Pakistan and the Energy Challenge

Zia Mian and Abdul H. Nayyar
zia@princeton.edu; nayyar@princeton.edu

ABSTRACT

Over its six decades as an independent state, Pakistan has found that its energy policies are a source of profound political problems. This chapter describes the evolution of the energy situation in Pakistan especially over the past twenty years. It reviews the current situation and plans for a large scale expansion of the energy sector, including proposals for a large increase in reliance on nuclear energy by 2030. The authors look in some detail at nuclear energy in Pakistan, including its important links to the nuclear weapons program, and the efforts to challenge the use of nuclear energy. Finally, the chapter examines at the issue of climate change and somewhat dismal prospects for renewable energy in Pakistan.

Keywords: Pakistan, energy policy, nuclear power

INTRODUCTION

Pakistan has historically seen itself as energy poor. Even before independence in 1947, when Pakistan was carved out of British India as a separate country, there were questions about its lack of energy resources and its economic prospects. In March 1946, Mohammad Ali Jinnah, the leader of the movement for a Pakistani state, was asked about the relative backwardness of his hoped for country, "What of the economic situation in Pakistan? There is no iron, no coal, no hydro-electric power, no industries." Jinnah replied "I am fully aware of these things. Our people have had no opportunity to develop these things. I have every faith... that, given the opportunity, they will achieve all this."[1] At other times, Jinnah was less optimistic, saying simply "If the worse comes to the worst, like a sensible man we will cut our coat according to our cloth."[2]

[1] Hector Bolitho, *Jinnah: Creator of Pakistan*, Oxford University Press, 1954, p. 158-159

[2] Naureen Talha, *Economic Factors in The Making of Pakistan 1921-1947*, Oxford University Press, 2000, p. 152.

At the time of independence, Pakistan inherited a total of 60 MW of electricity generation capacity, in the form of a small hydroelectric facility and a thermal power plant. It now has about 20,000 MW of installed capacity. An estimated 60% of its population of over 160 million people has some access to electricity. Pakistan has a per capita GDP of about $2,400 (adjusted for purchasing power parity) but is now ranked at 136 in the United Nations Human Development Index, out of 177 states, below India, Bhutan, Burma, Laos, Myanmar, and Botswana and other countries with lower per capita GDP.[3]

Over its six decades, Pakistan has found that its energy policies, especially those associated with exploitation of its crucial gas and hydroelectric resources, are a source of profound political problems. Pakistan's nuclear energy program has been a very small part of the energy mix so far. Despite this, the Pakistan Atomic Energy Commission has great political power and preferential access to scare resources of capital and technical skills.

POLITICAL ENERGY

In 1986, total energy consumption in Pakistan was estimated at 24.6 million tons of oil equivalent, only 16.35 millions of ton of oil equivalent was commercial with the non-commercial energy sources being wood, biomass, dung, etc. Total primary energy supply in Pakistan in 2005-06 was 57.9 million tons of oil equivalent, reflecting that more of the population has become urban, electricity supply has reached further into rural areas, and more rural livelihoods have become dependent on the market economy. The relative share of commercial energy sources in 1986 and 2005 is shown in Table 1.[4]

Table 1. Commercial primary energy supply in Pakistan

Energy source	% of total consumption	
	1986	2005
Gas	34.2	50.4
Oil	39.1	28.4
Hydro-electricity	18.5	12.7
Coal	7.4	7.0
Nuclear electricity	0.4	1.0
Liquefied petroleum gas	0.4	0.4

[3] United Nations Development Program, *Human Development Report 2007/2008,* http://hdr.undp.org/en/media/hdr_20072008_en_complete.pdf .

[4] Tufail Ahmad Khan, "Energy Shortage: An Analysis," *Dawn*, April 23, 1986, and *Economic Survey of Pakistan 2006-2007*, Government of Pakistan, Islamabad, 2007, http://www.finance.gov.pk/survey/sur_chap_06-07/15-Energy.pdf.

In the late 1980's there was an acute energy shortage in Pakistan. Even in the largest cities, there were regular power outages that lasted for many hours each day especially in the summer months and newspapers would publish the times that the electricity supply was to be shut down in different parts of each city. There was a lot of pressure for new capacity to be brought on line.

Energy consumption has been increasing rapidly over the past twenty years. Since 1990, the consumption of gas, electricity and coal has increased at an average rate of almost 5% a year, while the use of petroleum products has increased at an average rate of about 2.5% per year. Over the past five years, the rate of consumption of gas, electricity and coal has been increasing at much higher rates, (10.4% for gas, 6% for electricity and 14.6% for coal). This reflects both higher rates of economic growth compared to the 1990s, a decade during which the proportion of Pakistanis living below the poverty line increased from about 17% to about 33%, and the effects of energy policies put in place in the late 1990s which allowed private investment in the energy sector for the first time.

Geopolitics has been central to this recent period of growth. The U.S. search for allies and bases for its war on Afghanistan after the attacks on September 11, 2001, led it to lift sanctions on Pakistan that had been in place since 1990. In addition, the U.S. helped reschedule over $2 billion of Pakistan's foreign debt, gave it $1bn in soft loans and grants and arranged multilateral aid from the World Bank and IMF of over $2 billion, as well as offering $3 billion in economic and military aid over five years. This was the in return for Pakistan's support in the U.S. war in Afghanistan and against Al-Qaeda.

The most important current energy resources in Pakistan are natural gas and hydroelectricity, both have proved to come with intense political problems attached. These problems have to do with the appropriation of the gas for the major cities and industrial and agricultural areas all of which are located far from the gas fields and the damming of rivers (with attendant displacement of communities) to feed agriculture and produce electricity in politically powerful and rich upstream areas at the cost of the basic needs of downstream communities.

Pakistan's major gas fields are located in Baluchistan province. There remains, however, many areas in Baluchistan with no access to a gas supply. Baluch leaders have demanded greater autonomy and control over their natural resources, and there have been five insurgencies (1948, 1958, 1962, 1973-77, and since 2006), all of which were ruthlessly crushed by the Pakistan army. At present, national gas production capacity is 93 million cubic meters a day while the consumption is 82 million cubic meters per day. The proven reserves of natural gas are 0.8 trillion cubic meters while the estimated possible reserves are about 10 times as much.

There are long standing grievances among Baluch leaders and public about the lack of equitable access to the gas, insufficient jobs for local workers in the gas industry, and the failure by the federal government to compensate the

province adequately for the use of its resource. This sense of discrimination has exploded again over the past year as Baluchi tribesmen have obstructed and attacked gas facilities, gas and oil pipelines, electricity transmission towers, and train tracks.[5] They have also targeted foreign companies seeking to explore new gas fields in the province and working on other development projects there.[6]

Pakistan relies heavily on its hydroelectric dams for electricity. The installed hydroelectric capacity in 2005-06 was 6,463 MW, accounting for about 33% of total electricity generation capacity in the country. Built in the 1960s and 1970s, the biggest dams are Mangla and Tarbela and are located in the north of the country on the Jhelum and Indus Rivers respectively (the Jhelum is a tributary of the Indus). Many communities displaced by these dams, especially by Tarbela (which displaced about 96,000 people in the North West Frontier Province), have still not been adequately compensated.[7] Many in the North-West Frontier Province are opposed to future big dams in their area. Downstream, many in Sind province believe the dams have reduced their access to Indus water and have organized to oppose further dam building. There is no doubt that the combination of dams and large scale irrigation has severely reduced seasonal flows in the Indus.[8]

Pakistan's discovered and proven indigenous oil resources are estimated at 318 million barrels, with estimated total reserves of 27 billion barrels. Annual production of crude oil in 2005-06 was almost 24 million barrels, with imports of 63 million barrels of crude oil and about 42 million barrels of petroleum products. Pakistan thus heavily depends on imported oil.

Coal is a largely untapped resource. The local production of coal in 2005-06 was 4.6 million tons a year, while consumption stands at 7.7 million tons, with over 80% used in brick-making and cement production rather than power production. The present proven coal reserve estimates stand at 3.3 billion metric tons, but it is estimated that the Thar coal fields (in Sind province) may hold reserves of up to 175 billion tons.

The pattern of energy consumption in Pakistan (Table 2) reflects the enormous changes Pakistan has gone through, and that are still underway, as it makes a transition from a traditional, rural, subsistence society and economy

[5] "Gas Pipeline Blast Affects Supply to Many Cities," *Dawn*, April 21, 2004; Amanullah Kasi, "Train Tracks Blown up in Baluchistan," *Dawn*, January 28, 2005; "Blackout in Baluchistan as Towers Blown Up," *Dawn*, February 2, 2005; "Oil Pipeline Blown up near DG Khan," *Daily Times*, February 21, 2005.

[6] Zahid Hussein, "Gathering Storm," *Newsline*, February 2005; Frederic Grare, *Pakistan: The Resurgence of Baluch Nationalism*, Carnegie Endowment for International Peace, January 2006.

[7] *Tarbela Dam and Related Aspects of the Indus River Basin in Pakistan*, World Commission on Dams, 2000; http://www.dams.org/docs/kbase/studies/cspkmain.pdf.

[8] Erik Eckholm, "A Province is Dying of Thirst and Cries Robbery," *The New York Times*, March 17, 2003; Erik Eckholm, "A River Diverted, The Sea Rushes In," *The New York Times*, April 23, 2003.

into a modern urban, industrial one.[9] This process is likely to intensify in coming decades, with continuing wrenching social, cultural and political consequences.

Development has brought new perceived needs that now serve to drive energy policy further in the same direction. The availability of a reliable electricity supply, in particular, has come to be seen as a basic entitlement especially in urban areas. There were about 16 million consumers in 2005-06: household electricity consumption was over 45% of the total consumption, with industry consuming 29%. Frequent power breakdowns and rationing characterize the electricity supply system especially in summer months have returned, and lead to riots in many cities directed at the offices of the national electricity supplier, the Water and Power Development Authority. It has also led to small scale, informal energy entrepreneurs who run diesel generators and illegally sell electricity, especially in the city Karachi, as well as corruption in the electricity supply companies.

Table 2. Commercial primary energy consumption in Pakistan (2006)

Sector	Fraction of total energy consumed (%)
Industry	58
Transport	22
Household and commercial	17
Agriculture	2
Other	1

ENERGY PLANS, ENERGY DREAMS

Pakistan's current installed electricity generation capacity is about 20,000 MW. The government has offered a plan for electricity generation up to 2030 that expects an installed capacity of over 162,000 MW, an eight-fold increase. The plan (Table 3) reveals an enormous increase in reliance on coal, by a factor of over 100. There is also a twenty-two fold increase planned for the use of nuclear energy, and large expansion in the use of natural gas, hydroelectricity and renewables. It is especially noteworthy that electricity generation by renewables is projected to exceed that from nuclear energy by 2010 and to continue to remain on a higher level than nuclear for at least the subsequent two decades.

[9] Arif Hasan, *The Unplanned Revolution: Observations on the Process of Socio-Economic Change in Pakistan*, City Press, 2002.

Table 3: Pakistan's electricity generation plans 2005-2030 (MW)[10]

	Hydroelectricity	Oil	Gas	Nuclear	Renewables	Coal	Total
2005	6,460	6,400	5,940	400	180	160	19,540
2010	7,720	6,560	10,800	400	880	1,060	27,420
2020	19,990	7,160	30,910	2,800	3,150	8,260	72,270
2030	32,660	7,760	83,760	8,800	9,700	19,910	162,590

The energy plan by the government's own admission would require an investment of $150 billion. It envisages average annual investment of $2 billion from the public exchequer, and hopes for $ 4 billion a year of private investment. It is not clear that this scale of investment will be available given the perceived political instability in Pakistan. But high cost and uncertain access to foreign capital are not the only possible hurdles for this plan.

The government plans to build three large dams on the Indus River, the Kalabagh, Bhasha and Akhori dams, with electricity generation capacities of 3,600 MW, 4,500 MW and 600 MW respectively. These dams are controversial on several counts, with Kalabagh being the most contested.[11] In addition to the concerns by Sind province about the impact on its access to Indus River water mentioned earlier, there will be intense debate about the large human displacement and the environmental impact of each project. Displacement and ecosystem integrity were not considered as issues when Pakistan's existing large dams were built. The Kalabagh dam would displace 120,000 people; Bhasha dam would require resettling 24,000 people; and Akhori dam about 50,000 people. The prospect of Kalabagh dam has already ignited nation-wide protests.[12]

The efforts to expand the use of gas will involve both increased production of domestic gas as well as importing gas. The Asian Development Bank has predicted that Pakistan's domestic gas supplies could start to run out in 2008, unless major new discoveries are made.[13] In the longer term, there are plans for three major international pipeline projects that would supply gas to Pakistan. The most controversial of these is a 1650 km, 3 billion cubic feet per day, pipeline from Iran that would deliver gas to Pakistan and then continue on to India; a 1,600 km, 2 billion cubic feet per day pipeline from Qatar; and a 1,400

[10] "National Energy Needs", presentation by Humayun Farshori, Secretary, Planning and Development Division, Government of Pakistan, to Pakistan Development Forum, 26 April 2005, Islamabad, http://siteresources.worldbank.org/PAKISTANEXTN/Resources/293051-1114424648263/Session-VII-Energy.pdf

[11] Aly Ercelawn and Mohammad Nauman, " Damming Kalabagh: State vs Community, Centre vs Territory, Nation vs Federation," *The News*, June 21, 1998.

[12] Massoud Ansari, "The Water Divide", *Newsline*, January 2006.

[13] Farhan Bokhari and Jo Johnson, "Pakistan Keen to Close Deal on Gas Pipeline", *The Financial Times*, May 14, 2005.

km, 2 billion cubic feet per day, pipeline from Turkmenistan.[14]

All the proposed pipelines have problems. The pipeline from Iran will run through Baluchistan province and be hostage to its politics.[15] Moreover, the United States is opposed to this pipeline, because of its hostility to the government in Tehran. This is unlikely to end short of a forcible U.S.-led overthrow of Iran's government. The pipeline from Turkmenistan will have to cross through Afghanistan and it is unclear when there will be sufficient security to even consider starting work on this project regardless of the question of funds. Afghanistan has been under U.S. occupation since October 2001 and there seems to be every sign of continuing violence for the foreseeable future.

The third pipeline route is from Qatar; it would have to run underwater, including through Iran's coastal waters, to Pakistan, or go overland once it reaches Iran and pass through Baluchistan, to Pakistan. It would be the most complex and most costly option and probably take the longest to build. If it does go overland through Iran and Baluchistan, it would face the same problems as the Iran-Pakistan gas pipeline.

The use of coal is supposed to increase rapidly to reach 12% of electricity generation by 2030. The emphasis of the government is on using the discovered but untapped coal in the Thar Desert, bordering India. The government plans to invite investors to mine the coal to fire thermal plants built at the mine-head and sell the electricity to the national grid. However, neither the cost nor feasibility of mining this coal has been established. The national electricity grid would also have to be extended to the Thar Desert to accommodate the planned new generating capacity. The large scale use of coal-fired power generation would of course create significant harmful air pollution, and add greatly to Pakistan's greenhouse gas emissions.

THE NUCLEAR STATE

Pakistan's nuclear program is now over fifty years old. It was launched in October 1954, when the government announced the creation of an atomic energy research and development program. The announcement came on the same day and was reported alongside a meeting between Pakistan's prime minister and United States president Eisenhower at the White House. In December 1953, U.S. President Eisenhower had proposed his *Atoms for Peace* initiative, a way to win allies in the Cold War by sharing American nuclear

[14] "Oil Gas and Mineral Resources of Pakistan", presentation by Usman Aminuddin, Federal Minister for Petroleum and natural Resources, Pakistan Naval War College, Lahore, February 16, 2002, http://www.pakboi.gov.pk/Presentations/OilnGas/16-02-02WarCollege_%20Oil%20&%20Gas%20by%20Usman%20Aminuddin_files/frame.htm

[15] Zahid Hussein, "Musharraf's Other War," *Newsline*, January 2006

technology with developing countries and so helping them participate in what was described as an imminent "atomic age." Signing up for *Atoms for Peace* offered an easy way to show support for Eisenhower and Pakistan's leaders were seeking to build an alliance with the United States that would deliver military and economic aid and political support that Pakistan could use to bolster its position in its conflict with India.

Pakistan quickly began to receive military equipment and military advisors as well as economic advisers who came to help it prepare its economic development plans. They imagined a nuclear future for Pakistan. In the first economic plan, meant to cover the period 1955-1960, the planners described their task as "the formulation of programs and policies designed to lead [Pakistan] by a consciously directed and accelerated movement from a largely technologically backward and feudalistic stage into the modern era of advanced technology now on the threshold of atomic age."[16]

The Pakistan Atomic Energy Commission (PAEC) was set up to manage the effort. It used the *Atoms for Peace* program to send young scientists and engineers for training in nuclear science and engineering to the United States, and in time received a U.S.-supplied research reactor. The first power reactor, a 137 MWe pressurized heavy water reactor, was designed and built by Canada, near Karachi in 1970. Pakistan's refusal to sign the 1970 nuclear nonproliferation treaty, especially after India's 1974 nuclear test raised fears of a matching Pakistani nuclear weapons program and Canada ended its supply of fuel for Kanupp. This forced Pakistan to develop its own nuclear fuel technology, and look elsewhere for further nuclear reactors.

A 300 MWe light water reactor was provided by China and started operating in 2000, at Chashma in northern Pakistan. It is fuelled by China. Work is underway on a second power reactor at the same site. The new 300 MWe reactor is expected to cost $850 million and be completed in 2011.[17] But costs are likely to be larger and the construction time longer. All these reactors are under international safeguards.

The current nuclear generating capacity is about 340 MW, because the Karachi nuclear power plant has been working at about 40 MW since its life extension in 2002 (it is expected to be retired in 2019). The actual power generation is significantly lower than nominal production. A key challenge faced by nuclear power plants in Pakistan has been the unreliability of the electricity grid. The Kanupp reactor has been shut down repeatedly because of grid fluctuations, and these are reported to have been a "constant concern" since the start of the Chashma reactor.[18]

---

[16] *The First Five Year Plan 1955-1960*, National Planning Board, Government of Pakistan, 1957, p. 1-2.

[17] "Pakistan Starts Work on Second Chinese Made Nuclear Power Station," *Agence France Press*, December 28, 2005.

[18] "Chashma Nuclear Power Plant," *Inside WANO*, vol. 12, no.1, 2004, http://www.wano.org.uk/WANO_Documents/Inside_WANO/Vol12No1/Vol12No1_E.pdf

Pakistan plans to increase its nuclear capacity to 8,800 MW by 2030, enhancing the contribution of nuclear energy from the present 0.8% to 4.2%. These ambitious expansion plans face several potential obstacles. The first of these is that as a state that is not a signatory of the nuclear non-proliferation treaty, nor one that has all its nuclear facilities under IAEA safeguards, Pakistan is not eligible to purchase nuclear reactors from states that are members of the Nuclear Suppliers Group (NSG). China which had built the first Chashma reactor in the late 1990s joined the NSG in 2004, and is no longer allowed to sell reactors to Pakistan. The second Chashma reactor was apparently included in the original deal and is thus excluded from the new rules, or 'grand-fathered'. In 2008, Pakistan announced a deal for the purchase of two additional reactors from China. It is not clear whether these can be provided under current NSG rules.

Secondly, nuclear power plants are capital intensive with high construction costs and long construction times. Pakistan has relied on cheap credit from Canada and from China respectively in purchasing its two nuclear power reactors. But apparently China did not extend sufficient credit to meet the foreign exchange component of the third power reactor (Chashma-II) and Pakistan had to seek additional international financial market support.[19] This problem is likely to get worse if Pakistan tries to purchase a large number of bigger and more expensive reactors to meet its goals. Funding for new nuclear reactors will have to compete against the demand for money for generating capacity that is cheaper to build and could come on line more quickly. Only if both these issues are addressed would any nuclear expansion be feasible. To meet these challenges, in 2005, PAEC proposed that foreign companies could be invited to build, own and operate nuclear power plants in Pakistan with equity sharing in 'nuclear power parks'.[20]

Pakistan is looking at building 10-12 new reactors and is already considering sites for them along the Indus River and the coast.[21] The Atomic Energy Commission has proposed building a large civilian (i.e. safeguarded by the International Atomic Energy Agency) enrichment plant and a nuclear fuel production facility as part of this expansion.[22] If plans do take shape, they are likely to create opportunities for public debate and engagement on nuclear energy on a much larger scale than anything seen before as local communities wrestle with issues of living with potential risks and accidents and their hopes for employment and prosperity.

[19] "Financial Accord on Chashma Unit Likely in May," *Dawn*, March 12, 2005.

[20] "Nuclear Power Programme Meets Standards," *Daily Times*, March 26, 2005.

[21] Shahid-ur-Rehman, "PAEC says Pakistan taking steps toward new reactor construction," *Nucleonics Week*, January 12, 2006

[22] Mark Hibbs and Shahid-ur-Rehman, "Pakistan civilian fuel cycle plan linked to NSG trade exception," *Nuclear Fuel*, August 27, 2007.

THE LIMITS OF NUCLEAR POLITICS

PAEC is the most important force shaping policy and attitudes towards nuclear energy in Pakistan. A major source of its enormous political power is that the civil and military nuclear programs of Pakistan are intermingled (as is the case in several other countries, particularly India). This has meant that for decades PAEC has been able to claim to represent both national scientific and technological progress and national security. One measure of its continuing success at avoiding accountability is that even as recently as 2005 PAEC refused to provide its budgets to Parliament.[23]

Pakistan's nuclear weapons program was launched in the early 1970s, as part of PAEC's tasks. Led by some of its American and European trained scientists, this effort gained urgency after India's 1974 nuclear test. The goal was initially to follow a plutonium path to a weapons capability, through either diverting spent fuel from Kanupp or building a plutonium production reactor and separating the plutonium. But Pakistan first succeeded in producing fissile material for its nuclear weapons through the covert acquisition of centrifuge uranium enrichment technology by A.Q. Khan, a Pakistani metallurgist trained in Europe who worked for Urenco, a joint British, Dutch, German enrichment conglomerate.

Pakistan was able to enrich uranium by the early 1980s and was assumed thereafter to have a nuclear weapons capability. In 1998, Pakistan followed India in testing its nuclear weapons. The nuclear tests ushered in a period of intense crisis in South Asia that included both a war (1999) and a prolonged near-war situation (2001-2002) in which leaders in both states threatened the use of nuclear weapons.[24] The uranium enrichment program is believed to have produced sufficient material so far for about 60-70 nuclear weapons.[25] Pakistan also has a dedicated production reactor, at Khushab, for weapon plutonium, and may have started separating plutonium from it in recent years – two additional production reactors are under construction at the site.[26]

PAEC dominates the scene in other ways. It controls the overwhelming majority of scientific activity in the country, in terms of numbers of scientists and access to financial resources. This has historically given it a capacity to influence policy making in science and science related areas, as well as in nuclear energy and national security. PAEC has a near-monopoly on nuclear

[23] Rauf Klasra, "PAEC Refuses to Divulge Details to NA", *The News*, April 24, 2005.

[24] M.V. Ramana and Zia Mian, "The Nuclear Confrontation in South Asia," *SIPRI Yearbook 2003: Armaments, Disarmament and International Security*, Oxford University Press, 2004.

[25] *Global Fissile Material Report 2008*, International Panel on Fissile Materials, Princeton, NJ, www.fissilematerials.org. For a detailed analysis, see Z. Mian, A. H. Nayyar, R. Rajaraman, and M. V. Ramana, Fissile Materials in South Asia and the Implications of the U.S.-India Nuclear Deal, IPFM Research Report No. 1, September 2006, www.ipfmlibrary.org/rr01.pdf.

[26] Z. Mian, A. H. Nayyar, R. Rajaraman, and M. V. Ramana, *Fissile Materials in South Asia and the Implications of the U.S.-India Nuclear Deal*, IPFM Research Report No. 1, September 2006, www.ipfmlibrary.org/rr01.pdf.

expertise; it runs its own training institutes while nuclear engineering courses are not offered in most universities. As a result there is no academic community able to offer independent peer review of PAEC claims, and no significant critical technical input into public debate and policy making on nuclear issues.

PAEC has remained largely unchallenged by other branches of government, civil society and public opinion. This is despite the fact that it commands a disproportionate share of national economic and technical resources and functions as a state within a state. It is worth noting that while PAEC has built a large and powerful nuclear enclave, the combined enrollment rate for primary, secondary and higher education in Pakistan is about 35% and the adult literacy rate is less than 50%.[27] PAEC has many scientists and engineers, but the public and private higher education system is by and large barren when it comes to research and there is no industrial R&D to speak of. The failure to develop an education system that meets social and economic needs has been profound and has many long term consequences.[28]

There is no significant movement in Pakistan against nuclear energy, nor even any full-time independent research institutions or grass-roots activists working on this issue. This is true in other important public policy areas also. It is due partly to successive military regimes and authoritarian civil governments hampering the growth of civil society and social movements. Political energies and resources have been directed to organizing for basic economic and social needs, democracy and human rights, especially the rights of women. The emergence of a small environmental movement in the 1990s with both think-tanks and grass-roots organizations, and the network of groups mobilized against nuclear weapons (the Pakistan Peace Coalition) that took shape after the 1998 nuclear tests suggest things may be starting to change. But it is likely to be a long time before a broad, resilient and capable civil society capable of contending with the state will emerge.

The 1986 Chernobyl disaster left its mark in Pakistan but had no enduring impact on either policy or public attitudes. But it did create some doubts among the elite about the safety of nuclear facilities in Pakistan. In the days immediately following news of the accident, there was no comment from PAEC or other government officials. The Pakistan Medical Association branch in Karachi (the site of the only nuclear power reactor at that time), called for monitoring to determine if radiation from Chernobyl had reached the country; it was by then clear that radiation had already reached Europe.[29] A leading English-language newspaper editorialized that the accident suggested developing countries with nuclear reactors were at "considerable risk" and that "a grave cause of danger is the secrecy that often surrounds such facilities, since governments rarely disclose details which might alert the public,

[27] *Human Development Report 2005*, United Nations Development Programme, New York, 2005, p.260, http://hdr.undp.org/reports/global/2005.

[28] Pervez Hoodbhoy, ed., *Education and the State*, Oxford University Press, 1998.

[29] "Need for Monitoring Radiation Effects," *Dawn*, May 9, 1986.

particularly environmentalists, about possible hazards" and called for the government to "disclose full details about Kanupp's safety aspects."[30]

PAEC's first public response came in late May 1986, almost a month after the accident. The chairman of PAEC announced at a press conference that some increase in radioactivity had been detected (between May 11 and May 17), and that food and vegetation had been tested and found to be safe.[31] He explained that PAEC had been instructed by the government to improve safety at its nuclear facilities, and that this required compliance with strict safety procedures. The implication was that no new measures were required. He also emphasized the difference in the design of Kanupp from that of the Chernobyl reactor, presumably to suggest that it could not have a comparable accident.

However, questions continued to be asked. A Karachi news magazine observed that "Pakistan's nuclear programme has long been shrouded in secrecy, on grounds of security considerations; it has even been considered unpatriotic to even question the desirability of nuclear power. But post-Chernobyl, a new awareness is emerging."[32] It carried an article by a leading physicist, who asked, "Could a Chernobyl-like disaster occur in Karachi?" and used the disaster to raise concerns about the site of the reactor, pointing out that "even high-ranking PAEC officials now admit that Karachi's reactor is badly sited", emphasized the need for evacuation plans, and criticized the lack of an independent nuclear safety body.[33]

There were also questions about the safety of workers at Kanupp in the late 1980s. For example, there were reports that PAEC did not provide adequate protection for workers employed to clean-up leaks of heavy water contaminated with radioactive tritium. This led to a public meeting where PAEC took pains to say this was a minor and routine incident and that the Commission staff took all necessary care, but refused to give details. It became clear in the meeting, however, that there were serious issues of public concern that PAEC would rather hush-up. There continue to be doubts about the safety of Kanupp.[34] An accident could have catastrophic consequences given that Karachi city, with a population of about 16 million, and high population density, is only about 15 miles to the east of the reactor site and there is no possibility of a practical evacuation plan.

The most significant public debate over nuclear energy in Pakistan was triggered in 1999 by a technical study assessing the safety and possible consequences of a potential accident at the Chashma nuclear power plant,

[30] "Making Nuclear Facilities Safer," *Dawn*, May 18, 1986.

[31] "Munir Allays Fear of N-Fallout," *Dawn*, May 26, 1986.

[32] "Safety First?" *The Herald*, January 1987.

[33] Pervez Hoodbhoy, "If...." *The Herald*, January 1987.

[34] Zia Mian, *Some Issues Associated with Pakistan's Karachi Nuclear Power Plant (Kanupp)*, Sustainable Development Policy Institute, Working Paper #51, Islamabad, 2000.

which had then just been recently completed but was not yet operating.[35] The study identified a number of safety concerns; these included evidence of earthquake hazards at the site, the questionable reliability of the design given that it was based on a Chinese prototype with an uncertain operational history; and the questionable quality of the reactor components, some of which had never been manufactured in China before. An additional concern followed from details of a 1998 accident which shut down for a year the prototype reactor in China. Unable to diagnose and make the repairs on a reactor they had designed and built, China contracted a U.S. nuclear engineering company to assess the problem and make repairs. Similar assistance would not be available to Pakistan because it is not a party to the Non-Proliferation Treaty.

The safety study used data from the Chernobyl accident to constrain the possible radioactivity release that might follow a melt-down and containment failure at Chashma. It used a simple atmospheric dispersion model and data on wind patterns, local population density and standard cancer risks from radiation exposure to estimate that there could be 12,000-30,000 cancer deaths in the event of a major accident at the plant. The radioactivity that would be released could also contaminate the near-by Indus River, a crucial source of water for much of the country.

The Chashma report was reprinted by a leading environmental policy think tank in Islamabad, the Sustainable Development Policy Institute.[36] The issue was debated in newspaper articles, seminars at major think tanks, and at a public debate hosted by the Ministry of Environment to which senior PAEC officials were also invited.[37] The Advocacy and Development Network, a group of leading local NGOs working on sustainable development, took a public position calling for a halt to further work on the Chashma nuclear reactor pending an independent inquiry into its safety. Given the public interest, PAEC agreed to let one of the authors (AHN) of the report see the reactor safety documents that are otherwise regarded as confidential. The campaign failed in that the Chashma reactor commenced operating without an official independent safety review.

The debate around the safety of the Chashma reactor also led to a push for a more independent nuclear regulatory body. Pakistan's Nuclear Regulatory Board established in 1997 was far from being an independent watchdog body, even though it was officially described as one. The Chairman of PAEC, who is responsible for all nuclear facilities in the country, was also Chairman of the Nuclear Regulatory Board. There was no provision for either a separate

[35] Zia Mian and A.H. Nayyar, *Pakistan's Chashma Nuclear Power Plant: A Preliminary Study of Some Safety Issues and Estimates of the Consequences of a Severe Accident*, Princeton University/Centre for Energy and Environmental Studies, Report #321, December 1999.

[36] Zia Mian and A.H. Nayyar, *Pakistan's Chashma Nuclear Power Plant: A Preliminary Study of Some Safety Issues and Estimates of the Consequences of a Severe Accident*, SDPI Monograph No. 11, 1999.

[37] "Accident May be Disastrous: Chashma Reactor Not Safe, Says Expert," *Dawn*, December 21, 1999; "Nuclear Regulatory Board Should be Made Independent," *The News*, December 21, 1999;

budget or separate professional staff. A determined campaign finally led to an amended Nuclear Regulation Act that established a more autonomous Nuclear Regulatory Authority (PNRA). However, reflecting PAEC's continuing monopoly on nuclear expertise, even the PNRA relies for its staff on PAEC personnel, including its chairman.

CLIMATE CHANGE AND THE PROSPECTS FOR RENEWABLE ENERGY

As is the case in other countries, the need to address greenhouse gas emissions responsible for climate change is being used as a way to further promote nuclear energy in Pakistan. The former Chairman of PAEC, and now special advisor to the Prime Minister on 'strategic programs' (i.e., the nuclear weapons program), argued for example that "in the wake of irreversible global warming, it is nuclear energy alone which offers a viable and sustainable solution to the looming disaster predicted by the International (Intergovernmental) Panel on Climate Change. Nuclear energy is proven technology that is non-polluting, safe, and cost-competitive."[38] However, it is clear from the massive increase in coal use envisaged in its energy plan for 2030 that Pakistan's government is not serious about an energy future that is sensitive to the climate change challenge.

While energy policy appears to be less concerned with the issues of climate change and Pakistan's obligations in this regard than with ways to increase supply, there is at least on paper an intention to improve conservation and efficiency in transmission and distribution of electricity, and to foster renewable energy resources. However, it may be possible to do much more. Pakistan may be able to make considerable progress towards meeting the expected needs of its increasingly energy intensive economy and society with a focused program of conservation, efficiency and renewables.

Electricity transmission and distribution losses have historically been very high in Pakistan, and include significant power theft. Total losses have ranged from 23.4% in 1992-1993 to as high as 27.5% in 1998-1999 and were about 22% in 2005-06.[39] The difficulty in curtailing these losses is clear from the goal of the Water and Power Development Authority, which is responsible for the grid, to reduce these losses to 21.5% by 2010. This means Pakistan expects to continue to have a very inefficient electricity supply system and to make up for this by increased generation.

Pakistan has an official National Energy Conservation Centre, based in its Ministry of Environment, Local Government and Rural Development.[40] It is

[38] "Nuclear Power Programme Meets Standards," *Daily Times*, March 26, 2005.

[39] *Economic Survey of Pakistan 2006-2007*, Government of Pakistan, Islamabad, 2007, http://www.finance.gov.pk/survey/sur_chap_06-07/15-Energy.pdf.

[40] National Energy Conservation Centre, Islamabad, http://www.enercon.gov.pk/index.htm

not a very powerful bureaucratic player and has few resources. There are few recent studies of potential energy efficiency gains for Pakistan, but it is clear that substantial gains could be possible. A 1998 study estimated that almost 20% of electricity generation (over 7,000 MW) could be avoided for the period 1997–2015 by the adoption of already available energy efficient lighting, refrigeration, air conditioning and electric motors in the residential, commercial and industrial sectors.[41]

The energy plan for 2030 includes a major commitment to renewable energy, and foresees it having larger share in electricity generation than nuclear energy. Historically, official support for renewable energy technologies has been largely ceremonial: establishing a couple of research and development institutions without providing them sufficient funding. The performance of the Pakistan Council of Renewable Energy Technologies, itself a merger of several small organizations has been quite poor. Even after several decades, it has not been able to complete anything more than minor demonstration projects.

In May 2003, Pakistan set up an Alternative Energy Development Board (AEDB).[42] It is based in the Prime Minister's Secretariat, in Islamabad, giving it considerable bureaucratic authority. AEDB has developed a draft Renewable Energy Policy that aims to encourage investment in various renewable energy technologies. It has set several targets; renewable energy resources should be 10% of primary commercial energy supply by the year 2015; 2% of all investment made in the energy sector should be dedicated to development of the renewable energy technology base in Pakistan; all localities not planned to have access to grid electricity in the next 20 years are to be earmarked for the provision of renewable energy; and all solar and wind energy related technologies are to be indigenized over the coming decade through collaboration with international suppliers.

To achieve these targets, AEDB plans to focus on manufacturing renewable energy technology components such as solar cells, wind turbines and fuel cells, and building solar homes, generating biogas and bio-diesel, and constructing micro-hydroelectric plants. But it has already failed to meet its initial targets. The outlook is bleak for its future as a technology developer and provider.

There are larger problems facing the widespread utilization of wind and solar energy technologies in Pakistan. A major constraint is that it is not well-endowed in wind energy potential.[43] A US National Renewable Energy

[41] R. M. Shrestha, A. I. Jalal, M. Latif and W. K. Biswas, "Mitigation of Power Sector Environmental Emissions Through Energy Efficiency Improvements: The Case of Pakistan," *Journal of Environmental Management*, No. 54, 1998, pp. 249–258.

[42] Alternative Energy Development Board, Islamabad, http://www.aedb.org.

[43] A September 2007 US National Renewable Energy Laboratory wind resource map for Pakistan shows poor to marginal wind resource potential m across most of the country, http://www.nrel.gov/wind/pdfs/final1-1-1pwr50pk.pdf.

Laboratory estimate suggests a total theoretical potential for installed wind capacity for utility-scale operations of about 130,000 MW. A large, land-based, wind energy component in future energy generation seems to be possible in principle.

For the indigenous development of wind energy technology, sufficient research and development and industrial infrastructure has to exist in the country to make turbines and blades. None exists. The natural alternative is to invite international finance to invest in it. Recognizing that to attract an investor in the wind energy sector would require proper wind data sets, Pakistan embarked in 2002 on a project to generate wind maps for the coastal areas, in the south of the country. The effort was funded by the Global Environment Facility of UNDP. It was a dismal failure. Only 70 wind stations were established and those only in areas which were easily accessible by road. The data could neither be extrapolated to other areas nor to higher elevations. In any case, the instruments turned out to be not very reliable, and hence the entire data set is useless. The result is that any prospective investor in wind energy projects in Pakistan will have to first generate the data required to determine if an investment is even worth considering.

The story of solar energy technology is not very different. The indigenous capacity to produce solar photovoltaic cells is rudimentary and only exists at the pilot scale. The demonstration units set up so far have all been from imported technology which is very expensive in terms of initial investment. Hundreds of imported solar PV panels for demonstration projects were taken down after some years of use owing to lack of local technical support. A few private businesses in Pakistan also market solar PV panels, but there are few buyers owing mainly to the initial cost (which comes to over $7 per watt), absence of reliable technical after-sale service, and non-integration of the panel system with the electricity supply system in use in homes, businesses or factories.

The government also plans to use fuel ethanol in transportation. However, at present there are no fuel ethanol producing units in the country and there is no blending of fuel ethanol with petrol. Most of the molasses from the substantial sugar industry is either exported or used in the production of alcohol.

Given this sorry state of affairs, it is hard to see how renewable energy can ever come close to meeting the targets set in Pakistan's official energy policy. There is hope however in the fact that renewable energy is being developed elsewhere in the world and its adoption and use in Pakistan may follow in time.

CONCLUSION

Pakistan finds itself in an energy trap, caught between the ever more energy intensive development path it has chosen, its lack of access to high quality

energy resources, its political history and its location. Its efforts to meet its energy needs reflect and in important ways have worsened the many contradictions and crises Pakistan has failed to resolve as it has sought to modernize and develop as a society, a state structure, and an economy.

Nuclear energy is a small, almost negligible part of Pakistan's energy sector, in terms of generating capacity. It has become important because of the enormous and unaccountable power of the Pakistan Atomic Energy Commission that manages it, and through the link to the nuclear weapons program. These factors have made it difficult to create or sustain a significant, critical policy debate or mass mobilization on nuclear energy and its role in Pakistan's future, despite its potential for catastrophic failure, the unresolved problems of waste disposal, and the distortions that it creates in energy planning because of its need for large amounts of scarce capital and skilled personnel for long periods of time.

Pakistan's energy plans are ambitious and appear unrealistic. It is hard to see how it can generate and sustain the vast capital investments it would need to meet its energy goals, given its political instability, poor governance, and myriad groups that are willing to use violence against the state because democratic processes have not been allowed to develop. Should funds become available, and current plans begin to be put into effect, conflicts will likely worsen. A necessary condition for a viable energy policy in Pakistan is that it be built on foundations of democracy and social justice and watched over by a vigilant and powerful civil society. These basic political foundations still need to be laid and the social movements insert text need to be built.