CHAPTER 16

NUCLEAR ELECTRICITY FOR PAKISTAN IS NOT THE ANSWER

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Electricity blackouts are a daily occurrence in Pakistan. This 'load-shedding' has led industries to shut down; markets to close at peak business hours; and have imposed harsh physical conditions in tiny and cramped urban dwellings. In Faisalabad, the centre of Pakistan's textile industry, thousands of power looms are lying idle and workers have been laid off in large numbers. Due to these daily power outages for long hours, riots have frequently broken out, power substations set on fire, and property destroyed by angry mobs. Electric company employees have been attacked and sometimes even killed. Electricity has also become a political weapon: the Punjab government, locked in a confrontation with President Asif Ali Zardari's federal government, has openly encouraged mobs to keep their protests alive.[1]

It seems odd at first sight to understand why this should happen in a country that can make nuclear weapons and ballistic missiles, and which has an Atomic Energy Commission that employs over thirty to forty thousand people. Established in 1956, the PAEC (Pakistan Atomic Energy Commission) promised in the 1970s to meet nearly the *entire* electricity demand for the country. But almost forty years later, a miniscule amount was achieved—less than 2 per cent. Non-nuclear generation dominates: in 2006, ninety-eight billion kWh gross was produced, 37 per cent from gas and 29 per cent from oil. Pakistan's total generating capacity in 2011 stood around 22 GWE (22,000 megawatts of electricity), as shown in the table below.

Table 5

	Installed (GW)	Available (GW)
TOTAL	21.69	16.3–19.3
Oil/Gas	14.43	12.22
Coal	0.165	0.045
Hydro	6.63	3.68–6.63
Nuclear	0.462	0.390

Energy Profile of Pakistan 2011[2]

For the small share of nuclear energy, Pakistani authorities accuse Western countries for denying it nuclear energy; in turn those countries point to Pakistan's refusal to sign the Nuclear Non-Proliferation Treaty (NPT). The NPT expressly forbids transfer of any kind of nuclear technology, including that for power generation, to non-signatories. When Pakistan requests nuclear cooperation on the same basis as India, it is told that the risk of proliferation would be too high or that this could lead to an enhancement of Pakistan's bomb-making capacity. Thus Western nations have shied away from providing it with either nuclear materials or equipment.

In May 2009, President Zardari made a dramatic announcement upon his return from France—a French-Pakistani deal was in the offing. But nothing materialized. It turned out that the French had no intentions of copying the US–India deal and had actually offered to sell technology for safety and monitoring purposes only.[3] Only China sells nuclear reactors to Pakistan. On the other hand, India now enjoys a special deal with the West and may soon become a member of the NSG (Nuclear Suppliers Group).[4]

Unlike India, which has been manufacturing CANDU reactors for decades, Pakistan does not have the option of making its own electricity-producing nuclear reactors. Despite a fifty-year long nuclear history, and a huge nuclear establishment, this requires a technological infrastructure that is presently beyond Pakistan's capability. Power reactors are considerably more complex than nuclear bombs, or even dedicated military reactors.

Political circumstances became even more unfavourable for nuclear power in Pakistan after 11 September 2001, and were further exacerbated by the A.Q. Khan episode in 2004. Nevertheless, in 2010 the PAEC reiterated earlier promises of massive expansion and of achieving a target of 8.8 GW by 2030.[5] This claim was repeated two years later in 2012.[6] Installed nuclear capacity, according to the PAEC, was projected to increase in giant steps after every five year period.[7]

Table 6

2010–2015	0.9GW
2015–2020	1.5GW
2020–2025	2.0GW
2025–2030	4.0GW

PAEC's projections for nuclear electricity generating capacity

But the above projections do not compare well with the facts on the ground. The nuclear input to Pakistan's electricity grid in 2012 was about 0.7 GW. This is a pittance compared to expectations in the 1970s and 1980s.

The history of the nuclear electricity program is well known: a small 100 MW Canadian supplied natural uranium-deuterium reactor of the CANDU type, KANUPP, was Pakistan's first reactor. It was set up in 1972 but, following the Indian nuclear test of 1974, Pakistan refused to sign the NPT. Thereupon Canada withdrew fuel supplies and support. At much cost and effort, the PAEC had KANUPP running again—at least some of the time. Nearly thirty years passed before a second reactor came on line in 2005. This was a Chinese Pressurized Water Reactor (PWR), Chashma-I (or C-1). A similar unit, C-2, started producing electricity in mid-2011. All three reactors are small with design maximum of 0.1 GW, 0.33 GW, and 0.33 GW respectively. Together, they constitute about 2.5 per cent of Pakistan's total installed capacity but the actual amount of electricity produced is around 1.6–1.8 per cent. The next reactor to be connected to the grid may be 6–8 years away, even if some deal is solidified today. The connection between what was projected, and what actually is, is a distant one.

India's record on achieving nuclear targets is also less than stellar. In 1962, India announced that installed nuclear capacity would be 18–20 GW by 1987; but it could reach only 1.48 GW by that year. Vikram Sarabhai, Homi Bhabha's successor, had announced that, 'we have a formidable task to provide a new atomic power station of approximately 500 MW capacity each year after 1972–1973.'[8] Nothing of this sort happened: India's *first* 500 MW reactor—Tarapur 4—went online in 2005 almost thirty-five years later. As noted by Suvrat Raju (this volume) Indian authorities predicted that nuclear energy would provide more than 50 per cent of India's power generating capacity by 2050. Note that this is about 150 times the current nuclear power capacity of 4.12 GW. This amounts to only 2.64 per cent of the country's power generating capacity.[9] Cost overruns and delays are frequent in India. In 1994, an accident during the construction of two reactors at the Kaiga Generating Station pushed up their cost to four times the initial estimate.

COST AND EFFICIENCY

Is nuclear energy cost-efficient, and can nuclear power fulfil the energy needs of countries like Pakistan or India? Keeping for later discussion the issue of safety, we shall focus upon nuclear economics: whether power from uranium can be obtained which is cheaper than which is obtained from oil or gas.

Let us first look at the international context. The United States has the world's largest nuclear industry and generates about 30 per cent of the world's nuclear electricity. But, partly because of stringent safety requirements, it has difficulty in competing with other means (oil, gas, coal, hydroelectric). A 2009 MIT (Massachusetts Institute of Technology) study, which strongly advocates increasing the role of nuclear power globally out of climate concerns, estimates the cost of nuclear electricity in 2010 to be 8.4 cents/kWh and compares it against coal/gas—6.2/6.5 cents/kWh respectively. These costs were arrived at by using standard economic arguments and input costs.[10] One expects that as fossil fuel depletes, the nuclear-fossil price ratio will turn around in favour of nuclear. But this has not happened as yet.

No new nuclear plant has been commissioned in the U.S. over the last twenty years. France on the other hand, generates about 75 per cent of its electricity from nuclear. This may change, however. Whereas Nicolas Sarkozy, France's president, had reaffirmed the country's commitment to nuclear power even after Fukushima, François Hollande, his Socialist rival who won the 2012 presidential election had declared he would reduce nuclear's share of the national energy mix from 75 per cent to 50 per cent by 2025. That would mean shutting roughly 24 reactors. However, it is unclear whether Hollande will stay with his pledge.[11]

In May 2012, both the high capital investment needed for nuclear plants and the fear of Fukushima-type accidents led to Brazil's decision to cancel the building of new plants.[12] The previous government led by former president Luiz Inacio Lula da Silva had planned to construct between four and eight new nuclear plants through 2030.

While countries like France or South Korea do find nuclear energy economical, they may be exceptions to a general rule. Countries that lack engineering capacity, and cannot make their own reactors, will pay more to import and operate the technology.

In the early 1990s the World Bank had labelled nuclear plants 'large white elephants'.[13] Its Environmental Assessment Source Book says: 'Nuclear plants are thus uneconomic because at present and projected costs they are unlikely to be the least-cost alternative. There is also evidence that the cost figures usually cited by suppliers are substantially underestimated and often fail to take adequately into account waste disposal, decommissioning, and other environmental costs.'[14] According to the U.S. Nuclear Regulatory Commission, the cost of permanently shutting down a reactor ranges from $300 million to $400 million.[15] This is a hefty fraction of the reactor's original cost.

There is no evidence that nuclear power is economical for Pakistan. Reliable cost figures do not exist, although the PAEC claims that it is around 8.5 cents per KWh (i.e., about the same as in the U.S.).[16] While this figure may have been derived from the cost of the reactor and fuel, it is difficult to validate. Citing security reasons, the authorities reveal nothing of what has been spent over a period of five decades on creating a vast infrastructure that comprises of hundreds of buildings, fuel processing facilities, local and foreign training, salaries and benefits, security arrangements, etc. There exists zero public data on the funds used for buying smuggled goods such as computers, electronic and electrical machinery, chemical plants and chemicals, lathes and workshop machinery. Apart from the gross amount of the Pak–China reactor deal, nothing else has been made public.

Pakistan's existing reactors have not worked very well, although the performance is improving with added experience. It is perhaps too early to comment on C-2, but there is data on KANUPP and C-1 because all nuclear power reactors that operate under IAEA (International Atomic Energy Agency) rules are required to publish their operating records.

There are two especially important parameters in judging reactor performance: First, the energy availability factor, which is the energy produced after all losses are deducted and divided by total energy produced. Second, the capacity factor, which is the net energy produced divided by the total energy that could have been produced had the plant operated at full capacity all the time. These are computed by the IAEA and reported on an annual and cumulative basis in the Power Reactor Information System (PRIS) database for each commercial nuclear power plant operating in IAEA member countries.[17]

A 2007 Stanford CISAC report based on these reports comments on these two parameters: Inspection of the KANUPP performance data indicates a mediocre plant record with a lifetime energy availability record of less than 28 per cent. . . . Since the 1980s the plant operated at varying performance levels never exceeding 48 per cent and was down for different Pakistani initiated refurbishment campaigns. . . . This is particularly low for a CANDU type reactor, which operates on on-line refuelling principles and is thus expected to demonstrate high availability and capacity factors. In fact, KANUPP performance is lower than even the oldest CANDU reactors operated in Canada and elsewhere except for the Rawatbhata reactors in India. KANUPP represents the oldest CANDU model still refurbished and in commercial operation in the world today. Most other similar model CANDU reactors have already ceased operation and have shut down.[18]

On the other hand, the C-1 data shows significantly higher energy availability levels, in the range of 60 per cent plus, and has improved with time. However QINSHAN-I reactor in China, which is the prototype of the CHASNUPP reactor, does better:

CHASNUPP-1 performance record lags the record of QINSHAN Phase I plant—its reference plant—by ten to twenty annual percentage points over the same operating period. Review of the QINSHAN-I data in the PRIS database indicates that whereas QINSHAN-I has a cumulative (lifetime averaged) energy availability factor of close to 80 per cent over its first five operating cycles, CHASNUPP-1 has reacted a cumulative availability factor of 62 per cent only.[19]

Purely in economic terms, it does not appear that nuclear power has been a good investment for Pakistan. A convincing economic analysis, with reliable data inputs, is essential if the nuclear authorities want to make a strong case.

PAKISTAN–CHINA NUCLEAR COOPERATION

Western apprehensions that Chinese nuclear help to Pakistan's power sector could be used for military applications are frequently articulated at international forums—and promptly rebutted by China.[20] Today China is Pakistan's only nuclear supplier. It has set up the Chashma Nuclear Complex near Kundian along the left bank of the River Indus. The main part of the first nuclear plant was designed by Shanghai Nuclear Engineering Research and Design Institute (SNERDI), based on the Qinshan Nuclear Power Plant.

In February 2010, China agreed to Pakistan's request to build two additional civilian nuclear reactors in Pakistan, each of 330 MW (about one-third the size of most modern nuclear power plants). All four reactors would belong to the same genre, and be identical in essential respects but C-2, C-3, and C-4 would have added safety features. To make this affordable China offered to provide over 80 per cent of the total $1.9 billion cost as a 20-year loan.[21] But, because of cost over-runs across the board on public development projects, the Planning Commission declared that no funds remained for down-payment to meet international obligations for any more nuclear projects, including C-3 and C-4. The PAEC argued that this action 'has jeopardised the contract between the Chinese contractor (CZEC) and Exim Bank.[22]

There is a further stumbling block even if the funds can be found. In 2004 China joined the 46 nation Nuclear Suppliers Group (NSG), whose rules prohibit supply of nuclear materials to non-NPT states. China, which is a member of the NSG, has not yet formally notified this body of its intention to supply the two new reactors. It had earlier explained away the supply of the C-2 reactor under the so-called 'grand-fathering clause', arguing that an agreement had existed prior to China's joining the NSG. For the two new reactors to be supplied to Pakistan, the legality of the clause is unclear. The issue was to come to head in the NSG meeting held in 2010 at Christchurch in New Zealand but China did not bring it up. However, in 2012 it used the grand-father clause to justify the sales of C-3 and C-4.

The U.S. position so far has been to refrain from vocal opposition. Indeed, it has almost no alternative, having strong-armed the NSG in 2008 into agreeing upon a special India-specific exemption. Although the U.S. has a public position on global nuclear trade with non-NPT countries, its geo-political and economic interests sometimes make irrelevant those very restrictions for which it had vigorously worked. The U.S. also worries that any serious effort to block the Chinese sale would further irritate Pakistan, upon which the U.S. relies for helping it fight the Afghan war.

China's interest in pushing the deal with Pakistan is fairly clear. Pakistan is so far China's only client for its small and unattractive reactors of the QINSHAN variety. The sale of two small units is but a step in a larger plan to become a major producer and exporter of nuclear power plants. Although China has an ambitious nuclear power program and is developing new reactor types, it has not made it to the big league yet and must import major components, such as the reactor pressure vessel, from suppliers such as Westinghouse. It is negotiating with western companies to acquire their technology under license for critical components that would enable it to make reactors of 1000 MW and 1400 MW.

In any case, even if the Chinese reactors at Chashma are built, their impact upon Pakistan's energy crisis will be marginal. Because they would also be under full-scope IAEA safeguards, they would not contribute to Pakistan's bomb-making capacity. Moreover, it will take 6–8 years after the contracts are formally signed before their electricity reaches the grid—assuming that there are no unforeseen delays. The small capacity means that they can do little to lessen the severe power deficiency.

There are many implications that a large scale nuclear power program would have for Pakistan, if and when it comes into existence. Fuel is particularly important, so let us briefly consider the issue of nuclear fuel for Pressurized Water Reactors (PWRs).

A 1GW PWR reactor has 200–300 fuel rods containing enriched uranium dioxide (UO2), weighing about 80–100 tons. This is a huge amount, well beyond the capacity of an enrichment plant that is designed to make a few bombs annually. Therefore, in 2007, the PAEC announced its intent to set up its second uranium enrichment facility, which would be placed under international safeguards and geared exclusively for the country's civilian nuclear power program.[23] PAEC sources declared that the new enrichment facility was to be part of the nearly $2 billion Pakistan Nuclear Power Fuel Complex to be built at Kundian in the district of Mianwali in the Punjab

Province.[24] The proposed complex would comprise a fuel fabrication facility, a plant to produce hexaflouride gas (UF6), a zirconium tubing plant, a fuel-testing laboratory, and a uranium enrichment plant that would use thousands of centrifuges. The new facility would be 'much bigger than the controversial Khan Research Laboratory at Kahuta, also in Punjab, where weapons-grade uranium is enriched for use in Pakistan's nuclear weapons program.[25] While the KRL would continue enriching weapons-grade uranium, the new enrichment plant would enrich uranium only to the 3 per cent level needed for use with C-1, C-2, and future such reactors.

As it turned out, nothing came of these plans—there simply was no money to create the fuel complex. Also, the profit-conscious Chinese are keen that Pakistan should buy their UO2 fuel rather than have it prepared locally. Since Pakistan is restricted from purchasing nuclear fuel from any other country, it is far from clear whether it will get a competitive rate from China.

By agreement, and IAEA requirements, Pakistan is obliged to return spent fuel to China. Presumably this means the spent fuel rods rather than the large volume of low-level radioactive wastes. But what has actually happened so far is unknown; the PAEC has divulged no information. One therefore assumes that the spent fuel is stored in pools at, or near the reactor site. One recalls that such pools proved calamitous in the Fukushima disaster. It is not known what, if any, corrective action has been taken by the PAEC in this regard.

REACTORS AND CITIES

Situating reactors close to a city is potentially hazardous. While a nuclear reactor cannot explode like a bomb, after one year of operation even a rather small 200 MW reactor contains more radioactive caesium, strontium, and iodine than the amounts produced in all the nuclear weapons tests ever conducted. These devastatingly deadly materials could be released in nightmarish quantities if the containment vessel of a reactor is somehow breached.

Conscious of the deadly consequences, nuclear designers build redundancy into essential systems, such as those needed for cooling the reactor's super-hot nuclear core. Yet, in spite of all precautions, highly developed countries—Russia, United States, Britain, and Canada—have seen serious reactor accidents. In the country of the *hibakusha* (the surviving victims of the atomic bombings of Hiroshima and Nagasaki), all reactors go through a scrutiny that is more exacting than in any other country.

For a developing country like Pakistan, radiation dangers and reactor safety are yet to enter the domain of public debate. In 2001, the government announced the establishment of the Pakistan Nuclear Regulatory Authority responsible for 'siting, design, manufacturing, operation, QA (Quality Assurance), radiation protection, waste management, emergency preparedness, transportation.'[26] The current strength is 'more than 200 professionals appropriately trained in technical areas, management system and regulatory processes.'

While the PNRA's mandate appears comprehensive, it is important to note that its personnel are totally recruited from the PAEC. Thus, in effect, it is an extension of the PAEC rather than an independent monitoring agency. Citing national security reasons, all regulatory mechanisms are strictly controlled by the authorities. Non-PAEC/PMRA individuals, or non-government organizations, are forbidden from attempting to monitor radiation levels near any nuclear facility, whether civilian or military. This is typical of how the nuclear authorities in South Asia have created a veil of secrecy. For example, poor and powerless village communities in Pakistan and India that have experienced deleterious health effects from uranium and thorium mining operations, have been forced to withdraw their court cases.[27]

For Pakistan, which sees daily acts of terror directed against its people as well as institutions of the state, the prospect of militants seriously damaging a nuclear plant is a real one. Spent fuel storage, while relatively safe, is potentially vulnerable to theft or attack. As every flood and earthquake that has occurred in the recent past have shown, Pakistan has little capacity to deal with any kind of disaster, either natural or human-caused, such as the one that has left an enduring nuclear legacy at Fukushima.

FUKUSHIMA—A TURNING POINT?

On 11 March 2011, a 30-foot monster wave smashed into Fukushima Daiichi's complex of six nuclear reactors on the northern coast of Japan. Only a handful died from the released radiation but, with the exception of a few countries, everywhere else the dream of a nuclear renaissance suddenly turned nightmarish. Weeks after the disaster, Japan teetered at the knife-edge of a major nuclear disaster. Although heroic reactor operators did their bit—many put their lives on line and absorbed deadly quantities of radiation—the nuclear monster slipped out of their control. Four hydrogen explosions reduced three buildings in the 6-reactor Fukushima nuclear complex to smoking ruins. Radioactive emissions triggered a level-5 emergency which was later upgraded to level-7, and evacuations were ordered up to a 20 km radius.

A heroic effort finally prevented a large-scale melt-down of spent-fuel rods and thus averted catastrophic consequences. But reactor fires were still burning many weeks later. At one point, desperate plans had called for pouring thousands of tons of concrete and turning the reactors into permanent nuclear tombs, although this would not have solved the problem and, in fact, would have created new ones. Radioactive contamination spread far and wide from hydrogen explosions, reaching all the way up to Canada and Europe.[28]

The truth about Fukushima took months to emerge. Although Japanese leaders had spoken soothing words to the public, in fact, they had badly panicked after the tsunami. A 400 page report on the disaster, released in March 2012, quotes the chief cabinet secretary at the time, Yukio Edano, as warning that a 'demonic chain reaction' of plant meltdowns could result in the evacuation of Tokyo a hundred and fifty miles away.[29]

Tokyo escaped, but the damaged plant will take an estimated forty years to be finally closed down. Japan has lost large swathes of its territory to contamination. A 20-kilometre no-go zone surrounds the plants. In spite of much-vaunted Japanese technology and $13 billion so far, decontamination is haphazard and slow. In July 2011, supermarket beef, vegetables, and ocean fish were found to have radioactive caesium in doses several times the safe level.[30] In August 2011, Nameko mushrooms grown in the open air in Soma, a city about 40 kilometers north of the Daiichi plant, were found to contain nine times the legal limit of caesium.[31] Measurements on fields, city streets, and in buildings confirm widespread contamination: with caesium 137, and strontium 90. For the remainder of the twenty-first century, the people living in a wide area will live in contaminated houses, drink contaminated water, and eat contaminated food.

The amount of radioactive caesium ejected by the Fukushima reactor meltdowns is about 168 times higher than that emitted in the atomic bombing of Hiroshima. The Nuclear and Industrial Safety Agency (NISA) stated that the radiation released at Fukushima was about one-sixth of that released during the 1986 Chernobyl disaster, and that the crippled Fukushima No. 1 plant has released 15,000 tera-becquerels of caesium-137, which lingers for decades and can cause cancer.[32] New estimates are that a staggering 40,000 tera-becquerels of radioactive caesium were released. This should be compared with the 89 tera-becquerels released in the U.S. atomic bombing of Hiroshima.

Japan's traumatized population forced the government to shut down all 55 reactors in spite of the fact that nuclear power provided 30 per cent of Japan's energy needs. Germany decided to jump ship; within weeks of the disaster it announced its decision to close its nuclear plants permanently. A third of the country's reactors were decommissioned immediately, others will be wound down by 2022. In the UK, 61 per cent of people said they would be strongly opposed to a new nuclear power station being built near their home. Italy and Switzerland have also voted against nuclear energy, while France is engaged in deep self-reflection.

Fukushima also shook China and India, though much less. Earlier they had been planning 77 and 23 new reactors, respectively. But a normally passive population has begun to speak up in China. For example, the eastern province of China's Anhui province has opposed the Pengze plant in a highly populated area and a formal appeal has been made to Beijing to stop construction.

India's nuclear program, almost a sacred cow until now, is also being increasingly resisted by its citizens. Prime Minister Manmohan Singh angrily denounced protests against the Koodankulam nuclear plant in the Tamil Nadu state, claiming these were being led by foreign-funded NGOs. Mass protests and hunger strikes by social movements have led to deaths, injuries and riots in Maharashtra, Tamil Nadu and Jaitapur. The construction of two nuclear plants has been delayed and West Bengal has dropped plans for six Russian reactors.

Japanese disaster management, though now under severe criticism, was probably better than would be possible elsewhere in the world. Stoic and disciplined, the Japanese behaved wonderfully well. No looting, no panic, and no anti-government demonstrations followed the explosions. People helped each other, relief teams operated unobstructed, and rescuers had full radiation protection gear. Plant operators risked their lives by working in super-high radiation environments, and engineers showed their grasp of emergency reactor dynamics.

On the negative side: even elaborate earthquake-protection and tsunami-protection measures failed badly. The design protection was for a maximum 20 feet tsunami wave. But power sources for emergency cooling pumps were destroyed by the 30-foot high wall of water. Storing thousands of spent-fuel rods on the reactor site turned out to be a terrible mistake.

KARACHI—MORE AT RISK THAN ANY OTHER CITY

Post Fukushima, the science journal *Nature* recently teamed up with the NASA centre based at Columbia University to see which nuclear plants have the largest populations surrounding them and, therefore, could be the most dangerous if something should go wrong. At the top of the list is Karachi, a city of 20 million that has more people than any other in the world who live within 30 km of the plant.[33]

The Karachi Nuclear Power Plant, (KANUPP) located by the seashore, is an aging 40 year reactor that produces only a little electricity but is plagued by plenty of problems—including periodic leakages of heavy water.[34] Supplied by Canada, it went into in operation since December 1972 and completed its 30-year life span in 2002. But lifetime extensions have been routinely sought—and granted since then. According to IAEA statistics, has been unavailable for power production 70.4 per cent of the time. Even if it had operated as per design (120 MW of electrical power), it could supply only 6–7 per cent of Karachi's total electrical power needs, barely enough for the areas of Golimar and Lyari.

Although the gain is small, KANUPP puts much of Karachi's population at risk. Sabotage, terrorist attack, equipment failure, earthquake, or a tsunami could result in large scale radioactive release. The reactor has tons of radioactive material. Deadly radioactivity could be carried by the sea breeze toward the city and the population would need evacuation. The rich and the fortunate might succeed—and then too only if they exceptionally lucky. But the poor would be doomed. In a city that is chaotic even in the best of times, an orderly and disciplined evacuation, as in post-tsunami Fukushima, would be impossible. Looters would strip everything bare, roads would be clogged, and vital services would collapse.

While the safety of nuclear power is under question everywhere, there is—or should be—particular concern wherever a safety culture is absent. Pakistanis are habitual risk-takers looking for shortcuts, choosing to put their faith in God rather than precautions. This could be true for nuclear plant operators who can overlook critical safety procedures; there is simply no way for an outsider to know. Ostensibly for reasons of national security, everything nuclear is kept under wraps. This also covers up for bad practices.

The world may worry about Fukushima, but Pakistani authorities shrugged it off. Even as explosions tore through the nuclear complex, 'experts' summoned on local television channels glibly declared that this could never happen in Pakistan. The PNRA (Pakistan Nuclear Regulatory Authority) issued the following guarantee: 'Due to geographical differences between Pakistan and Japan, the likelihood that similar extreme natural events may occur in the vicinity of the country's nuclear plants is quite small.'

Since no two extreme natural events are likely to be identical in detail, this is technically correct—Pakistan is not located in the Pacific Ocean. But how would one deal with radioactive releases following deliberate sabotage, a terrorist attack, equipment failure, or operator error? Officials and other high-ups in Pakistan have never paid the price for false statements. The aftermath of the recent floods and earthquakes in the country are proof of the fact that our capacity to deal with any kind of disaster, either natural or man-made is minimal.

After dismissing Fukushima as irrelevant, the PAEC announced that it will seek to further extend KANUPP's life.[35] It has further declared that KANUPP-II and KANUPP-III, each more than ten times the power of KANUPP-I, will be built at the same site.[36] Locating nuclear reactors near a megacity that is impossible to evacuate shows poor judgment.

DEALING WITH LOAD-SHEDDING

At 20 GW, Pakistan's installed capacity is in principle roughly adequate for the average power demand of around 17 GW. But a mere 14.3 GW average is actually generated; about 30 per cent of current capacity is not used. The situation with Pakistan's electricity production and distribution system is similar to that of its railways, education, and health systems—they do not deliver, or deliver much below capacity. Mis-management, rather than lack of installed capacity is the problem.

A key element of the management crisis is 'circular debt'—meaning the non-payment of electricity bills by the military and various government departments to other government departments. This means electricity producers are not paid on time and hence cannot import fuel oil. Their expensive imported plants stand idle; capacity goes waste.

But the problem only partly lies at the production end. The difficulty is enormously compounded by problems at the distribution and consumer ends.

First, an inefficient distribution system wastes about 10 per cent of the electricity as it travels along transmission lines through transformers, and in bad connections. The electricity grid is incapable of effectively distributing electricity from power plants to consumers. Electricity is stolen by rich and poor alike while consumers in the FATA (Federally-Administered Tribal Areas) region have often destroyed substations which have ceased supplying electricity because bills are not paid. Elsewhere, for a small bribe, electric company employees tamper with electricity meters and create unmonitored bypasses called 'kundas'. Electricity producers and distributors thereby lose revenue. The solution lies in rigidly enforcing the rule: you use, you pay. Technology can be pressed into service for this; 'smart meters' that are tamper-proof and remotely read are available and need to be widely installed. Stopping power theft would save far more megawatts than will be generated by Chashma's four nuclear reactors combined, whenever they come on line.

There is much wastage as well: Pakistani factories, offices and homes use machinery and appliances that do much less work with the electricity that is available. A serious energy efficiency and conservation program is needed which is quick to implement and could avoid the need to build additional power plants.

A scientific approach to power planning had indeed been taken in the mid-1980s by the Planning Commission and extensive mathematical modelling was employed using software packages that were used successfully in a number of countries. This is important because, for example, energy demands fluctuate over the year and it is important to be able to predict demand over different seasons and times of the day. But modelling capability requires high-calibre personnel who remain at their jobs for a sizable period of time. A recent report states that this condition was not fulfilled and the maintenance of a reliable repository of data became difficult.[37] Energy plans were hereafter made on mere hunches and influenced by personal factors. The same report predicts a severe energy crisis by 2030 when proven conventional natural gas reserves will be depleted and energy imports will jump from 27 per cent to over 45 per cent.

The opinion is shared by those who have looked at the present system in detail. Wikileaks cables, obtained by the daily *Dawn*, show that energy policy-making in Pakistan's energy sector left U.S. Ambassador Anne Patterson worried. In June 2008, she reported back to Washington that, 'the haphazard mix of horizontally and vertically placed institutions which comprise the energy policy-making sector of Pakistan' has prevented a resolution of the country's power crisis.[38]

Patterson remarks that the situation is enormously complicated by 'the complex maze of GOP policymakers who cannot coordinate Pakistan's energy policy due to overlapping and contradictory authorities. . . . A lack of coordination and absence of any clear line of authority hampers any formulation of policy efforts to address the current energy crisis in Pakistan.'

Indeed, the mess is quite mind-boggling. The water and power ministry with its nineteen subordinate agencies, the ministry of petroleum and natural resources with its sixteen subsidiary agencies, and four other ministries and seven agencies are all involved in setting energy policy and running the power sector. Deprecating the 'insanity that prevails in Pakistan's energy sector', Patterson wrote: 'The lead line agency in government for the electric power sector is the Ministry of Water and Power (MWP). . . . However, the Ministry of Petroleum and Natural Resources (MPNR) controls fuel supplies; the Finance Ministry holds the purse strings; the Planning Commission manages the investment approval process; and the National Electric Power Regulatory Authority regulates companies operating in the power sector.' Patterson remarked: 'the fact is that not a single megawatt of electricity has been added to Pakistan's national grid since 2000 despite record-breaking economic growth and population expansion.'

CONCLUSION

Climate change gives urgency to finding non-fossil fuel energy alternatives. But a convincing case for nuclear power is hard to make. Neither cheap nor safe, it faces an uphill battle in much of Europe and the United States. Unless there is a radical technical breakthrough—such as a workable reactor fuelled by nuclear fusion rather than nuclear fission—its prospects for growth globally look bleak.

Although nuclear technology has not met any reasonable fraction of Pakistan's energy needs, it remains especially dangerous for multiple reasons—terrorism, sabotage, war, accidents and malfunctions, and natural disasters. Public consciousness and knowledge of waste disposal matters is low, opaque regulatory mechanisms are strictly controlled by the authorities, and disaster management capacity is close to nil. There is little or no public pressure for verifiable safety measures, nor is there an appreciable history of activism on social causes. Hence a hazardous technology becomes still more hazardous. It is therefore time to stop trying to add to Pakistan's nuclear fission power production.

In the public perception, nuclear reactors are conflated with nuclear weapons. But Pakistan's power reactors make no contribution to Pakistan's bomb-making capacity—the fissile material for these is entirely produced in its centrifuges and military reactors.

If nuclear electricity is not the answer then what is? There is no simple quick fix. Until nuclear fusion power becomes available decades from now, Pakistan, like other countries, must rely on a mix of oil, gas, hydro, coal, solar, wind, and other renewable sources.[39] Windmills and photovoltaics must be developed but they are incapable of adding more than a few per cent in the next decade. Pakistan can build gas-fired power plants and fuel them using natural gas imported from Iran. For new electricity generation capacity, Pakistan might use its vast deposits of poor quality Thar coal to meet its energy needs. But this should be done using appropriate technology, such as carbon sequestration, to minimize the negative environmental consequences. At the present time, it is not clear whether investment in Thar coal is viable. A long-term energy strategy is needed that takes into account efficiency, environment, economy, and changing patterns of social life in Pakistan.

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