Going up in smoke

BY A. H. NAYYAR

Pakistan's economy is growing and the country demands more energy, much of which will have to come from indigenous resources and greater efficiency in energy use. To achieve this increase, Pakistan must rework its energy plan and policies, more actively exploring renewable sources and assessing the environmental and political implications.

Pakistan has no energy policy as such, but the contours of a policy can be construed from two major official documents: a chapter on *Energy Security in the Medium Term Development Framework 2005-10* and Pakistan's Alternate Energy Policy. These contain the seeds of the Action Plan to meet the country's growing energy needs that the President and the Prime Minister approved in February 2005.

This article surveys the energy scenario of the country. It then focuses on the issues around electricity generation, giving the salient features of the energy policy as construed from the two documents above and critically analysing some of the policy decisions. Because of the paucity of independent sources, it relies heavily on official data. The chapter then discusses the prospects of renewable energy and some environmental issues.

The Energy Scenario Today

Pakistan's per capita energy supply is 0.30 metric t of oil equivalent, less than one fifth the world average. Per capita consumption is only 14 million Btu. The under-development of the society is indicated by the fact that 31 million Btu is used to produce 1 US$ of GDP, compared to 6 Btu in Japan and the UK, and 27 in India.

The total energy consumption in Pakistan in 2003-04 was 50.8 million t of oil equivalent, of which nearly 80% came from oil and gas. Oil constituted nearly 30%, natural gas 50%, coal 6.5%, hydroelectricity 12.7%, nuclear 0.8% and liquefied petroleum gas 0.4%.

The known indigenous oil resources are estimated at 300 million barrels, out of a prognostic estimate of the total reserves of 27 billion barrels. Indigenous annual production is 22.6 million barrels, against annual consumption of 100 million barrels. Pakistan thus heavily depends on imported oil. It imports 7.8 million t of crude oil and 5.2 million t of oil products annually, which cost US$ 3.1 billion in 2003-04.

Pakistan's proven reserves of natural gas are 0.8 trillion cubic metres, while the prognostic reserves are estimated at 10 times as much. The production capacity is 93 million cubic metres a day, while consumption is 82 million cubic metres a day.

The proven coal reserves are estimated at 3.3 billion t, but the so-far untapped resource of Thar mines may take that to 185 billion t. Local coal production is presently 3.3 million t a year, while consumption stands at 6.1 million t.

The installed hydroelectric capacity is 6,459 MW, nearly 36% of total electricity generation in the country.

The total installed generation capacity of nuclear power is 425 megawatts from two reactors: the Karachi and Chashma nuclear power plants. The former recently received an extension of life after serving for over 30 years. Its present capacity is stated to be about 80 MW.

The major energy-consuming sectors of the country are industries (38.3%), transport (32.0%), household and commercial (25.0%), agriculture (2.5%) and others (2.2%).

The bulk of the oil consumption is in transportation (63.1%) and electric power generation

(20.4%). Industry consumes 11.1%, agriculture 1.4%, government 2.3% and domestic use 1.7%.

Electricity generation is also the largest consumer of natural gas. In 2003-04, it consumed 44.7%, while general industry consumed 19.1% and the fertiliser industry 18.4%. Domestic and commercial consumption accounted for about 17%. The use of natural gas in transportation is still very low, 1.5% of the total gas consumed.

Nearly 85% of the coal consumption is in the cement industry and brick kilns. There is only one coal-fired electric power plant (150 MW).

Electricity

Pakistan's installed electricity generation capacity is 20,289 MW, of which hydroelectricity contributes the most (6,459 MW), followed by oil-fired plants (6,400 MW), gas-fired plants (5,940 MW), and coal, nuclear and renewables (906 MW). The current hydel-thermal mix is 33:67 as compared to 28:72 in 2001. The annual cumulative growth rate in electricity generation in the last five years has been 3.2%. This has catered to an additional 1.7 million consumers.

The total energy consumption in Pakistan in 2003-04 was 50.8 million t of oil equivalent, of which nearly 80% came from oil and gas. Oil constituted nearly 30%, natural gas 50%, coal 6.5%, hydroelectricity 12.7%, nuclear 0.8% and liquefied petroleum gas 0.4%. Electricity generation is also the largest consumer of natural gas.

Several public sector hydroelectric projects amounting to about 800 MW capacity are at different stages of implementation and others amounting to about 100 MW capacity have been approved for implementation.

Pakistan's electricity sector has been historically dominated by the public sector utilities, Water and Power Development Authority (WAPDA) and Karachi Electric

Supply Corporations (KESC), which until recently enjoyed an absolute monopoly over power generation, transmission and distribution. According to the government's own admission, "these institutions emerged as large monolithic, vertically integrated utilities with overstaffing, declining skills, deteriorating maintenance of Infrastructure, financial and technical inefficiencies, poor governance, excessive dependence on public sector development resources, neglect of customers and lack of competitive spirit" (Energy Security Action Plan (ESAP), in Medium Term Development Framework 2005-10).

Starting in 1994, in the face of an ever widening gap between demand and supply that resulted in frequent power outages, and the consequent adverse impact on industry, private investment in power generation was encouraged. Besides incentives in the form of tax holidays and freedom of choice of fuel, the investors were assured of capacity payment even when their power was not purchased. Instead of an initial plan to allow an additional 3,500 MW generation capacity, much more private investment was allowed that created an enormous surplus of electric power that the public utilities were forced to purchase, or pay the capacity charges for. This further weakened the utilities.

WAPDA is going through an unbundling process, in which generation and distribution parts are being separated from it and privatised. As a result, it has been reorganized into four generation companies and nine distribution companies. WADPA's transmission business is handled by the National Transmission and Dispatch Company, while KESC's transmission aspect is to be handled by a special-purpose transmission licensee. WAPDA's mandate is to develop and manage hydroelectric utilities and regulate water distribution. KESC has been on line for privatisation. By the fiscal year 2003-2004, there were 16 licensed independent power producers and 25 private small power producers (industries or clusters of industries setting up thermal power plants for their own use) with a total generating capacity of 6000 MW, nearly as much as in the public sector.

Pakistan's electricity system, however, continues to suffer transmission and distribution losses as high as 26.5%, according to the government. Others quote a much higher figure. Most of the losses are attributed to a weak distribution system. The ESAP vows to reduce losses in the next five years to 21.5% by privatising distribution and rationalising subsidy and free units to WAPDA employees.

The plan is essentially an admission on the part of the public sector of its inefficiencies. Privatisation therefore seemed an inevitable remedy, but it can cause serious problems to consumers unless a system of checks and balances is simultaneously created.

The government has also constituted a National Electric Power Regulatory Authority (NEPRA) with powers to grant licenses to generating, transmitting and distribution companies in the public as well as private sector. NEPRA reviews organisational affairs of generation, transmission and distribution companies and sets tariffs and performance standards. Because of its crucial role in safeguarding the public interest in all the spheres of power generation and supply, NEPRA holds public hearings of all the license generation and tariff review applications.

However, the public does not adequately participate in the regulatory mechanism. While the license applicants hire lawyers to represent their cases in the hearings, the public, including local governing bodies and civil society organisations, is ignorant of the issues involved and the most efficient ways to address them. Its concerns therefore go unrepresented.

Future Electricity Generation

For future electricity generation, the government relies heavily on private investments. It aims to increase the present installed capacity of 20,289 MW by another 7,100 MW by 2010 and take it up to 143,310 MW by 2030. This is a gigantic target and would require an additional investment of US$ 150 billion. It envisages average annual investment of $2 billion from the public exchequer and hopes to elicit $4 billion a year from private investments through build-operate-transfer and private-public partnership modes.

Of the 22 projects identified in the ESAP, there are only 8 in the public sector and for 14 the government hopes to attract private financing. Those planned in the public sector are all small hydroelectric projects totalling 755 MW. The remaining 6,345 MW is to come from the private sector, the largest of the hopefuls being an unidentified gas-fired power plant of 3,100 MW capacity. Of the planned 7,100 MW, the net hydroelectricity planned for the next five years is only 1,257 MW. This is clearly going to reverse the hydel-fossil fuel mix in energy generation. In spite of this the ESAP claims: “In power generation a total of 23 hydel projects are planned to be initiated during the MTDF period, out of which 14 hydel projects will be completed, so that hydel-thermal mix is shifted towards hydel generation.”

The Tarbela dam in the North West Frontier Province, Pakistan

The ESAP lays down the following objectives for energy sector development:

- to enhance hydropower exploitation and exploration and production activities of oil, gas and coal resources, and increase the share of coal and alternate energy in the overall energy mix;
- to optimise use of the country's indigenous resource base to reduce dependence on imported fuel through an institutionalised strategy;
- to create an environment conducive to private sector participation; and
- to develop the energy scenario in the context of a regional perspective.

It goes on to say: "The energy demand over the next five years is expected to grow at a rate of 7.4 percent per annum. To meet future requirements with indigenous resources, domestic exploration, if feasible, would be intensified. Simultaneously, the energy supply options would be diversified, with import of gas and LNG. ... 900 MW capacity would be increased through coal-based projects."

Contentious Issues

Besides the micro- and minihydel projects envisaged in the ESAP, the government plans to build large dams on the Indus river, the Kalabagh, Bhasha and Akhori dams, with electricity generation capacities of 3,600, 4,500 and 600 MW respectively. The costs are initially estimated at $5.65 billion, $6.7 billion and $1.6 billion respectively. These dams are controversial on two counts: the politics of water in the water-starved country and issues of human displacement and impact on environment. The Kalabagh dam would displace 120,000 people, Bhasha 24,000 and Akhori 49,300. The effect of large dams such as Tarbela and Mangla are already visible in the lower riparian regions. In the words of an expert (Shaheen Rafi Khan, *The Case against Kalabagh Dam, in The Politics of Managing Water*, Kaiser Bengali (Ed.), Sustainable Development Policy Institute, Islamabad and Oxford University Press, Karachi, 2003):

> "The large reduced outflow has resulted in visible Indus delta degradation ... [and] a four-fold reduction in the silt discharge from an original annual discharge level of 100 million tons. The subsequent effects of these have been felt by the mangroves, which are a foundation of the Indus Delta ecosystem. Mangroves need fresh water to survive and grow and are natural hatcheries for a variety of fish. They also act as natural barriers to sea encroachments and bank erosions and are an important source of fodder and fuel wood to the fishermen living in the Indus delta along the Sindh coastline."

The government plans to build large dams on the Indus river, the Kalabagh, Bhasha and Akhori dams, with electricity generation capacities of 3,600, 4,500 and 600 MW respectively. The costs are initially estimated at $5.65 billion, $6.7 billion and $1.6 billion respectively. These dams are controversial on two counts: the politics of water in the water-starved country and issues of human displacement and impact on environment.

The construction of additional large dams on the Indus system would accentuate these problems.

Big dam projects lead to displacement from ancestral habitats, impoverishment as a result of forced eviction and inadequate compensation, and loss of common resources. Every project promises compensation to the displaced people, but the alternative land has never been as

fertile, and the monetary compensations have never been paid in full and in time, as noted in a report titled *Development Induced Displacement in Pakistan* (by Atta ur Rehman, published by the South Asian Forum on Human Rights (SAFHR), http://www.safhr.org/refugee_watch15_3htm):

Tarbela dam was launched in 1967 with the World Bank assistance. At the outset it was assessed that 80000 people would be displaced and 100 villages will come under water. But 96000 people had been dislocated and 120 villages submerged. The main occupation of those displaced was agriculture. A comprehensive resettlement programme was adopted but resettlement is not yet complete. After the passing of 30 years still 2000 families are waiting to get their claims settled. 170 families, who were allocated land in other provinces, could never get possession of the land.

Tarbela dam was launched in 1967 with the World Bank assistance. 96000 people had been dislocated and 120 villages submerged. The main occupation of those displaced was agriculture. A comprehensive resettlement programme was adopted. After the passing of 30 years 2000 families are still waiting to get their claims settled. 170 families, who were allocated land in other provinces, could never get possession of the land.

The government's attempt to build large dams has also created a political controversy. The smaller provinces of Sindh and North West Frontier have serious objections on account of the fears of reduced amounts of water and silt reaching the lower riparian Sindh, and inundation of large habitats in the Frontier. The opposition to Kalabagh dam has taken the shape of political defiance of smaller provinces against the centre. The central government's insistence on building the dam has aggravated Sindh's sense of political and economic persecution and strengthened Sindhi nationalism. The dam thus has a political cost too.

The devastating 2005 earthquake further puts a question mark on the suitability of large dams in the northern mountainous region of Pakistan, such as Bhasha dam in Chilas. All the existing and proposed big dams are situated in earthquake-prone regions, and ensuring their survival in the face of a strong jolt would substantially increase their cost of construction.

The second serious issue is that of diversifying energy generation to coal. The coal component

of primary energy resources is still at 6.5%, but the ESAP is to increase this to nearly 20% by 2030. Included in the present 6.5% is the use of coal in the cement and brick kiln industry, and a 185 MW thermal power plant at Lakhra. The emphasis of the government is on using the discovered but untapped resource of 185 billion t of coal in the Thar desert bordering India. The government plans to invite investors to install thermal power plants, mine the coal to fire the plants and sell the electricity to the national grid. In 2002, the Government of Pakistan allowed the Shenhua Group, a Chinese company, to look into establishing a 3000 MW (3 GW) power plant near Islamkot in Thar.

The Sindh government has now signed memoranda of understanding with the Shenhua Group for a 600 MW coal-fired power plant and with an Australian firm for a 1200 MW plant, also at Thar, using underground coal gasification. The Private Power Infrastructure Board has also advertised a 450 MW coal-fired plant at Lakhra.

The Thar coal is lignite with 6.24% ash content, 16.67% carbon and 6.6% nitrogen and sulphur.

Female activists of a 19-party anti-dam alliance protest in Karachi against the construction of Kalabagh dam

The government's attempt to build large dams has also created a political controversy. The smaller provinces of Sindh and North West Frontier have serious objections on account of the fears of reduced amounts of water and silt reaching the lower riparian Sindh, and inundation of large habitats in the Frontier. The opposition to Kalabagh dam has taken the shape of political defiance of smaller provinces against the centre.

Our estimate is that coal-fired power plants of 3,000 MW capacity would collectively emit every year 7.5 million t of CO2, 300,000 t of sulphur dioxide (SO2), 31,000 t of nitrogen oxides (NOx) and 700,000 t of fly ash containing large amounts of toxic metals and metalloids such as arsenic, mercury, nickel, zinc, cobalt and copper.

The high quantity of CO2 released would have a major impact on production of greenhouse gases. The nitrogen and sulphur oxides contribute to atmospheric acidification and the particles of metals and metalloids such as arsenic, cobalt, lead and mercury are highly harmful. Exposure to such particles causes increased risk of carcinogenicity and cardiovascular and vascular diseases. These toxic emissions thus increase morbidity and mortality. For example, the power sector in China has been shown to be responsible for the loss of 2.1 million years of life per year and caused economic losses of an estimated 45 billion US$ per year.

The second serious issue is that of diversifying energy generation to coal. The emphasis of the government is on using the discovered but untapped resource of 185 billion t of coal in the Thar desert. It plans to invite investors to install thermal power plants, mine the coal to fire the plants and sell the electricity to the national grid. Our estimate is that coal-fired power plants of 3,000 MW capacity would collectively emit every year 7.5 million t of CO2. Using this coal without a mitigation technology would certainly violate the pollution limits permitted by the Kyoto Protocol..

Continuing to generate 30,000 MW over 30 years would seriously imperil the environment. The mines are near the coast and the sea breeze would allow emissions to go beyond the desert region. Many far-off cities would be affected. Using this coal without a mitigation technology would certainly violate the pollution limits permitted by the Kyoto Protocol.

Technologies for the mitigation of emissions from a coal-fired power plant include sequestering CO2 and other emissions, converting coal into some other solid or liquid fuel to reduce CO2 and particulate emission, and gasification of coal. Low-grade coal, which contains up to 40% water, can be converted to dry, stable, high-heating-value solid fuels and clean liquid fuels. Rosebud SynCoal(r) in Colstrip, Montana (USA), has upgraded low-grade coal (with moisture content 25-40%, sulphur content 0.5-1.5%, and heating values 5500-9000 Btu per pound) to SynCoal(r) with a moisture content 1%, sulphur content 0.3%, and heating value up to 12,000 Btu per pound.

The Government of Pakistan is currently stressing coal gasification, but any mitigation technology would increase the cost of electricity production. In addition, the government is planning to induce the cement industry to shift from gas to coal.

Nuclear Energy

From the existing 425 MW (in effect 380 MW because the Karachi nuclear plant has been working at a capacity of about 80 MW since 2002), the ESAP plans to increase nuclear energy capacity to 8800 MW by 2030, thereby enhancing the contribution of nuclear energy from 0.8% to 4.2% by 2030. For this the government would allocate Rs 69 billion to the Pakistan Atomic Energy Commission in the first 5 years alone. The next nuclear power plant coming up is a light water reactor of 300 MW bought from China for which the fuel would also have to bought from China.

Reliance on nuclear energy is problematic in several respects. Shorn of state subsidies and hidden costs, nuclear energy is more expensive than any other. Nuclear plants have a long gestation period. While thermal power plants come into operation less than 3 years after the foundation laying, nuclear plants in Pakistan have taken 9 to 10 years. They are also capital intensive and involve foreign loans and the consequent debt burden and net resource outflow. Most important, the world still does not know a safe way to dispose of the highly radioactive spent fuel waste.

Renewable Energy Technologies

The ESAP lays a great deal of emphasis on exploring and using renewable energy technologies to meet demand. Historically, the government support for these technologies has been ceremonial: establishing a couple of R&D institutions without giving them sufficient financial support. The performance of institutions such as the Pakistan Council of Renewable Energy Technologies has been quite poor. After decades, they have not completed anything more than demonstrative projects.

The government has now constituted an Alternate Energy Development Board (AEDB), which has developed a policy to reduce the energy shortage through investment in various renewable technologies.

The AEDB has set the following targets:

- Alternative or renewable energy resources will be developed so as to achieve 10% share in primary commercial energy supply by 2015.

- Two percent of investment made in the power sector should be dedicated to development of an alternative or renewable energy technologies base in Pakistan.
- All localities not expected to be connected with the national grid in the next 20 years are to be earmarked for alternative or renewable energy resources.
- All solar and wind energy technologies will be indigenised in the next decade through national or international collaboration.

To achieve these targets, the AEDB plans to focus on the following technologies:

- Solar cell manufacture
- Solar homes
- Solar water heaters and cookers
- Solar thermal power generation
- Solar stilling engines
- Wind turbines
- Biogas/biodiesel
- Fuel cells
- Microhydel

AEDB also plans off-grid electrification in rural areas. It had planned to install 100 MW wind power by December 2005 at Kati Bander and Gharo Sindh. Its target is to increase wind power to 700 MW by 2010 and to 9,700 MW by 2030, raising the contribution of renewable energy resources to 5% of the total national power generation. It also aims to electrify 54,000 homes in remote villages by solar, wind, or microhydel technologies by 2010 and develop solar lights, fans, cookers and heaters through private sector participation.

The ESAP plans to allocate nearly Rs 20 billion to AEDB to meet these targets over the next five years. Given that the target of generating 100 MW of wind power by December 2005 is nowhere near implementation, the remaining targets seem incredible. The windmills that have been put up in some places can barely generate a few hundred watts. The ESAP therefore has failed to see what is possible and what is not. It would be interesting to see why AEDB has failed to meet the targets in spite of financial allocations.

Both the wind and solar energy technologies face serious technical problems that neither the ESAP nor the AEDB addresses. Pakistan does not have as much wind energy as neighbouring India. Only the coastal belt and high mountains have steady winds of sufficient velocity for most of the day. A rough estimate indicates that the maximum potential in the coastal area, from the India border to the Iran border, is 5000 MW. To expect more from wind energy would be unrealistic.

For indigenous development of this technology, sufficient R&D and industrial infrastructure has to exist in the country to make turbines and blades. None exists. The alternative is to invite international finance, which requires proper gridded wind data showing where the potential exists. Pakistan embarked on a project in 2002 funded by the UNDP to chart out wind maps along the coast in the south of the country. The project implementation had serious shortcomings. Only 70 stations were established, in areas easily accessible by road. Hence there were about 10 or so clusters of stations and the data cannot be extrapolated to other areas or to higher ground. The instruments were unreliable and hence so is the data. The result is that any prospective investor in wind energy projects in Pakistan has to first generate its own data in order to plan the windmill size.

Public sector organisations, on the other hand, have their own technical and manpower limitations, and have succeeded in putting up only small demonstrative units, such as water pumps, housetop windmills to power a couple of bulbs, or some street lights.

The story of solar energy technology is not very different. Indigenous capacity to produce solar photovoltaic cells is at the pilot scale. The demonstrative units set up so far have all been from imported technology, which is expensive in terms of initial investment. The hundreds of imported solar PV panels for demonstration installations were removed after some years owing to lack of technical support that should have accompanied the plants in remote villages.

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 panels with the main energy supply systems in households or factories. Solar water heaters are manufactured by some private companies but have failed to come into popular use because they are not integrated with gas or electric water heating systems and the public sector R&D organisations have made no effort at integration.

Solar cookers require the user to also stand in the hot sun, with the pan at an uncomfortable height. Again, public sector R&D organisations have not tried to remedy this problem. Solar homes require heavy investment, and not enough has been done to urge people to invest in them. Solar cells have so far been used only in some highway telecommunications and park lights.

There have been some success stories in biogas plants in villages, but large-scale state patronage is absent.

At present there are no fuel ethanol-producing units in the country and there is no ethanol-petrol blend. Most of the molasses from the substantial sugar industry is either exported or used to produce alcohol. Alcohol from molasses is the only major value-added product manufactured in the country. Ethanol production during 2004-05 in the country was 350-500 million litres. The government now plans to increase it for use in transportation.

A major hurdle is the lack of state commitment to invest heavily in renewable energy options. The state should:

- make sure that solid and reliable wind energy charting is done at the earliest;
- establish an industry for manufacturing wind turbine components;
- carry out a study on how to make people adopt renewable energy technologies and launch a massive campaign to popularise their use;
- mandate institutions in the public sector to integrate renewable energy technologies with other energy systems to make them user friendly.

Environmental Issues

The ESAP admits that the power sector contributes over 80% of total CO2 emission and states that over the medium term "conversion of existing thermal power stations from fuel oil to natural gas would substantially reduce the CO2 and particulate emission."

There is a gross inconsistency in the plan. While the government shows concern for environmental degradation, it sees use of Thar coal as a solution to the energy problem, knowing

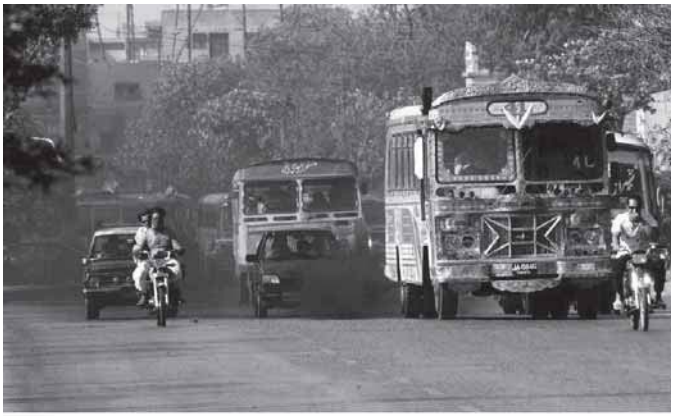
well that it would contribute much more to production of greenhouse gases and other toxins. Unless prospective investors in Thar coal power generation are forced to use clean technologies, environmental problems will worsen. Details of the deals with the investors have not yet been disclosed to the public.

Similarly, plans to develop large hydroelectric dams such as Kalabagh and Bhasha would severely impact the ecosystems of those areas and of the lower riparian regions.

Pakistan's greatest energy consumption is in transportation. The sector is extremely inefficient in energy use and a major source of environmental degradation. Public transportation depends heavily on diesel engines. Because of low incomes of owners, old vehicles continue to be used well after their nominal life. Technical know-how in transport maintenance is low. As a consequence almost all Pakistani cities are pollution nightmares.

Pakistan's greatest energy consumption is in transportation. Public transportation depends heavily on diesel engines. Because of low incomes of owners, old vehicles continue to be used well after their nominal life. Technical know-how in transport maintenance is low. As a consequence almost all Pakistani cities are pollution nightmares.

The National Energy Conservation Centre, a public sector institution under the Ministry of Environment, has developed several schemes to improve efficiency of boiler furnaces, steam and electrical systems, tube wells, and road transportation. Most of the projects are funded by donor agencies, mainly UNDP. Its scope needs to be enlarged, and adequate financial support is provided to it from the public exchequer.



Traffic in Karachi, Pakistan

Conclusion

Pakistan has had a period of low productivity in the last two decades, but the economy is now touching 6-7% annual growth rates and now demands greater energy production. The government's projection of a 7% increase in energy demand is quite credible.

Rapidly increasing international oil prices have already put severe strains on Pakistan's economy. The country therefore needs to develop indigenous resources and economise on energy use. While the former requires heavy investment through public spending or in public-private partnership, the latter requires implementation of strict policies to control wasteful energy use. Electricity transmission and distribution losses must be brought down to well below 20%. Inefficiency in the transport sector must be checked.

Since the government plans to increase the role of private sector power, a reliable system of checks and balances must be put in place. Regulatory authorities such as NEPRA and the Oil and Gas Regulatory Authority need to be strengthened and steps taken to ensure informed participation of the general public, local governments and civil society organisations in the regulatory proceedings.

The role and technological capacity of organisations developing and promoting renewable energy must be enhanced, but these organisations must also seriously aim toward integration with other energy systems and steps that would make the public use such technologies. The wind charting exercise will need to be undertaken more accurately and gridded.

Lastly, the government must weigh the benefits of an energy resource against its environmental and political costs. ■