of a planet we get.

Nuclear energy is the big bang still reverberating. It's the power to light a city in a lump the size of a soda can. Peter Huber and Mark Mills

have written an iconoclastic new book on energy, *The Bottomless Well*. They see nuclear power as merely the latest in a series of technologies that will gradually eliminate our need to carve up huge swaths of the planet. “Energy isn’t the problem. Energy is the solution,” they write. “Energy begets more energy. The more of it we capture and put to use, the more readily we will capture still more.”

The best way to avoid running out of fossil fuels is to switch to something better. The Stone Age famously did not end for lack of stones, and neither should we wait for the last chunk of anthracite to flicker out before we kiss hydrocarbons good-bye. Especially not when something cleaner, safer, more efficient, and more abundant is ready to roll. It’s time to get real.

Green vs. Green

The environmental movement, once staunchly antinuclear, is facing resistance from within.

by Amanda Griscom Little From Greenpeace to the Green Party, some of the most prominent environmental groups today made their reputations in the 1970s as opponents of nuclear power. So it was no wonder that greens were vexed last summer when prime minister Tony Blair proposed a new generation of nuclear power plants for Britain to confront the problem of climate change. But what galled them even more was the response to Blair from Hugh Montefiore, a

former Anglican bishop and longtime trustee of Friends of the Earth. Writing in the British journal *The Tablet* in October, Montefiore committed what colleagues viewed as the ultimate betrayal: “I have now come to the conclusion that the solution [to global warming] is to make more use of nuclear energy.” When Montefiore told fellow trustees that he planned to speak out, they made him resign his post.

Montefiore isn't the only dyed-in-the-wool green who has been exiled for advocating nuclear power. Greenpeace cofounder Patrick Moore left the organization after embracing atomic energy. British biologist James Lovelock, whose Gaia theory was an environmental watchword before he turned pro-nuke, is now persona non grata within the movement. “There are members of my former organization who would agree with me but have not gone public about the matter,” Montefiore laments. “If only we had a few more people who would stick their necks out, it would help.”

Maybe not. Consider the green reaction to the National Commission on Energy Policy, whose board of directors includes a Harvard professor emeritus of environmental policy and a senior attorney at the Natural Resources Defense Council. In December, the commission released a 150-page report that proposed reinvigorating the nuclear industry with billions in subsidies. The US must seek “a substantial expansion” of atomic power to counter climate change, the report said. Environmental groups bristled. The NRDC rejected the report's nuclear section as “old-style

thinking.” Members of Greenpeace, the Sierra Club, and the Union of Concerned Scientists heaved their own brickbats.

So what would it take for environmentalists to accept nukes? Although green opinions vary, sources in the movement say much of the resistance would soften if the industry dealt with four persistent issues.

The top priority for many environmentalists is to counter proliferation of nuclear weapons. To stem the creation of weapons-grade materials, they want to prohibit plants from recycling fuel and install robust security at reactor fuel production facilities. Second, to diminish the risk of Chernobyl-style accidents, they’d like to see aging plants updated, safety protocols strengthened, and oversight tightened. Third, greens want a secure place to put waste. Yucca Mountain in Nevada, they say, needs to be proven capable of holding radioactive refuse for the hundreds of thousands of years it will take to decay; alternatively, a national system of short-term interim storage might be acceptable. Fourth, environmentalists insist that uranium mines, which are notorious polluters, employ cleaner extraction methods and submit to tougher environmental regulations.

“If our concerns were thoroughly addressed, there could be a greater role for commercial nuclear power that we would support,” says Geoffrey Fettus, senior project attorney at the NRDC. “But the devil is in the

details, and the industry hasn't acknowledged that the problems even exist."

While none of the leading environmental groups are going to lead the nuclear charge, insiders say the Union of Concerned Scientists has a growing pro-nuke faction. But don't look for a trend. "I want to drive a stake through the heart of the nuclear industry," says Greenpeace senior nuclear policy analyst Jim Ricchio. "I don't expect that to change."