6. POWER SECTOR REFORM, PRIVATE INVESTMENT, AND REGIONAL COOPERATION

INTRODUCTION

6.1 Modern infrastructure, particularly electricity, telecoms, and roads, is critical to economic development. Electricity provides light, the ability to use modern equipment and computers, and access to information and communication technology (ICT). Telecoms facilitate information exchange and access to the rest of the world, while transport infrastructure is critical for trade, and, by lowering transport costs, extends the market and increases competition. Studies of the productivity of infrastructure (Canning 1999; Canning and Bennathan 2000) suggest that infrastructure has strong complementarities with other human and physical capital. If there is a surplus of infrastructure, more investment adds little to total output, but if there is a deficit, then shortages constrain total output, magnifying the impact, so that the return to reducing that deficit can be very high indeed.

6.2 This can be seen most clearly for electricity. Once there is an adequate reserve margin of generation and adequate transmission and distribution to deliver the power to customers, more capacity has almost no extra value, and the efficient (and competitive) price of power falls to its short-run avoidable cost, essentially the cost of the fuel used in the least efficient plant dispatched. If there is a shortage, the value of lost load can be tens or even a 100 times as high. In Britain during the period 1990–2001, the wholesale market (the electricity pool) set a capacity payment based on the value of lost load, initially taken as £2,000/MWh (megawatts per hour) when the average wholesale price net of the capacity payment was less than £20/MWh. The value of lost load reflects the considerable inconvenience of unexpected disconnection, while the value of unserved energy in a country familiar with power shortages may be lower, as users take precautions such as installing backup or stand-alone systems. Nevertheless, these are often many times as costly as reliable centrally generated power, showing the potentially high returns to investing to deliver that power, particularly to customers with a high willingness to pay (commercial and industrial customers in particular).

6.3 The demand for infrastructure, and particularly electricity, is growing rapidly in the region, and at low levels of income per head, can be expected to grow more rapidly than GDP as the economies modernize and shift resources from agriculture to industry. Figure 6.1 shows the electricity intensity of a selection of South Asian and other countries, measured by production of electricity per thousand US$ gross domestic product (GDP) (at 1995 constant prices). Indian electricity production is rising considerably faster than GDP, as is that in Pakistan and even more so in Bangladesh (although the arithmetic scale may not show this clearly).

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49 This Chapter was prepared by David Newberry, Professor of Economics, Cambridge University, England. The views in this paper are solely the author's and do not necessarily reflect those of the World Bank or its Executive Directors.

50 The price paid to generators was the sum of the system marginal price, the price of the most expensive bid accepted (if they were dispatched) and the capacity payment for plant declared available.
Figure 6.1: Comparisons of Electricity Intensity of Southeast Asia, the United States, China, and the European Union-15

Electricity Intensity SE Asia and comparators 1971-99

Table 6.1: Rates of Growth of Energy Intensity 1986–88 to 1996–98 (percent per annum)

<table>
<thead>
<tr>
<th>Country</th>
<th>Electricity production</th>
<th>GDP US$95</th>
<th>PPP US$96</th>
<th>Electricity production/US $95</th>
<th>Electricity consumption/PPP 96</th>
</tr>
</thead>
<tbody>
<tr>
<td>India</td>
<td>7.78</td>
<td>5.84</td>
<td>4.08</td>
<td>1.84</td>
<td>1.59</td>
</tr>
<tr>
<td>Pakistan</td>
<td>7.39</td>
<td>4.59</td>
<td>1.77</td>
<td>2.70</td>
<td>2.47</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>7.90</td>
<td>4.44</td>
<td>2.70</td>
<td>3.34</td>
<td>5.48</td>
</tr>
<tr>
<td>Malaysia</td>
<td>12.38</td>
<td>8.57</td>
<td>5.64</td>
<td>3.53</td>
<td>4.46</td>
</tr>
<tr>
<td>Sri Lanka</td>
<td>6.53</td>
<td>4.75</td>
<td>3.42</td>
<td>1.68</td>
<td>1.35</td>
</tr>
<tr>
<td>Nepal</td>
<td>8.10</td>
<td>5.02</td>
<td>2.61</td>
<td>2.92</td>
<td>3.28</td>
</tr>
<tr>
<td>Singapore</td>
<td>8.34</td>
<td>8.81</td>
<td>6.71</td>
<td>-0.44</td>
<td>-0.44</td>
</tr>
<tr>
<td>China</td>
<td>8.52</td>
<td>9.67</td>
<td>5.91</td>
<td>-1.03</td>
<td>0.42</td>
</tr>
<tr>
<td>United States</td>
<td>3.07</td>
<td>2.91</td>
<td>1.86</td>
<td>0.16</td>
<td>-0.03</td>
</tr>
<tr>
<td>European Union-15</td>
<td>1.91</td>
<td>2.10</td>
<td>-0.19</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: World Bank 2002; Penn World Tables 6 and Appendix.

6.4 Table 6.1 gives the rate of growth of electricity production and of GDP (at constant US$ and also constant purchasing power parity (PPP) dollars) and of electricity intensity (which is also the rate of growth of electricity production less the rate of growth of GDP). India (and even more so China) looks surprisingly electricity intensive at market exchange rates (nearly three

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51 PPP is a measure of the real standard of living, taken from the Penn World Tables version 6. The relationship between the growth rates is not exact as the rates of growth are found by averaging the initial and terminal values over three years.
times as much as the United States and more than four times as much as the European Union-15). This continues to be true for India and Pakistan when GDP is measured at PPP. Figure 6.2 shows consumption (rather than production) per thousand PPP, \textsuperscript{52} together with the predicted consumption for South Asian countries as a whole (excluding Bhutan) using the regression estimates presented in the annex. India and Pakistan track each other closely, and are considerably more electricity intensive than (more than three times as much as) the smaller countries, Sri Lanka, Bangladesh, and Nepal, and almost twice the predicted level.

\textbf{Figure 6.2: Electricity Consumption in South Asia Compared to Predicted per US$ Thousand PPP}

Thus, whether electricity intensity is compared at market exchange rates or at PPP rates, India and Pakistan appear more electric intensive than might be expected. One obvious explanation of this high intensity is that electricity is underpriced in many countries (both directly, and effectively through the failure to collect bills and prevent theft). Countries that have a lower than expected electric intensity usually also have a low penetration of electricity, particularly in rural areas. In that respect India appears to do quite well, given its per capita income.

\textsuperscript{52} The difference between consumption and production is mainly losses, except for exporting countries like Bhutan (not shown) or India (which imports a very small share of consumption from Bhutan). PPP measures come from the Penn World tables and attempt to correct for different relative prices in poorer countries, primarily the lower prices of nontradables, as well as distortions that cause differences between domestic and world prices for tradables.
THE PROBLEM

6.6 Not all South Asia countries suffer from the same problems, but as a generalization the region still has the legacy of state-owned vertically integrated electricity supply industries, often with the characteristic politicization of tariff setting that leads to excessively cheap electricity to domestic consumers, high levels of nontechnical losses (that is, theft or failure to collect bills), high levels of debt or arrears, high levels of manning, and poor commercial performance (as measured by the ability of revenues to cover costs). As a result, it is difficult for the sector to finance its investment needs on commercial terms. The shortage of revenue leads to poor maintenance with frequent equipment failures (for example, as measured by transformer failures and low generation availability), resulting in power shortages and load shedding. Figure 6.3 gives time series of losses as reported by the World Bank, although for India these are considerably below those reported by various states.

Figure 6.3: Electricity Losses in South Asia and China

![Graph showing electricity losses as percent of generation for different countries](image)


6.7 The India National Electricity Plan notes that “the country faced energy shortage of 7.1 percent and peaking shortage of 11.2 percent in 2003-04” (CEA 2004). ICRA (2004) gives statewise score card data for India for 2004 stating that “the power sector in the country is grossly over staffed leading to low productivity…” and “the proportion of billing on metered basis at less than 50 percent of energy input into the system” (ICRA 2004, p. 10). “Despite progress, the coverage of costs through revenues is still low for most states…” “... in the North East, the coverage … is very low and typically less than 35 percent” (ICRA 2004, p. 11). Taking a sample of states, we find that for Delhi “the generation plants are aged and have a low PLF (48.5 percent) and low availability (62.2 percent). The commercial viability of DISCOMs is contingent upon improvements in the low level of metered billing … reduction in the high levels of AT&C losses of 52.8 percent and improvement in distribution infrastructure. The power sector as a whole has...
negative net worth ... with a low cost coverage ratio of 43 percent" (ICRA 2004, p. 15). For Andhra Pradesh, initially one of the more progressive reformers, "the GoAP has deferred the time frame (of privatizing its distribution companies) indefinitely and currently has no time frame for the final privatization of these distribution entities" (ICRA 2004, p. 17). The average adjusted book losses declined to Rs2526 crores in the years 2001–2 and 2002–3 from Rs3166 crores in 2000–1 (that is, from roughly US$630 million down to US$500 million). The power utilities had realized average revenue per unit of Rs1.71" (3.6 UScents/kWh) "in 2002–3 against an average cost of supply of Rs2.17" (5.65 UScents/kWh) or a coverage of 78 percent.

6.8 For Maharashtra "MSEB [Maharashtra State Electricity Board] has been unable to meet the reform schedule laid down" (in the Memorandum of Understanding with the Ministry of Power). "(a) significant number of consumers (85 percent of agricultural consumers) continue to be unmetered. Further there has been no addition to the generation capacity either by MSEB or from the private sector in the last few years. This is a cause for concern in the face of mounting demand supply deficits in the state power sector" (ICRA 2004, p. 47). Evidence for daily load shedding can be downloaded from the dispatch center Web site (http://www.sidemsebindia.com), and a randomly chosen weekday in April 2005 is shown in Figure 6.4.44

6.9 Orissa is another disappointment, given that it was the first Indian state to start power sector reforms, with the passage of the Electricity Reforms Act in 1997 setting up the Regulatory Commission. "The state government has directed district administrators and police officials to support the distribution companies for curtailing frauds, theft, etc., but the actual implementation of the same had so far been quite lax. The government has not enacted the anti-theft legislation like most other majority states" (ICRA 2004, p. 90). "[P]rivate investors in distribution companies have faced steep distribution losses till OERC recognized them in 2002. OERC has

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53 PLF is plant load factor, AT&C is aggregate technical and commercial losses, GoAP is government of Andhra Pradesh
54 There are curious features of this graph that raise questions: Specifically, why does hydro supply remain high in the early hours and then fall when load is shed.
been advocating the multi-year tariff policy as per GoO directions to embark upon long-term business plans by power utilities.” Lengthy legal litigation has delayed the introduction of SERC’s tariff orders, and generation availability is 10 percent below norms. “AT&C losses were quite high at 54 percent ...” and “... long-term viability of the power sector reforms heavily depends on the state government’s support and far reaching operational improvements in distribution segment” (ICRA 2004, p. 61).

6.10 The former Minister of Power, Yoginder Alagh, who introduced the Electricity Regulatory Bill to the Lok Sabha in 1997, noted that “by early 2001, SEBs [State Electricity Boards] as a whole faced an average 50 percent level of technical plus non-technical losses, and they collectively owe around [US]$5 billion to the Government of India undertakings” (Ruet 2005a, p.13). The situation does not seem to have improved since then, with losses of the SEBs overall reported as Rs21,000 crores (about US$4.2 billion) by the prime minister in May 2005. He expressed concern over continuing electricity shortages, and argued that the power sector needed urgent reforms, including unbundling.55

6.11 These problems are not peculiar to India, although their sheer scale there dwarfs those elsewhere. Thus, Bangladesh suffered energy shortages for much of the 1990s. In the fiscal year to June 1998, the Bangladesh Power Development Board, the main electricity producer, provided uninterrupted supply on only 49 days. Much of the time, 25 percent of peak power was unserved (World Bank, 1998). Unreliable power is estimated to have led to a loss of 10 percent of industrial output. As industry accounts for 15 percent of GDP, compared to electricity at only 1 percent, the social cost of electricity shortfalls are substantially larger than just the value of the unproduced power. Only 2,400 megawatts (MW) or 77 percent of nameplate capacity of 3,100 MW was available in 1998. The plant load factor was only 55 percent, despite excess demand. The poor availability and load factors result from poor maintenance and plant derating. This situation appears to have continued, with the Energy Information Agency (EIA) reporting in August 200556 that “The World Bank has estimated that Bangladesh loses around US$1 billion per year in economic output due to power outages and unreliable energy supplies. Only two-thirds of Bangladesh’s total electric generating capacity is considered to be ‘available.’ Problems in the Bangladeshi electric power sector include high system losses (up to 40 percent), delays in completion of new plants, low plant efficiencies, natural gas availability, erratic power supply, electricity theft, blackouts, shortages of funds for power plant maintenance, and unwillingness of customers to pay bills. Overall, the country’s generation plants have been chronically unable to meet system demand over the past decade.”57

6.12 The same EIA source58 notes that in Pakistan “Rotating blackouts (“load shedding”) are, however, still necessary in some areas. Losses are about 30 percent, due to poor quality infrastructure and a significant amount of power theft. Periodic droughts affect the availability of hydropower.” The World Bank notes that in the KESC “System losses have increased from 17 percent in 1985–6 to 40 percent in 2001–2. The experiments with public sector management through non-traditional methods including the induction of army personnel in uniform as top managers since 1999 have not shown any signs of significant improvement” (Alexander, Raza, and Wright 2003). The government of Pakistan still heavily subsidizes the power sector.59 Losses

56 Available at http://www.eia.doe.gov/emeu/cabs/bangla.html.
57 Available at http://www.eia.doe.gov/emeu/cabs/pakistan.pdf.
58 The Water and Power Development Authority was reported in May 2005 as requesting Rs26 billion (nearly $US500 million) for 2004–5 (http://www.dawn.com/2005/05/04/top5.htm), while in November 2004 the Daily Times reported that the federal government had decided to pay Rs15 billion (US$250 million) “to subsidize electricity for domestic and...
in KESC have fallen a small amount since then, as have total losses for the public utilities (down to 27.6 percent for the year up to June 30, 2003, according to the *Pakistan Energy Yearbook 2003*).

**REFORMS**

6.13 The high rates of growth of electricity production shown in Table 6.1 (typically 7–8 percent per annum [p.a.]) and the high levels of unserved demand in some parts of the region (certainly in Bangladesh, India, and Pakistan) appear to require high rates of investment in generation if supply is not to become an increasing constraint on growth. State and central budgets are under stress, and the electricity companies are often effectively bankrupt, so the apparent solution has been to bring in private capital.

6.14 Under pressure from the International Financial Institutions (IFIs) and prompted by the apparent success of reforms in Latin America, many countries in the region have considered or embarked upon reform programs to allow private investment in the sector. The first step involves passing an electricity law to allow private investment, then establishing regulatory agencies to set tariffs, unbundling the natural monopoly transmission and distribution businesses, and in some cases privatizing distribution companies and some generation assets. The typical form of private participation has been by independent power producers (IPPs) signing long-term Power Purchase Agreements (PPAs) with the single buyer (normally the incumbent power company or SEB, but the standard model recommended is with a separate transmission company buying in a nondiscriminatory way from existing and new generation companies).

6.15 The results of these reforms have often been disappointing (Ranganathan 2003). Elsewhere in Asia, currency crises undermined the ability of the single buyer to honor the PPAs, which were often largely denominated in foreign currency (Newbery 2002). More generally, the tariffs needed to finance foreign direct investment (given the perceived level of risk and the short tenor of most debt finance) has led to high initial charges for electricity purchased from these IPPs. The mismatch between the cost of these new PPAs, the average cost of existing generation (with tariffs based on written-down asset values and often underpriced fuel), the lower average tariff of retail electricity, and the even lower average revenue per unit generated, placed the SEBs or their counterparts under increasing financial stress.

6.16 Ruet’s (2005a, b) analysis of the problems of the SEBs is that they currently act as administrative bodies that are unresponsive to incentives, and for whom the concept of cost do not apply. Their concept of rationality involves following procedures (particularly based on paperwork) rather than taking cost-benefit–based decisions. The lack of proper management accounting, the absence of a proper internal allocation of discretionary power (to take sensible day-to-day operational decisions), and the pre-eminence of administrative rules, makes attempts to reform the structure of incentives and property rights (through privatization) ineffective without first changing the nature of the SEBs. Of course, there are major beneficiaries from this opacity of accounting that may account for the extreme resistance to meaningful reform. Reflecting on the reforms of the 1990s, Ruet (2005, p. 206) notes “the structural reforms as

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60 In India, the required rate of return on assets was set at 3 percent in 1947, which even in real terms is well below a sensible economic rate.
envisaged by the Government of India and enforced by some States do not lead to any substantial change neither of the organization nor of the administrative nature of SEBs."

6.17 The solution Ruet proposes is "enterprisation," to be contrasted with corporatisation, which just changes the legal status of the SEBs, and which in any case would be a necessary first step toward the kind of restructuring envisaged by the reform program. The institutional changes required involve fundamental changes in management accounting, creating cash flow rights for the enterprise and allocating rights to and control over these cash flows to the relevant decentralized units, limiting the executive instructions from the state, while providing the information needed to expose corruption and clientalism.61

6.18 One central problem is that much electricity is not sold at remunerative prices, and a large fraction of customers are either not charged at all (agricultural consumers in some areas) or bills are not collected. The obvious solution is to install meters where these are lacking, to set remunerative tariffs by regulators charged to ensure that tariffs are cost-reflective and capable of financing both operations and investment of efficient companies, and then to privatize distribution companies to provide incentives to collect bills due. This strategy worked well in Chile (Galal et al. 1994), but appears not to have been successful in Orissa, where it was first tried. Apart from Ruet's diagnosis of the need to create proper enterprises before privatization (as was done in Chile in a lengthy preparation to eventual privatization), there are several serious difficulties facing distribution companies in India. Dealing with the high levels of nontechnical losses requires installing (and reading) meters, ensuring that the meters are not tampered with, ensuring that those collecting the money are not corrupt, and protecting them when reading the meters and collecting bills, and, most important, having the legal authority and actual will to cut off those not paying.

6.19 One practical problem is forecasting a realistic set of targets over time at which the nonpayment rate will be reduced (too low and the distribution company will make a windfall gain, while too stringent may cause financial distress, and an inability to make investments to reduce losses) (Ranganathan 2005). This requires sophisticated multiyear regulation (probably with profit-sharing arrangements) insulated from political pressures that keep tariffs low and provide free electricity. Here the record is disappointing, with frequent political reversals of cost-justified tariff increases. Of course, when the whole industry is fraught with over-manning, poor maintenance, poor bill collection, and other obvious inefficiencies, it is easy for politicians to argue that removing such inefficiencies would deal with losses without tariff increases, and there is some force in these arguments, as discussed below.

**OBSTACLES TO PRIVATE INVESTMENT**

6.20 The main obstacle to private investment is the fear that once the investment is sunk, it will not be allowed to earn a remunerative return. The electricity sector is particularly problematic as private investors supply an essential service directly to a large fraction of the voting population in competition with underpriced supply from the state-owned sector. As prices will have to rise to ensure that the investments are remunerative, the price rise will be associated with the reforms that brought in private investors, and will be doubly resisted on that account.

6.21 Many of the current beneficiaries of opaque accounting, cross-subsidies, patronage in the appointment of regulators and senior management, and so on will have an interest in preserving the status quo, including the low prices that deter efficient commercial competition. The fact that

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61 See also Irwin and Yamamoto (2004).
external bodies such as the World Bank are pressing for such reforms provides additional reasons for populist resistance, for the price rises that are needed to ensure investment adequacy yield current pain while the benefit of improved quality of service may be some way in the future, and beyond the politician’s invariably short time horizon.

6.22 Private foreign investors are wary of investing in hydro capacity, which is both capital intensive, with long construction periods, and often subject to water management regimes that may conflict with power generation. Coal-fired power stations can be similarly problematic where they are dependent on domestic coal, as coal mining is often fraught in terms of labor relations. Coal-fired stations using imported coal could be economically attractive but may be discouraged if there are inefficient domestic mines whose employees may object. The logical choice for IPPs is therefore gas-fired combined cycle plant using either indigenous piped gas (as in Bangladesh, Pakistan, or India), or where local gas is not available, liquefied natural gas (LNG) imports. India is increasingly turning to that source to supplement inadequate domestic gas. Petronet LNG has a 5 million tonne LNG terminal at Dahej that is being expanded to 12.5 million tonnes. Petronet is also setting up a new 5 million tonne facility at Kochi, and is also taking over completion of the 5 million tonne terminal at Dabhol (as described below).

6.23 The Dabhol power plant in Maharashtra illustrates some of the problems facing private investors. In 1992 India opened up the electricity sector to foreign investment, and officials visited the United States to encourage investors, an invitation that Enron rapidly followed up with a proposal to build a large LNG terminal to supply a combined cycle gas turbine generating station of about 2,000 MW at Dabhol, on the coast some 180 kilometers south of Mumbai. Negotiations ensued with respect to the project contracts and led to the signing of a PPA in 1993. The first phase of 740 MW was commissioned in 1997 before the LNG terminal was completed and ran on liquid fuel (initially distillate but then naphtha). The price charged by MSEB to consumers for power was less than it cost to generate power at the Dabhol plant, given the high cost of fuel and the capital costs associated with the project. As the amount of power purchased increased, the financial ability of MSEB to pay came under increasing stress, in large part because of the government of Maharashtra’s failure to effect necessary (albeit politically unpopular) reforms in the power sector, such as charging market rates for the power produced. “Payment problems with the ... MSEB, however, prompted Enron-backed Dabhol Power Corporation (DPC) to serve notice of breach of contract on MSEB in May 2001. Construction on phase II was halted in June 2001.” The resulting acrimonious dispute lasted from 2001 until July 2005, when settlements were reached between MSEB and GE and Bechtel (the surviving equity holders after the bankruptcy of Enron) of various arbitration claims.

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62 That does not stop some apparently uneconomic coal-fired stations being built. In June 2005, a consortium of the China National Machinery Import and Export Corporation and the Xuzhou Coal Mining Group Company Ltd. signed a contract to run the management and production of the Barapukuria mine in Northwest Bangladesh. The only use for such coal would be for electricity generation in a country well endowed with cheap indigenous gas. See http://www.eia.doe.gov/emeu/cabs/bangla.html.

63 Petronet is a joint venture between Oil and Natural Gas Corporation, the Indian Oil Corporation, the Gas Authority of India Ltd., the National Thermal Power Corporation, and Gaz de France.

64 There is extensive material on Dabhol: http://www.atimes.com/reports/CA13A101.html and for more recent material and an archive http://www.rediff.com/money/enron.htm. The author should declare an interest as an expert witness acting for some of the investors in DPC, which was, however, settled before going to arbitration. The text is based solely on material publicly available from the web and whose accuracy is not guaranteed, and makes no use of any confidential material that may have been seen by the author.

6.24 The successor company Ratnagiri Gas and Power Pvt. Ltd. (RGPPL) with the National Thermal Power Corporation and the Gas Authority of India Ltd (GAIL) subsequently took over the almost completed 2,148 MW plant. On September 22, 2005, the Bombay High Court issued an order on a consent term jointly filed by the DPC, RGPPL, and the IDBI Bank-led lenders. Petronet LNG was then asked by the Ministry of Petroleum and Gas to complete the LNG terminal that will supply the power plant. Effectively, what was originally the largest IPP in India has now been taken back into public ownership after a lengthy and costly dispute during which the 2,000 MW that was potentially available to deal with shortages that were typically of the order of at least 2,000 MW (see Figure 6.4 above) were not available to MSEB and the state.

6.25 Three problems compound the difficulties facing such plants in India. The first is that while GAIL sells its domestic gas at a price below import parity (that is, subsidizes it), imported liquid fuels such as naphtha and distillate are taxed. There are sound public finance principles arguing that inputs into production should not be taxed (except to correct externalities such as pollution or CO₂ emissions), and any taxes should fall on final consumers (Diamond and Mirrlees 1971; Newbery 2005). As the public power is invariably subsidized to most final consumers, it is particularly perverse to tax fuel inputs into electricity. Not surprisingly, RGPPL appealed to the Maharashtra government in October 2005 for a "waiver in sales tax and excise in a bid to maintain the per unit tariff of Dabhol phase-I (740 MW) at around Rs3.60 as against Rs2.50 by use of LNG."

6.26 The second is that LNG prices are both volatile and typically linked to oil prices, which have considerably increased in recent years, undermining the apparent attractiveness of gas-fired power stations. The third is that the energy cost of gas-fired generation can rise above that of indigenous fuels, encouraging dispatch centers to dispatch gas at lower load factors, further increasing the average cost of electricity, and straining the contractual relationship with the IPP when it is the average and not the marginal cost that is reported.

6.27 Pakistan’s experience with IPPs also dates back to the mid-1990s, under encouragement from the World Bank’s Power Sector Development Project. The Bank’s project goals included restructuring and privatization, investment, and technical assistance to improve the operations and managerial efficiency of the power system (World Bank 1994). Before that date, there was little investor interest in Pakistan's power sector after the government first allowed private investment in 1992, because of the high duties on imported equipment and the time taken to deal with the bureaucracy. In 1994 the Government published its Policy Framework and Package of Incentives for Private Sector Power Generation Projects in Pakistan. This provided an attractive formula for setting the PPA terms (according to the World Bank a bulk tariff of 6.5 US cents/kWh indexed to fuel prices, United States and Pakistani inflation, exchange rate fluctuations, operations and

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69 The case for taxing distillate, given the prevailing emissions standards, while underpricing domestic coal is perverse on environmental grounds.
70 Oil taxation is justified on a variety of grounds, of which the most relevant here are to prevent substitution of legitimately taxed road fuels, and as part of an optimal import tariff to cover the costs of maintaining security of supply. Nevertheless, there should be less distorting ways of meeting these objectives for large power station fuel supplies.
72 The situation is further complicated by the terms under which the gas is purchased. LNG contracts are typically long-term take-or-pay contracts and the relevant opportunity cost may be near zero, arguing for base-load dispatch, while the apparent energy cost may suggest that it should run only at the peak. Such confusions undermine rational discussion between IPPs, regulatory agencies, politicians, and consumers who may appeal tariff decisions and may delay tariff adjustments and reduce investor confidence.
maintenance costs, and so on), tax holidays, and a standardized security package that included model agreements. These and other incentives resulted in considerable foreign interest, and led to the development of the Hub Power Company (Hubco). Hubco built a 1,300 MW oil-fired power station located on the Hub River estuary owned by a consortium of International Power (United Kingdom), Xenal (Saudi Arabia), and Mitsui Corporation. It is described by Water and Power Development Authority (WAPDA) as "the first and largest power station to be financed by the private sector in Southern Asia and one of the largest private power projects in the newly industrialized world."

6.28 The Hubco project, completed ahead of schedule and on budget (US$1.6 billion) in 1997, was structured through four detailed agreements following the standardized model: the PPA, the Fuel Supply Agreement, the Implementation Agreement, and the Operations and Maintenance Agreement. These four key agreements formed the security package against which project funding was secured. In 1998 a tariff dispute caused the suspension of all dividend payments for a three-year period until it was resolved in December 2001. Shares in the company are locally traded, allowing the foreign investors to withdraw equity and invest in other power projects. Thus International Power had cut its holdings in Hubco from 26 percent to 16 percent by May 2004 but recently acquired 40 percent equity stake in the 586 MW Uch Power project, a 400 MW dual-fired project to supply the textile industry in Faisalabad.

6.29 Reforms of the state-owned companies continue, and WAPDA has recently been unbundled "in an attempt to create a more competitive, market-oriented environment." However, "Due to weak investor interest, KESC was not privatized as planned during 2002 and the process of unbundling WAPDA, although formally completed by December 2003, has not yet created the needed financial and managerial autonomy" (World Bank 2004). WAPDA continues to control all financial flows in the sector, including practically all decisions on allocation of funds, while non-technical losses and subsidies remain. KESC was reported to be finally privatized by the Daily Dawn on February 22, 2005, although the deal fell through, and the cabinet then approved the sale of 73 percent to the second highest bidder, Hassan Associates. The sale was finally signed on November 19, 2005.

6.30 Investors appear to have responded positively to the Private Power Investment Board's announcement of three large power projects, "including a proposal from AES to develop a US$1 billion coal project in Thar, and the announcement of increased investment to the tune of US$1 billion from CDC Group's Globeleq, which already owns 50 percent of the Lahore-based Orient Power." In addition, if the government finds enough uninterruptible gas, Hubco may be allowed to build two gas-fired power generation plants (of 300 and 600 MW) at Karachi. Whether these positive responses will translate into investments will in part depend on resolving the sector's chronic financial problems.

6.31 Bangladesh has also been successful in attracting foreign private investment in electricity generation. According to EIA, "Given Bangladesh's electricity supply shortage, in 1996 the government issued the Private Sector Power Generation Policy of Bangladesh and began to solicit proposals from international companies for IPPs. Among the first IPPs were a 360-MW gas-fired combined-cycle plant at Haripur, which began operation in October 2001, and a 450-MW gas-

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73 WAPDA was created in 1958 and is one of two vertically integrated state-owned electricity companies, the other being KESC, which serves only Karachi and surrounding areas. Together, WAPDA and KESC transmit and distribute all power in Pakistan, more than half to household consumers. See http://www.hubpower.com/n/about.html.
fired combined-cycle plant at Meghnaghat, which began operation in November 2002. Both plants were sold to the British firm CDC Globeleq in December 2003. India’s Bharat Heavy Electricals Ltd. completed a 124-MW gas-fired Baghabari generating unit in November 2001.  

6.32 It is worth asking why Bangladesh (and to some extent Pakistan) appear to have been more successful than India in continuing to attract foreign private investment. The case of Bangladesh is particularly interesting as it was, according to Transparency International, the most corrupt country in the world in 2005. The most obvious reason is that indigenous gas is cheap, and Bangladesh was lucky in attracting AES to invest. AES is a company noted for its enthusiasm to build power stations in risky parts of the world supported by PPAs with very reasonable terms. The combination of cheap gas, moderately cheap capacity charges and excess demand for power made the project attractive both to the investor and also to the government. Unfortunately, AES’s share price fell from a peak of $70 in 2000 to less than $2 in 2002, forcing asset sales, and making expensive foreign ventures both unattractive and infeasible. It is perhaps noteworthy that AES sold to CDC Globeleq, which has a mission to help developing countries improve their power sectors, and may not be the best test of commercial willingness to invest in the depressed post-2000 power sector investor climate.

6.33 If Bangladesh has the advantage of cheap gas, then Pakistan, which appears to have some 33 years of reserves at current rates of consumption, also might expect to be attractive to gas-fired private generation investment, but reliable supplies of the required volumes appear to be problematic. It is hardly surprising that an oil-fired plant like Hubco (using expensive imported fuel) experienced difficulties over the tariff, although it is not clear to what extent the domestic cost of fuel oil is insulated from world oil price movements. Given that domestic consumers are still heavily subsidized, and nontechnical losses remain high (losses had only fallen from a high of 41 percent in 2002 to 38 percent in 2004, when KESC was to be privatized), one must be cautious in judging whether the apparent recent interest in private investment reflects confidence in the reform program or reassurance that the model agreements will adequately protect investors. The fact that the army was called in to manage KESC in 1999 may indicate that there is more evidence of political commitment to reform than in India, although as noted above their arrival in 1999 did not noticeably improve KESC’s performance.

6.34 To summarize, private investors need confidence that the necessary contractual underpinnings (PPA, fuel purchase agreements, sovereign guarantees, and so on) will be honored, that any legal disputes will be settled rapidly and fairly, with appeal to expeditious international arbitration, and that the underlying causes of disputes (inability of the counter party, either the single buyer, SEB, or the distribution companies to pay because of inadequate revenue) will be sustainably addressed. Opening access to the national transmission grid is one obvious step to reduce reliance upon populist-swayed state governments and bankrupt SEBs, providing there is enough transmission capacity and a sensible way of pricing access and use, and providing large customers can secure reliable power as a result (which may require direct connection to the grid rather than to the local distribution network). The Indian Electricity Act 2003 requires

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78 India was ranked 88 out of 159 and Pakistan is ranked 144.
79 The Commonwealth Development Corporation (CDC) was set up in 1948 as the U.K. government’s instrument for investing in the private sector in developing economies. In 2002, CDC launched Globeleq, an operating power company solely focused on the emerging markets of Africa, the Americas, and Asia.
80 “Improvement of the availability and quality of power supply in Karachi is a priority for the government of Pakistan. To facilitate this, management control of the company (KESC) was handed to the army in 1999. The army management has made progress in a number of areas, such as reductions in commercial losses, decreases in accounts receivable, and restructuring of the organisation aimed at increasing the quality of customer services and the profitability of the company.” The Dawn (2005).
nondiscriminatory open access in transmission and the adoption of multiyear tariff principles, while the creation of the Power Trading Corporation in 1999 is gradually increasing power exchanges between state utilities and private generators, reaching 4.2 TWh in 2002–3 (Singh 2006). The five regional grids are interconnected with high voltage DC lines with a capacity of 5,000 MW (4 percent of installed generation capacity) and interregional transfer capacity is 9,450 MW carrying 12 TWh. POWERGRID has plans to increase this to 37,150 MW by 2012. If these principles are effectively implemented, they will go some way to improving a commercial approach to the sector, although reforming the distribution companies remains critical.

6.35 If anything, private involvement is far more important in the distribution sector than in generation, for without commercial distribution charging cost-reflective tariffs, the counter parties to any power contracts will be financially weak and the PPAs will lack the credibility needed to attract private investment into generation. Reforming the distribution companies therefore has high priority. There is general agreement that sustained improvements will require privatization, although preparing the companies or boards for privatization requires considerable care, not least in ensuring adequate information (from metering, management budgetary systems, and so on) is available to regulators and investors before final privatization, to avoid costly mistakes and painful policy reversals (Ranganathan 2005; Ruet 2005a).

ALTERNATIVE SOURCES AND USES OF INVESTMENT FINANCE

6.36 Foreign private investment in power has a major advantage but one obvious disadvantage. The advantage is that it brings best practice in terms of contracting and efficiency (both in construction and operation) that puts pressure on the country’s electricity supply industry to shape up, make necessary reforms, and establish sensible regulatory bodies and tariff-setting practice. The model agreements proposed by Pakistan, and insurance against opportunistic tax and legal changes, may provide a good model, but will have to be supported by evidence of enforcement. There is ample evidence from elsewhere that private ownership delivers more efficient construction and operation than state ownership. The disadvantage is that the cost of finance is likely to be high, as sovereign and regulatory risk are perceived as high. If a larger fraction of the finance could come from low cost debt finance (supplied either by the government through its state banks or IFIs, with suitable exchange rate guarantees), then the overall cost of finance will fall (although the equity component is still likely to be costly, its share may be low enough to reduce the overall cost).

6.37 Some South Asian governments have now accumulated considerable foreign exchange reserves that allow both increased domestic lending and foreign exchange rate guarantees, although it still ought to be preferable to agree conditions under which IFI finance becomes available, as this is likely to give better signals to the private investment community. Clearly, the lending by India to Bhutan to finance dams (discussed below) suggests that public funds can be used effectively; and for high capital cost low running cost projects such as dams and transmission, cheap finance can be critical to economic success.

6.38 The central problem in making use of this cheaper finance is that unless the distribution companies are reformed to become commercial and regulated to set (and collect) cost-reflective tariffs the revenue flows even to service cheaper debt will be lacking. If capital (including the revalued modern equivalent asset value of existing plant) earns a sensible return (8–10 percent

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82 This requires PPAs that reward capacity availability and pass through energy costs at a specified energy efficiency to encourage efficiency operation, to give sensible average and marginal cost signals to the dispatch center.
real) then the electricity supply industry would become largely self-financing at current demand growth rates (from Table 6.1 of 7–10 percent). If power were sensibly priced, then excess demand might rapidly disappear, providing the time and resources to improve maintenance and availability, further reducing costly load shedding. The paradox is that without reforming distribution (which will eventually require privatization to sustain the reforms) private investment in generation may fail, and with effective reform in distribution and a more intelligent approach to losses, private finance in generation may not be necessary (although good practice management and operations still argue for private ownership or at least management).83

6.39 Ruet (2005b) has demonstrated most effectively that finance should not be a constraint by comparing the profitability of investing in new generation capacity (and the associated transmission) in India with alternatives. He estimates that eliminating nontechnical losses at 2002 tariff levels would give an internal rate of return (IRR) of 339 percent, compared with new generation yielding 8.6 percent, although increasing the plant load factor (PLF) from 67 to 70 percent would reduce the amount of new capacity required and would deliver an IRR on the total investment needed of 13.4 percent. Just investing in refurbishment and maintenance to raise the PLF alone yields 116 percent return, while investing in better transmission and distribution to reduce technical losses yields 27 percent return. The implication is that much can be done to bridge the supply-demand gap with less finance than just building more generation capacity. If existing resources can be reallocated to reduce various losses, then considerable extra cash flow would be generated to expand the system when needed, but this will require a radical change in management culture in the SEBs.

THE ROLE OF ENERGY TRADE

6.40 The Agreement on the South Asian Free Trade Area was signed on January 6, 2004, to enter into force on January 1, 2006. However, progress seems somewhat troubled as Bangladesh on August 8, 2005, “once again outright rejected an Indian proposal for signing Free Trade Agreement (FTA) with her, urging the counterpart to sign the proposed South Asia Free Trade Agreement (SAFTA) for boosting the regional trade and commerce.”84 Counterbalancing this, on August 15, 2005, the Indian Express announced plans for promoting trade between India and Pakistan via a free trade area in Kashmir. “In a radical proposal to end the current Indo-Pak conflict over water resources of J&K (Jammu and Kashmir), Burki is calling for joint development of the power potential of the Indus waters that run through the state. Instead of separately developing hydel power in their own parts of J&K and raising suspicions across the border, Burki proposes joint generation of hydel power for use in both parts of J&K and selling the surplus to northern Pakistan and India through a common electric grid. Such an approach, according to Burki, does not involve either a renegotiation of the Indus Waters Treaty or a reduction of water flows to either India or Pakistan. It needs a mutually satisfactory reinterpretation of the treaty and negotiating a subregional agreement on hydel power generation and distribution.”85

6.41 The potential for mutually advantageous energy trade in South Asia is considerable. India is short of indigenous gas and is actively importing expensive LNG. Bangladesh has substantial reserves estimated by the Oil and Gas Journal in 2005 at 10.6 trillion cubic feet (Tcf) and net proven reserves estimated by Petrobangla in 2004 at 15.3 Tcf, compared with a 2003 production (and consumption) of 420.2 billion cubic feet. At that rate based on Petrobangla’s estimate,
reserves would last 36 years, although if demand grows at a projected 6 percent p.a. the reserves would only last 19 years. In addition to proven reserves, the U.S. Geological Survey has estimated that Bangladesh contains 32.1 Tcf of additional “undiscovered reserves,” which would increase the ratio of reserves to use to over 100 years or nearly 50 years at a growth rate of 6 percent. On the other hand, Bangladesh has been suffering from gas shortages, despite these abundant gas reserves. The immediate cause is a combination of underpricing, poor collection rates, and theft, which have created serious financial shortfalls, and hence an inability to finance the required maintenance and investment. The deeper cause is poor management and extensive political interference in tariff setting and reform efforts. The fundamental problem is one of pervasive corruption, in turn sustained by a lack of political accountability.

6.42 Bangladesh is short of foreign exchange and government revenue, both of which would be significantly enhanced by exporting gas to India, ideally by pipeline to the Delhi area where electricity demand is high (in comparison to the adequate supply of coal-fired generation near the India-Bangladesh border). Finding an outlet for exported gas priced in foreign exchange would encourage more gas exploration and development. It is therefore particularly perverse that both major political parties are officially committed to reserving gas for domestic use until “proven reserves will cover 50 years of domestic demand.” One confidence-enhancing step might be to allow transit gas from Burma to India via Bangladesh, and this is under discussion.

THE CASE FOR A SOUTH ASIA ENERGY CHARTER

6.43 Energy trade requires costly infrastructure that can be stranded without continuing cooperation, so the case for some legally binding treaty underwriting assurances on continued cooperation is strong. The European Energy Charter signed on December 17, 1991, might form a useful model to promote such trade. The 51 signatories agreed to cooperate under a legally binding Energy Charter Treaty “designed to promote east-west industrial cooperation by providing legal safeguards in areas such as investment, transit and trade.” The proposed gas pipeline from Burma to India might encourage the signing of an Energy Charter and if Bangladesh believed that Burmese gas could supplement domestic gas in future if local supplies proved inadequate, then the deadlock over Bangladesh gas exports might be broken.

6.44 Similarly, India would then have access to two additional sources of gas (although both coming through Bangladesh) and would feel greater security of supply. A similar transit proposal to deliver gas from Iran through Pakistan to India would have the further advantage of securing additional gas to meet Pakistan’s rapid growth in demand for power generation, although again mistrust between the two countries (and United States hostility to trade with Iran) have hampered progress. Again an Energy Charter guaranteeing security of transit might break the deadlock. According to the EIA, Pakistan could earn US$600 million p.a. in transit fees from this US$3 billion project.

6.45 Apart from the obvious benefit that India should enjoy cheaper additional supplies of gas than from LNG imports and more diverse and thus more secure sources of supply, there are further benefits from the kinds of agreements, treaties, and contracts needed to underwrite gas imports. Most obviously (and this is also a potential benefit from LNG imports), the gas would be priced in foreign exchange at market levels, and would provide pressure to set fuel and electricity

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87 It is cheaper to move gas than transmit electricity, hence the preference for a pipeline.
prices at market levels. Second, and perhaps more important in the longer run, it ought to encourage a more commercial approach to contracts in the energy industries, and that would provide the kind of comfort that foreign private investors seek. That in turn should lower the cost of capital, which in capital-intensive industries such as electricity, feeds straight through to consumer (and creditor) benefits. Third, gas (particularly pipeline gas) has lower CO2 emissions per unit of electricity generated than coal or oil. At some stage this will have a cash benefit when emissions trading is extended more widely. Finally, creating a regional gas market with proper pricing would encourage private investors to develop indigenous gas fields, and might eventually lead to gas-on-gas competition (as occurred in the United States and Britain) to mutual benefit.

6.46 The other major potential source of mutually beneficial trade relates to the more efficient exploitation of hydro resources, particularly in Nepal and Bhutan, where domestic electricity demand may be inadequate to justify large dams, but where exporting electricity to India would earn valuable foreign exchange and relieve India’s power shortages in a zero-emissions way. Nepal has large untapped hydro potential, estimated by EIA at 43,000 MW (of which 244 MW has been developed). Promisingly (at least from the viewpoint of regional energy cooperation), in October 2002 “Australia’s Snowy Mountains Hydro signed a Memorandum of Understanding for the development of the 750-MW West Seti hydroelectric dam. It is scheduled for completion in 2005 and will export power primarily to India. Renewable power sources are increasing in Nepal through rural electrification programs which aim to lessen the disparity in electricity access between rural (30 percent) and urban (90 percent) areas. The overall quality of Nepal’s electricity infrastructure, however, is low and is frequently a target for attack by Maoist rebels.” In 2003, Nepal’s industrial sector was reported as losing US$25 million annually, 4.4 percent of its gross output value. If hydropower were developed for export, the annual contribution to GDP could rise from $96 million in the early years up to US$1.51 billion by 2027. By 2010 royalty earnings at 10 percent of electricity sales would yield US$46 million p.a. and rising (USAID, n.d.).

6.47 Bhutan’s hydropower potential is estimated by EIA at 30,000 MW (of which 16,000 MW are safe and exploitable). Bhutan and India have been actively cooperating in its exploitation since the signing of the Jaldhaka agreement in 1961, and hydroelectric exports are the largest single source of foreign exchange, demonstrating the value of such regional cooperation. According to Bhutan News Online, “the Chukha Hydro Power Corporation has been earning more than 40 percent of the national (government) revenue of Bhutan.” Exports in 1995–6 were 1,564 GWh, and are projected to rise to 6,400 GWh in 2006 when the 1020 MW run-of-river Tala Hydroelectric Project Authority is commissioned. “India’s Tata Power Company and the Power Grid Corporation of India Ltd. have formed a partnership to construct the 1,020-MW Tala hydropower project in Bhutan and a 750-mile transmission line to export power produced by the Tala project to New Delhi and surrounding areas of India.”

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92 As always, large dams attract considerable criticism, and there are particular concerns that a high (195 meter) rock-filled dams might be unsafe in such a geologically active area. See http://www.nepalnews.com.np/contents/englishweekly/spotlight/2004/dec/dec31/opinion.htm and http://www.dams.org/kbase/submissions/showsub.php?rec=soc031.
6.48 Clearly it would be desirable to develop a regional electricity grid connecting India, Bhutan, Nepal, and Bangladesh to increase security, allow profitable exports from land-locked countries, and further build confidence in regional energy trade and investment. The Bhutan example shows what can be achieved, although the political obstacles remain significant. The USAID (n.d.) study reports estimates of the benefits of a regional grid in reducing power losses by 90 MW (sic), saving US$79 million in investment.

CONCLUSIONS

6.49 South Asia started the 1990s with growing disillusionment with the existing inefficient and bankrupt state-owned vertically integrated electricity supply industry and strong internal and external pressure to reform the sector. The incompletely understood diagnosis was to encourage private investment to overcome the lack of finance for the investment needed to address shortages and power cuts. The simplest route appeared to be to allow IPPs to sell power under PPAs to the largely unreformed SEBs.

6.50 Buying increasing amounts of higher cost power when these SEBs could not even cover the cost of underpriced wholesale electricity from state-owned generators was a recipe for financial distress and conflict. Reforming the SEBs, through unbundling, creating commercial disciplines in retailing electricity, and subjecting the sector to multiannual regulation insulated from clientalist political pressures, is therefore an essential first step, although one that was bound to be keenly resisted by current beneficiaries. When this has been successfully completed, privatization is the logical next step to ensure that the reforms are sustainable (Ranganathan 2005; Ruet 2005a). With commercially viable privatized distribution companies successfully operating under multiannual cost-reflective tariffs, the way is open for more sustainable private investment in generation.

6.51 In India the central government appears to have relatively few effective levers with which to reform the SEBs, although the Electricity Act 2003 has good intentions, particularly in requiring metering, multiannual regulation, and requiring regulated third-party access to large customers through the national transmission grid. Elsewhere, central governments may have more control and may even use that wisely to press for effective reform, although progress appears to be slower than expected.

6.52 Perhaps the main leadership role that governments in the region could contribute would be to agree and enforce a regional energy charter to underwrite increased energy trade. Such steps have been effective in integrating the transition countries of Central Europe into the European Union, and stimulating foreign direct investment into the power sector, and might have similarly stimulative effects in South Asia, quite apart from creating profitable trade opportunities and increasing regional security of supply and greater resilience against external oil shocks. Opening access to industrial customers would help assure the financial viability of investments in cross-border infrastructure.
Table A.1: Energy Supply Indicators: South Asian Countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Crude oil, (million barrels)</th>
<th>Dry natural gas, (trillion cubic feet)</th>
<th>Coal, (billion short tons)</th>
<th>Petroleum, (thousand barrels per day)</th>
<th>Dry natural gas, (trillion cubic feet)</th>
<th>Coal, (million short tons)</th>
<th>Electric generating capacity, (million kilowatts)</th>
<th>Crude oil refining capacity, (thousand barrels per day)</th>
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</thead>
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<tr>
<td>Bangladesh</td>
<td>56.0</td>
<td>10.6</td>
<td>0</td>
<td>5.0</td>
<td>.38</td>
<td>0</td>
<td>3.6</td>
<td>33</td>
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<tr>
<td>Bhutan</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.06</td>
<td>0</td>
<td>0.4</td>
<td>0</td>
</tr>
<tr>
<td>India</td>
<td>5,371.2</td>
<td>30.1</td>
<td>93.0</td>
<td>661.8</td>
<td>.88</td>
<td>392.6</td>
<td>120.3</td>
<td>2,135</td>
</tr>
<tr>
<td>Maldives</td>
<td>0</td>
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<td>0</td>
<td>0.01</td>
<td>0</td>
<td>0.03</td>
<td>0</td>
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<tr>
<td>Nepal</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.01</td>
<td>0</td>
<td>0.4</td>
<td>0</td>
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<tr>
<td>Pakistan</td>
<td>288.7</td>
<td>26.8</td>
<td>2.5</td>
<td>60.9</td>
<td>.81</td>
<td>3.7</td>
<td>18.0</td>
<td>269</td>
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<tr>
<td>Sri Lanka</td>
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<td>0</td>
<td>0</td>
<td>0.01</td>
<td>0</td>
<td>2.1</td>
<td>48</td>
</tr>
<tr>
<td>Total</td>
<td>5,715.9</td>
<td>67.5</td>
<td>95.5</td>
<td>727.7</td>
<td>2.07</td>
<td>396.4</td>
<td>144.8</td>
<td>2,485</td>
</tr>
</tbody>
</table>


a. Includes crude oil, natural gas plant liquids, other liquids, and refinery processing gain.

The Relationship between Electricity Consumption and GDP

6.53 Figure A.1 shows the scatter plot of the three-year average values of per capita annual electricity consumption against the corresponding three-year average values of per capita GDP at constant 1995 US$, plotted on a double log scale, together with the regression line of best linear fit and the evolution of the annual per capita annual electricity consumption against the corresponding annual values of per capita GDP (US$1995) for selected South Asian countries, China, and the United States. The value of $R^2$ is 0.8 and the slope coefficient is 0.98 (s.e. = 0.03), not significantly different from 1, so that the income elasticity of demand for electricity is unity. The quadratic regression shown has a slightly higher $R^2$ of 0.81 and both GDPpc and GDPpc squared terms are significant at the 1 percent level, but if anything this regression line suggests that India and Pakistan are even more electricity intensive than might be expected.
6.54 Figure A.2 repeats the exercise but using real or PPP GDP per capita from the Penn World tables which gives a slightly better fit \( R^2 = 0.85 \) but a considerably higher PPP income elasticity of 1.63 (s.e. = 0.04), reflecting the higher ratios of real to market GDP at lower income levels. The quadratic terms are not significant. The obvious reason for the higher elasticity is given by noting that a regression of ln(RGDP) on ln($GDP) has a coefficient of 0.6; that is, ln(RGDP) = 3.84 + 0.6*ln($GDP), or \( Y/L = (R/L)^{1.66} \) explaining the higher PPP elasticity exactly. The regression results are used to predicted South Asia consumption in Figure A.2

Figure A.2: Electricity Demand as a Function of Real GDP/Head

Electricity Consumption v RGDP per head averages

6.55 Figure A.3 shows the importance of price in influencing electricity demand. The cross country partial regression has \( R^2 = 0.9 \) and a price elasticity of -1.2 (s.e. = 0.11). Figure A.4 shows that this relationship continues to hold for nonindustrial consumption \( (R^2 = 0.83, \text{ and a price elasticity of -1.04, s.e. } = 0.15) \).
Figure A.3: The Relationship between Price and Electricity Consumption for Developed Market Economies and Transitional Countries

Electricity consumption and price 1993

Figure A.4: The Relationship between Nonindustrial Electricity Consumption and Price
6.56 Good electricity price data are not readily available, but if effective retail prices should be raised by 50 percent to address losses and underpricing of wholesale power, then demand might (eventually) fall by about 50 percent, and would return India and Pakistan to the regression line in Figure A.1.

6.57 Note that both Bangladesh and Nepal fall considerably below either regression line, even though there is no reason to believe that pricing is higher in those countries than in India and Pakistan. The obvious explanation is that electricity penetration is considerably lower than in those two countries, and the movement toward the regression line probably reflects increasing coverage of the population.