COMMENT

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San Onofre Nuclear Generating Station, California.

A US nuclear future?

Building nuclear power plants in the United States could be the best clean alternative to coal in the near future. Or it could be a costly mistake.

POINT
The best way forward

Charles D. Ferguson *and* Lindsey E. Marburger
of the Federation of American Scientists.

Although no single energy source offers a cure-all, nuclear energy must have an important role in reducing the use of fossil fuels in the United States. In February 2010, US President Barack Obama announced an US$8.3-billion loan guarantee for a power company hoping to build two new reactors, and the White House is asking the US Congress for an additional $36 billion in loan guarantees for similar projects. This is a crucial part of the policies and finance mechanisms that must be put in place for a competitive, sustainable nuclear energy industry to develop.

US electricity demand is projected to grow by almost 30% by 2035 (ref. 1). The needed investment in energy facilities to fulfil this demand is larger than it first seems, because most coal and nuclear plants are past the middle-age of their permitted 60-year **PAGE 392 ▶**

COUNTERPOINT
Not wanted, not needed

J. Doyne Farmer *of the Santa Fe Institute and* Arjun Makhijani
of the Institute for Energy and Environmental Research.

The costs of nuclear power, from the cash investment to the risks of proliferation, disaster and environmental harm, are simply too high — especially when one considers that many of the true costs are obscured by government subsidies. Fortunately there are plenty of workable alternatives with low-to-zero carbon dioxide emissions.

The current total power requirements of the United States could theoretically be supplied by solar power plants covering about 36,000 square kilometres of land in the desert southwest, an area an eighth the size of the state of Nevada. Wind energy could produce about nine times the current annual US electricity generation.

Although both resources currently provide only a tiny proportion of US energy, they can be ramped up quickly. Annual installation of wind-energy capacity in the United States has quadrupled from **PAGE 393 ▶**

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POINT: THE BEST WAY ▶ lives. By 2035, more than half of the nation's coal plants and 40% of the nation's nuclear capacity will be retired unless the plants receive operation extensions[1].

Natural gas — a relatively low-carbon-emission fossil fuel — has been the preferred fuel for new electrical capacity over the past two decades. Resource discoveries and advances in extraction technologies have made natural gas seem inexpensive. But as US demand increases for gas in heating, cooking and transportation, its price will rise. Natural-gas electricity is highly vulnerable to price changes and fuel costs can account for upwards of 70% of the cost of generation (compared with about 30% for coal and about 15% for uranium-fuelled nuclear)[2]. Smart policy would be to reduce the use of natural gas in electricity generation.

Although, theoretically, renewable-energy technologies such as solar and wind have the potential to meet all of the world's energy needs, and will be a key component of the future low-carbon electricity mix, the intermittent nature of these technologies currently prevents them from being a viable source of steady, base-load electricity. Today, nuclear is the only available, proven and affordable large-power and near-zero carbon emission electricity generation.

At least 28 new 1,000-megawatt reactors will have to be built by 2035 just to keep nuclear providing the business-as-usual level of 20% of US electricity needs, given the increase in projected electricity demand as well as the impending retirement of existing power plants. There are currently 19 licence applications, for 30 new reactors (see map), filed with the US Nuclear Regulatory Commission (NRC). This burst of activity follows a long pause: the last US nuclear plant to be built obtained its permit in 1973. It is imperative that applications for about this number of new reactors be approved and that policy and economic steps are taken to ensure their success.

BEST OPTIONS

The cost of nuclear plants may seem prohibitive. A large US nuclear facility typically requires an initial capital investment of $6 billion to $9 billion, and takes about 10 years to permit and build. But this can be improved. The Korea Electric Power Corporation (KEPCO) has recently won a contract to build four 1,400-megawatt reactors in the United Arab Emirates for $20 billion. The projected construction time of 48 months aligns with the build time of the latest South Korean reactor. By emulating KEPCO's efficiencies and streamlining the regulatory process, the total build time in the United States could be reduced, shrinking capital cost and investor risk.

"Risks are manageable if available best practices are followed throughout the industry."

Although a commercial-scale renewable-power plant can be permitted and constructed in less than a year in many cases, the best sites for wind and sun are usually far from population centres and the electricity grid. Thus such facilities often require the installation of power lines crossing state boundaries. This is politically arduous; from 2000 to 2009, only 14 cross-state power lines have been built. Building a truly national grid, or a 'smart' grid that connects small, hyper-local power sources as opposed to commercial-scale facilities, is a daunting task. In the meantime, it is easier to build large-scale facilities where the grid already exists — for which nuclear has the advantage.

Nuclear power poses substantial risks; an 'inherently safe' nuclear plant simply doesn't exist. But risks can be made manageable by ensuring best practices are followed throughout the industry, and by working to improve controls. For example, the incentive for weapon-capable states to become nuclear-armed can be reduced through security alliances and monitoring. Much more can, and should, be done to improve controls. To start with, the International Atomic Energy Agency (IAEA) Board of Governors and the Nuclear Suppliers Group should hold all nuclear states to the Additional Protocol — which gives the IAEA access to more information and inspection rights. In addition, governments and industry should increase funding to the IAEA commensurate with the growth of nuclear facilities.

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Further reading accompanies this article at
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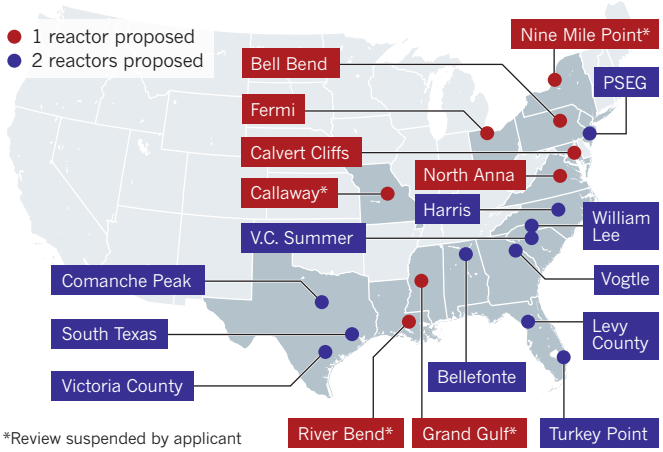
APPLICATIONS FOR NEW NUCLEAR REACTORS

19 sites in the United States have applied to build one or more reactors.



Nuclear capacity will not grow unless governments and industry make nuclear power more affordable. To achieve this goal, the US government must first put a price on carbon emissions. Second, it should streamline the regulatory process. The NRC has already taken steps to improve the process by combining construction and operation licences. Companies should play their part by ensuring that their applications are complete and do not cut corners .

Third, effective and innovative financing needs to be developed by governments. Countries such as China and France, which have state ownership of their utilities, have generally been much more successful in building nuclear plants. China, for example, has more than 20 reactors currently under construction — more than any other country. The small utility companies in privatized US markets usually lack access to the collateral necessary to take out a multibillion-dollar loan for a nuclear plant. So, alternative financing mechanisms are necessary.

Loan guarantees are one good idea, provided that they do not expose taxpayers to undue financial risk. From past experience, the default rate for loans on US nuclear plants may be as high as 50%, potentially leaving taxpayers to cover up to $18 billion of the $36 billion in loan guarantees. To reduce this burden, the US government should charge a credit subsidy fee: high enough to protect the taxpayer, low enough to encourage project development.

Another innovative financing scheme is to encourage utilities to merge so that the market capitalization of the combined company is large enough to attract investors — but not so large that they give companies monopolistic power. A related mechanism is to allow loans from, or mergers with, foreign firms; this was done in a recent deal between the French state utility EDF and the US company Constellation Energy, which plan to build a new nuclear reactor at Calvert Cliffs, Maryland.

Nobel-prizewinning physicist Hans Bethe, one of the founders of the Federation of American Scientists, wrote in 1976 that "objections can be raised to any attainable source of power", and concluded that "nuclear fission is the only major non-fossil power source the US can rely on for the rest of this century and probably for some time afterward". He remains correct. ■ SEE NEWS P.376

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1. *Annual Energy Outlook 2010 with Projections to 2035* (Energy Information Administration, 2010); available at http://www.eia.doe.gov/oiaf/aeo/electricity.html
2. *Projected Costs of Generating Electricity: 2010 Edition* (OECD, 2010).

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COUNTERPOINT: NOT NEEDED ▶ about 2,500 megawatts in 2006 to about 10,000 megawatts in 2009. Multiple groups have shown that wind-power capacity could grow to provide 30–40% of US electricity supply within 30 years. In 2008, a US Department of Energy report concluded that using wind energy to meet 20% of energy needs by 2030 "while ambitious, could be feasible"[1]. One comprehensive study of the potential of solar energy showed that it "has the technical, geographical, and economic potential to supply 69% of the total electricity needs and 35% of the total (electricity and fuel) energy needs of the US by 2050"[2]. None of this will be easy: it will require energy and carbon policy capable of redirecting the massive capital investment in fossil fuels and planned nuclear power. But the difficulties are political, not technological.

Wind power and solar power are often criticized for being too intermittent and unreliable. Solutions to these problems are available today. Compressed-air energy storage is cost effective, and has been used commercially with coal-fired plants since 1978 to smooth out peaks in demand. In addition, the technique of using molten salt to store the heat energy produced by concentrating solar thermal power plants is now being commercialized. A large 280-megawatt plant with six-hour salt-storage is planned in Arizona, with a tentative completion date of 2013. Existing hydropower could be used to even out remaining gaps in the power supply.

BETTING THE FARM

The cost of a nuclear reactor is often so large — US$8 billion to $10 billion — as to be comparable to the market capitalization of the company proposing the project. As a result they are considered a 'bet the farm' risk by Wall Street, which refuses to finance them.

The history of the US nuclear industry has been rife with construction delays, cost overruns and cancellations. The last reactor to come online, completed in 1996, took 23 years to build. Capital costs rose from about $1,000 per kilowatt in 1970 to $5,000–9,000 per kilowatt in the 1990s (ref. 3). The reasons are debated, but include loss-leader pricing in the early years, expensive design changes required by regulators in later years for safety, and interest-rate fluctuations. The enormous cost of reactors makes learning very expensive. Estimates over the past few years have shown that there is little reason to expect reactor construction costs in the United States to fall.

By contrast, between 1981 and 2001 the capital cost of wind power dropped by a factor of about four. Over roughly the same period (see graph), solar photovoltaic energy costs decreased by a factor of almost ten[3]. Since about 2003, increases in the costs of materials, due in part to the dramatic growth in demand in China, have pushed up the capital costs of all energy-generation technologies except solar.

Nuclear currently costs from about 12 cents to more than 20 cents per kilowatt-hour, and coal just 7–8 cents per kilowatt-hour, without the cost of carbon capture and sequestration. Wind is already generally cheaper than nuclear: we calculate that the full cost, including capital, fuel, operation and maintenance, is 11–14 cents with compressed-air energy storage. Large-scale solar photovoltaic energy without storage is currently at about 16 cents. By our estimate, only about $100 billion of additional built capacity (equivalent to the cost of a dozen nuclear reactors) is needed before solar energy will be cheaper than coal[4].

"Nuclear power cannot stand on its own feet after half a century."

Current price estimates for nuclear energy ignore important hidden costs. The US Price–Anderson Act caps the liability of the nuclear power industry at a few hundred million dollars per plant. By law the nuclear industry also maintains an 'insurance pool' that would pay up to about $11 billion in case of an accident. This is a meagre sum compared with the estimated damages of the most severe accidents, which could run into hundreds of billions of dollars. Clearly the Price–Anderson Act needs to be amended so that the cost of nuclear power reflects the full risks.

SCALED-UP DANGERS

There are also undesirable side effects of using nuclear power. To make a large dent in CO_2 emissions, 2,000–3,000 reactors would be needed worldwide by 2050 to replace an equivalent coal capacity and to increase the share of nuclear electricity to about 30%. This poses a huge proliferation hazard. Two medium-sized uranium–enrichment plants would need to be built every year to fuel so many nuclear reactors, increasing the risk that some fuel would be diverted and enriched to weapons-grade material. A major US push for nuclear power will make developing countries more likely to demand the capacity to enrich their own fuel, vastly hampering efforts to clamp down on nuclear proliferation.

In addition, each 1,000-megawatt reactor generates about 30 nuclear-bombs' worth of plutonium each year. There is still no long-term solution for the safe disposal of nuclear waste. This year, the office managing the US Yucca Mountain storage project is being closed down, leaving the discussion potentially back at square one after a 30-year and $12-billion effort.

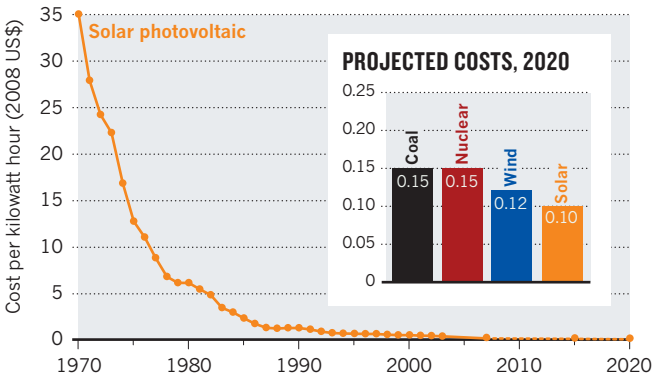
Finally, each 1,000-megawatt nuclear plant loses between 40 million and 80 million litres of water a day through evaporation. Wind, solar photovoltaic and concentrating solar thermal power plants (if they are air-cooled) consume little by comparison. Switching from coal and nuclear sources to renewable energy could save about 7 trillion litres of water a year in the United States.

The nuclear power industry survives thanks to government lifelines. By its own reckoning, the US nuclear industry cannot be revived without massive loan guarantees, continued insurance subsidies and government guarantees to do something with the waste. Nuclear power cannot stand on its own feet after half a century. There are cheaper, quicker and better solutions at hand. President Barack Obama needs to abandon the government lifelines for nuclear energy, and instead push for 30–40% renewable-electricity production by 2025. Such a course would convert cheap talk about US leadership into a reality. ■ SEE NEWS P.376

CHANGING ENERGY COSTS

The price of solar power continues to plummet; its cost is projected to fall below those of nuclear and coal.

SOURCES: BASED ON REFS 2–6



Projected wind and solar costs include compressed air energy storage; historical solar costs do not. Coal cost includes carbon capture and sequestration. Nuclear subsidies not included.

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