Three Strikes and Out? Nuclear Energy in the United States in the Wake of Three Mile Island, Chernobyl and Fukishima

By Dr Charles Ebinger, Senior Fellow and
Director, Energy Security Initiative, Brookings Institution

Since President Eisenhower's "Atoms for Peace" speech before the United Nations in December 1953 nuclear energy in the United States has been seen in the 1954 words of Levi Strauss either as a vital source of electricity that within fifteen years would be "too cheap to meter" or as a Faustian bargain with the devil that has no place in the world's future energy mix. Coming out of the US Navy's atomic submarine programme, commercial nuclear power for civilian use received a major boost in 1963 when a New Jersey public utility ordered the first commercial-scale plant from General Electric. Over the next decade nearly 50 reactors were ordered either from General Electric, which initially sponsored a BWR (Boiling Water Design), or Westinghouse which supported a PWR (Pressurized Water Reactor). While other vendors in the US and abroad experimented with modifications of these designs or their own technologies, the use of commercial nuclear power sky rocketed with projections that nuclear energy might provide up to 50% of US electricity by 2000.

Ironically it was this hubris, with each vendor or utility wanting its own unique design, that came to haunt the industry in the following decades, since this approach led to a plethora of different issues for regulators at both the state and federal level to address. This diverse set of designs, rather than the industry agreeing on one or two more " standardised designs", meant that each licensing hearing occurred in a vacuum with little ability to draw lessons learned from previous decisions and, as reactors moved from the design stage to construction and operation, problems began to arise. The fact that all these technologies were new and had no experience on which to draw meant that regulators in the early days were often deciding issues by the seat of their pants with no firm knowledge of all the issues that would inevitably arise.

The fact that siting, construction and operational licenses were often bifurcated with state and federal regulators each doing their independent reviews rather than acting in concert, also added to the time required to build a nuclear plant. Since at the time these capital intensive plants were not allowed to recover any of their costs from ratepayers until the plants commenced operation led to an escalation in costs that during a high inflation era such as the Carter Administration led plants that had been forecast to cost $200-300 million dollars to rise to more than ten times that cost and, in the case of the Nine Mile 2 plant outside Syracuse, to hit over $9 billion dollars. The problem was further exacerbated by environmentalists opposed to nuclear power who used this rate base procedure to delay plants in court, or in regulatory procedures based on a host of questions such as the adequacy of evacuation plans, etc until which time the plants, because of cost escalation, could no longer be justified in the marketplace. While many other factors by the 1970s and 1980s were also responsible, ultimately more than $100 billion dollars of nuclear power plants became stranded assets.

The twin OPEC oil price shocks of 1973-4 and 1979-80 had divergent effects on the market for nuclear power. On the one hand the oil shocks led to renewed concerns about energy security, notably in Europe and Asia which, especially in the power sector, were both more dependent on imported oil and who saw nuclear power as a means to diversify their economies away from oil. On the other hand, skyrocketing oil prices led to global inflation and high interest rates making nuclear power much less competitive. High inflation led to sagging economies and falling demand for electric power making earlier assessments of electric power supply/demand projections obsolete. This was especially true for large base load plants, the demand for which had been growing 6-7% in the 1960s and now fell to 1-2% per annum.

As if these market problems were not enough to contend with, the Indian detonation of a nuclear device in May 1974 raised new concerns about the links between commercial nuclear development and potential nuclear weapons proliferation. While the Indians technically diverted plutonium from a research reactor and not from a commercial power facility, this nuance was lost on the broader public which was concerned that as commercial nuclear power expanded around the globe, the danger of nuclear weapons technology proliferating would occur.

This concern over time led in 1968 to the passage of the Non Proliferation Treaty (NPT) which entered into force in 1970. The fact that India was able to acquire sensitive nuclear weapons technology so soon after the passage of the NPT left little reason to be sanguine and bolstered the resolve of opponents of commercial nuclear power who, despite assurances by the industry that no state had acquired a nuclear weapon by diversion from a commercial nuclear facility, saw nuclear power and nuclear weapons as directly related.

The accident at Three Mile Island outside Harrisburg, Pennsylvania on 28th March 1979 marked a watershed in the American nuclear energy industry as, whether rightly or wrongly, it had convinced a broad swath of the American people that nuclear technology is too complex a factor which causes reactor operators to erroneously take disastrous actions based on poor instrumentation leading to a significant

meltdown of part of the reactor core. In response to numerous reports on the accident, including one by Admiral Rickover the founder of the modern nuclear industry, it was determined that nuclear reactor technology is so complex that cooperation between the reactor vendor and regulators would never be enough to avert a future nuclear accident. It was also suggested that the nuclear industry should form a central organization that could lead a coordinated expert and technical input group able to draw on its years of experience which no utility, in and of itself, would have the technical or financial resources to muster. As a result, shortly after TMI, the industry created the Institute of Nuclear Power Operations (INPO) to serve as the lead oversight organization of all nuclear operations, as the industry as a whole recognised that another serious accident anywhere in the world, could signal the death knell of the industry.

In the aftermath of TMI, nearly 100 orders for commercial nuclear reactors were cancelled, but this was not nearly as significant as the fact that only one reactor which had started construction in 1976 was completed in TMI's wake. The next several decades were devastating to the industry. In some cases reactors such as the Shoreham nuclear power plant on Long Island were scrapped, even though it was 90% complete, owing to evacuation concerns. With only reactor maintenance and refurbishment business readily at hand, young engineers stopped enrolling in nuclear engineering departments leading to a growing scarcity of trained personnel and rising concerns, even after the advent of the much vaunted nuclear renaissance in the last few years, that with so much of the work force near retirement, whether a nuclear renaissance could occur without a major effort by the government to support a reactivation of academic departments around the country.

While little noticed at the time, the accelerated decontrol of domestic oil and natural gas prices in the early 1980s led to an explosion in natural gas drilling in both the United States and Canada where construction of the Canadian portion of the Trans Alaska pipeline provided a logistics system encouraging exploration companies to drill along its route. Ironically while gas at the time might have substituted for the ailing nuclear industry, Congress in 1978, believing that gas was in short supply, had passed the Power Plant and Industrial Fuel Use Act banning the use of gas in power plants and industrial boilers. Then in 1986, the nuclear accident at Chernobyl in the Ukraine led most of the world, with the exception of France and Japan, to move away from atomic power or at least to reduce previous optimistic assessments about the technology's future.

As Daniel Yergin notes in his new book, The Quest, the US decision not to pursue either nuclear energy or natural gas to meet its burgeoning electricity demand left only coal, which the US has in abundance, but which was already coming under attack for a host of environmental concerns. Still other changes loomed on the horizon. Despite declining average electricity costs between 1934-1970, by the early 1970s, as a result of many of the factors described above, these costs had begun to rise and, in the case of large coal and nuclear power plants, they escalated dramatically. With rate shocks hitting all classes of consumers, Congress passed in 1978 the Public Utility Regulatory Polices Act (PURPA) mandating that utilities had to buy power at "avoided costs", equal to what they would have had to pay to build their own facilities, from small scale wind, hydro and other energy sources. However no sooner had this law been enacted, creating havoc in the market especially for franchises that had long held monopoly power in their geographical service territories, that oil and gas prices in the early to mid 1980s began to fall forcing electricity consumers to pay prices far above " free market rates" for these high cost fuels, including coal and nuclear as well as renewables.

As a result of these forces, the concept of "deregulation" of the power market occurred and set off an ideological battle over the wisdom of such a move, a battle that continues to be waged worldwide to this day. While the full complexities of this process are beyond the scope of this article, during the 1980s the US power market underwent a vast transformation. While new grass roots nuclear construction was moribund, as the 100 plus plants under construction prior to TMI came on line, they eventually accounted for about 20% of total generation capacity. With natural gas utilization still under regulatory constraints, coal-fired facilities using abundant and inexpensive coal found its contribution soaring during the 1980s and early 1990s to form nearly 55% of US electricity supply. In time, as gas supplies proved to be abundant and cheap following price decontrol, Congress removed the constraints on natural gas use in power plants. This policy shift, combined with advances in highly efficient gas turbine technology developed from jet aircraft, allowed gas-fired plants to be built more quickly than coal or nuclear plants, and at less risk since they could be built in smaller increments at lower cost.

The next great policy shift in the US occurred in 1992 with the passage of the Electricity Policy Act which, under the rubric of unbundling, established the concept of the "wheeling" of electricity, thus allowing utilities in one part of the country to contract with a less expensive generator to transport power to its service territory in another part of the country. As Yergin notes, "both merchant generators and traditional utilities realised that they could become more competitive by fuelling the new power plants with cheap natural gas" This set off the mad "dash to gas" as generation capacity expansion exploded between 1998-2004 with gas-fired generation accounting for over 90% of this new capacity. However, as in the case of all market bubbles, enthusiasm for gas led to an overbuilding of electricity capacity and as gas demand skyrocketed, renewed upward pressure on gas occurred making it less competitive against coal.

In 2000-2001, the nation was rocked by the California electricity crisis that sent shock waves throughout the US political system. While the causes were a combination of many factors (bad regulatory design of an only partially deregulated system; market manipulation; political posturing; adverse weather; low hydroelectric supplies from outside the state; technical problems, etc) the net effect of the crisis in the rest of the country was that as Yergin notes "the brakes were slammed on the movement toward deregulation." While about half of the states remain traditionally regulated, the other half has varying degrees of market competition. To make matters even more complex, a number of companies have operations in both regulated and non-regulated markets. This dual nature of the US electric power system has made fuel choice, and not deregulation, the critical issue confronting the country today.

With US electricity demand projected to grow at an average annual rate of 1.4% per between now and 2035, it will be necessary to increase installed capacity by about one third, an amount equal to 300 standard new coal-fired plants or 150 nuclear facilities. Currently coal accounts for about 45% of generation capacity with natural gas at 23%, hydropower (7%),

nuclear (20%) and oil (2%).Solar energy contributes less than 1%.

The above statistics pose a prodigious challenge for the United States especially since coal, the country's primary electric fuel, is under vigorous assault with its impact on air and water quality and its effect on climate change through CO_2 emissions. This is despite the fact that modern coal plants emit 40% less carbon dioxide than plants built 20-30 years ago. In 2011 roughly 25 coal-fired plants are under construction in the US. However, despite the improvements that have been made in coal technology, many coal plants that were nearly complete (as in the earlier case of nuclear technology) have been scrapped making it nearly impossible to build a new coal plant today. While proponents of carbon capture and sequestration believe that development of this technology will solve this problem, to date there are only a handful of facilities around the world that can do this and the costs are extremely expensive.

At the same time as coal has come under assault, volatile natural gas prices have made power producers move away from the early enthusiasm for gas-fired power plants until the last 4-5 years when the discovery of large shale gas resources in North America have transformed perceptions about future US gas supply. Previously there had been a consensus that by 2030 the US would have to import 40% of its natural gas as LNG. Now given the size of projected shale gas resources it is believed that the US can actually increase the percentage of natural gas in the nation's fuel mix and keep it there for 100 years at prices over the next 20 years in the $4 to $5 per MMBTU indexed for inflation. There is also the possibility that the US could become a net gas exporter. With gas prices projected to be so low, two leaders of the nuclear energy industry in the US have recently stated that they see no reason why their utilities would build a new nuclear facility for at least a decade.

While these events were raging, interest in nuclear energy and promise of a "nuclear renaissance" occurred as the result of (1) the fact that in a carbon-constrained world increasingly concerned about climate change, nuclear energy is the only near term scalable source of electricity that is carbon free; (2) improvements in the efficiency of nuclear plants after TMI and Chernobyl, from 55% to more than 90%, making existing plants that were already or nearly depreciated extremely lucrative and (3) a change in regulatory procedure which extended the license of nuclear power plants from the original life expectancy of 40 years to sixty with some people arguing, with retrofits, that 80 years is possible. To date roughly half of the 104 operating plants have received life extensions.

Nuclear energy received another boost in the Energy Policy Act of 2005 which provided loan guarantees and tax credits for up to $18.5 billion for the first six gigawatts of nuclear power plants that would come on line by 2020. These were later extended by the Energy Policy Act of 2007 to $54.5 billion. In early 2010, President Obama stated that "we are going to restart the nuclear power industry" and announced that two new reactors would be built at the existing Vogtle plant in Georgia. He also announced that the first six plants would be eligible to receive several hundred of millions of dollars in federal funds to reimburse them for any breakdown in the regulatory process or litigation which in some cases had kept plants in limbo for decades. To demonstrate the seriousness of this issue, it is estimated that to acquire a new license to construct and operate a nuclear power plant will cost $500 million.

Amidst the enthusiasm generated by the President's initiative nearly 30 new reactors were proposed with at least 20 for specific sites at existing facilities. While it was believed that this would obviate public opposition in comparison to new sites, in reality the industry remains moribund. The South Texas Project led by NRG Energy in a deregulated market has collapsed and while there is some spark of life for the TVA to restart a shuttered reactor at Browns Ferry in Alabama, and talk of movement for a new plant in South Carolina, the reality is that nearly seven years after the passage of loan guarantees, the industry is in crisis with no expectation even among nuclear advocates like myself that the US will build more than four or five nuclear reactors over the next 10 to 15 yeas. This was the reality before Fukishima and little has changed as a result of that terrible tragedy.

Meanwhile nearly thirty years after the passage the Nuclear Waste Policy Act of 1982 which committed the Department of Energy to recommend a long-term nuclear waste repository and a subsequent DOE mandate to have the site up and running by 1998, President Obama cancelled funding for the project while appointing a "blue ribbon" commission to take up the problem with a report due out in early 2012. Ironically in the interim utility consumers around the country have been charged $20 billion to pay for the repository with nothing to show for it and a legal DOE mandate seemingly forgotten in a politically-divided Washington.

While TMI, Chernobyl and Fukishima may not have killed the industry completely, they began to sow the seeds of its burial - a tragedy that will not be easily overcome with no alternative scalable electricity source imminently on the horizon.