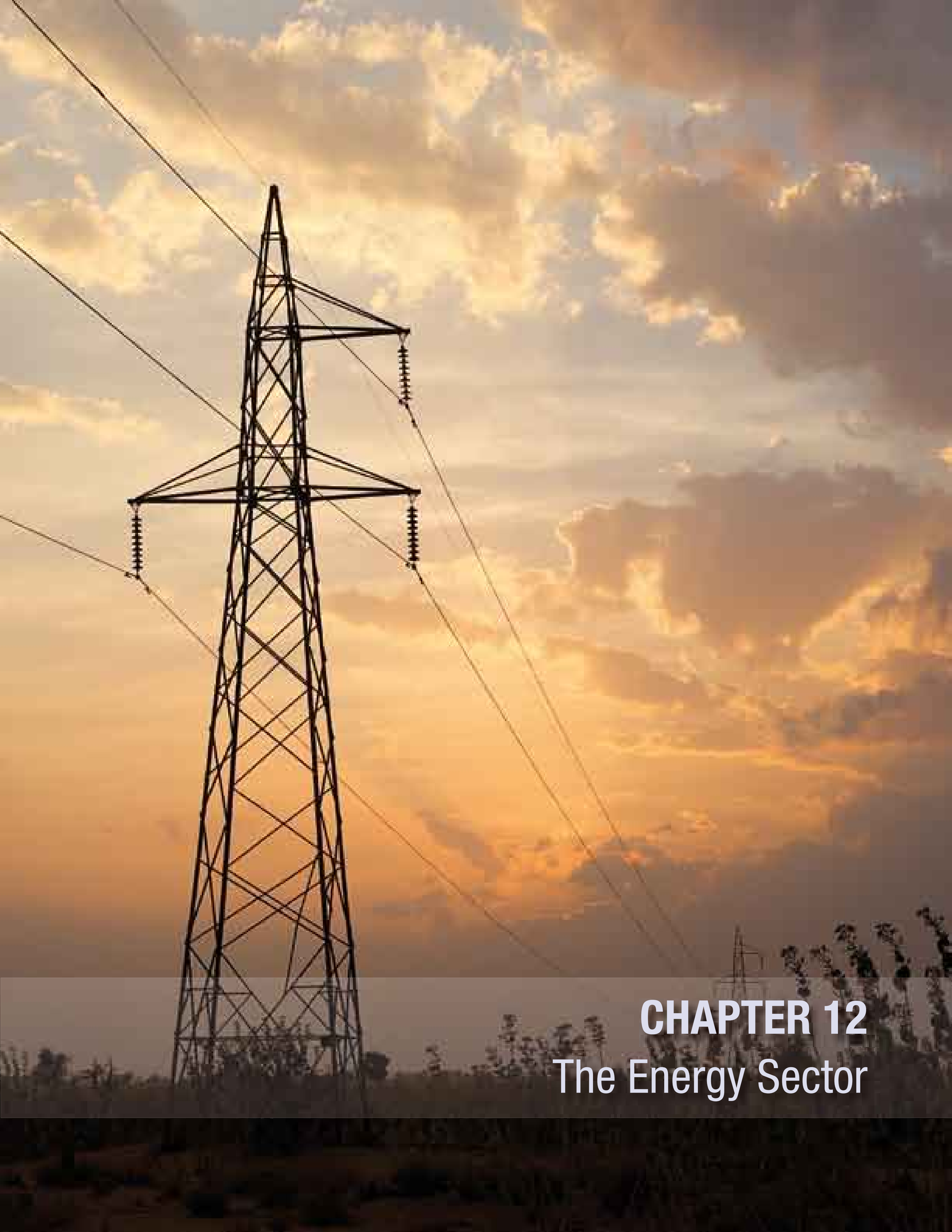

CHAPTER 12
The Energy Sector

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Buoyant economic growth in the past decade has fuelled an insatiable thirst for energy in South Asia. Rising energy demand is driven by urbanization, industrialization, and prosperity, all of which are parts of a broader process of development that is lifting millions out of poverty. However, increased energy consumption has been accompanied by rising greenhouse gas emissions. On average, emissions have risen by about 3.3 percent annually in the South Asia region since 1990, more rapidly than in any other region except the Middle East and North Africa. Total emissions exceed 2.5 billion tons of carbon dioxide equivalents and the region has emerged as one of the major contributors to global GHG emissions. As the region strives to meet its development goals, the potential for further growth in emissions is enormous. More than 400 million people in the region have no access to electricity, more than in all of sub-Saharan Africa. How the region meets these demands will have far-reaching consequences on global greenhouse gas emissions.

Reflecting the size of its economy, population, and territory, India remains the largest contributor to GHGs in the region, accounting for about 75 percent of emissions. Consequently, greater attention is focused on India in this chapter. Though globally India is the seventh largest emitter of greenhouse gases,[77] it has low per capita emissions and low-carbon intensity. In terms of emissions per unit of GDP,[78] India remains an exceptionally low-intensity producer of CO_2 emissions. Per capita emissions in India, and the region as a whole, are low by international standards. In India, per capita energy consumption is less than 10 percent of the average of the OECD and about one-half the average for developing countries. Of the remaining seven South Asian countries, the following discussion mostly concerns Bangladesh, Pakistan, and Sri Lanka, where incremental emissions could be globally significant but where future emission paths can potentially be influenced. The energy outlook and energy options available to these countries are discussed in detail in the following section.

South Asia Region: Energy Outlook and Options in Selected Countries

India

Coal is the backbone of the Indian energy sector. India has about 38 billion tons of oil equivalent of proven coal reserves (approximately 207 years

76 Authors in alphabetical order: Jeremy Levin and Alan F. Townsend.

77 See Figure 2.5.

78 When GDP is measured either by purchasing power parity or nominal exchange rates.

reserve life[79]), the third largest in the world after the United States and China. Though coal is abundant, it is of low calorie and high ash content and, therefore, highly polluting. Currently, about 70–80 percent of the country's electricity is produced from coal. Poor-quality coal, aged legal framework, low levels of plant efficiency, and an ageing capital stock combine to make the power sector highly carbon intensive. Average emissions in Indian power plants are significantly higher than the global average.[80] Transmission and distribution losses are a further drain on system efficiency and may exceed 20 percent in some states, well above global best practice (Government of India, Press Information Bureau 2001). Consequently, energy-efficiency opportunities exist to reduce the carbon intensity of power production while simultaneously increasing electricity supply.

Strategies to lower emissions by diversifying into cleaner sources of power are constrained by the country's energy resources and import possibilities. India is not well endowed with reserves of cleaner fuels such as oil, gas, and uranium.[81] Hydropower potential is significant and large in absolute terms (150,000 megawatts) but small compared to the country's vast energy needs. In addition, there are possibilities for importing about 50,000 megawatts of hydropower from Bhutan and Nepal, and perhaps as much as 20,000 megawatts of wind power from Sri Lanka. However, even when exploitation of hydropower is technically feasible, there are social and environmental concerns to take into consideration, and there remain difficulties in establishing transboundary energy trade agreements. Hydropower development is also made more complex by glacial melting, which increases the medium- and long-term hydrological risk associated with such investments.

Under most plausible scenarios, detailed assessment by India's Planning Commission suggests that coal is expected to remain the dominant fuel used for power generation, even under the most optimistic scenarios. Renewable energy sources (including wind, solar, and hydro power) and nuclear power would play a minor role in the country's energy mix (Box 12.1). For India, transformational climate-change interventions would therefore need to increase the efficiency of coal use through migration to more efficient technologies. In parallel, other future technology options such as mass solar power should be pursued, as has been suggested in the India National Action Plan on Climate Change (Government of India, Prime Minister's Council on Climate Change 2008). To be truly transformational, such supply-side interventions would need to be complemented by energy-efficiency initiatives, so that growth in overall energy demand is better managed. Box 12.2 illustrates the energy mix under alternative scenarios and reinforces the likely importance of coal in the energy mix.

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[79] Reserves/Production (R/P) ratio: If the reserves remaining at the end of the year are divided by the production in that year, the result is the length of time that those remaining reserves would last if production were to continue at that rate. BP Statistical Review of World Energy 2009, http://www.bp.com/productlanding.do?categoryId=6929&contentId=7044622, accessed October 22, 2009.

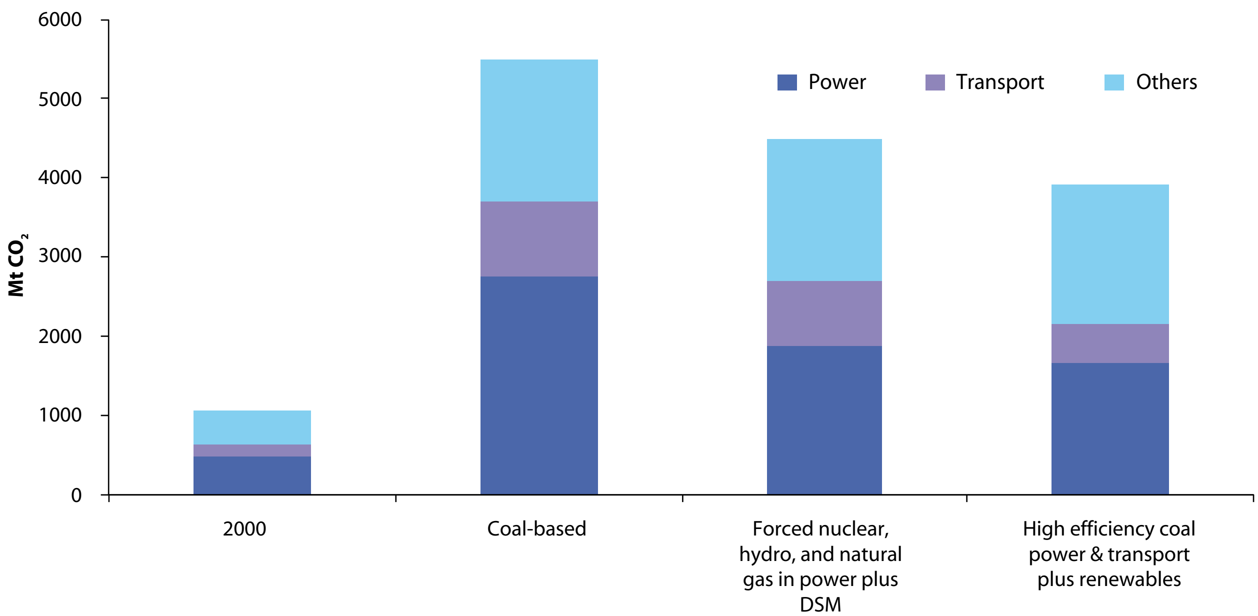
[80] With emissions from the power sector of roughly 750 grams of CO_2 per kilowatt, India's power sector is, for instance, 50 percent more CO_2 intensive than the United Kingdom's. (Government of India, Ministry of Power, Central Electricity Authority, 2007; H.M. Government, UK, Department of Trade and Industry 2007).

[81] In 2005–06 oil reserves were estimated at 786 metric tons and gas reserves are 1,101 billion cubic meters (Government of India, Planning Commission 2006).

Box 12.1 India's Supply Options for Lowering Emissions: Planning Commission Estimates

India's Planning Commission has explored possibilities for energy diversification to meet the demands of a rapidly growing economy. The figure below presents estimates for three scenarios in 2031. The economy is assumed to grow at 8 percent on average, which in turn implies more than a tripling of energy needs. In the business-as-usual scenario, more than 60 percent of generation is coal based. In this case, by 2030, India's emissions approach those of the United States today (approximately 6,000 million tons). The forced nuclear, hydro, and natural gas scenario and the high-efficiency coal, power, and transport plus renewables scenario are the most optimistic cases and are useful in illustrating limits and possibilities. These assume that all available hydropower potential (150,000 megawatts) is exploited, nuclear capacity increases at an optimistic pace, demand-side management reduces demand by 15 percent, and at least 11 percent of generation is from gas, irrespective of price differentials. Even in the most optimistic scenario, coal remains a dominant fuel, accounting for more than 40 percent of the mix, though emissions decline somewhat to about 4,000 million tons. The implication is clear: Under any plausible setup, coal is likely to dominate and other fuels will play a lesser role, even under extreme assumptions that are very favorable to the growth of those alternatives. Consequently, a clean energy effort must aim to lower emissions from coal.

India's CO_2 Projections in the Integrated Energy Policy Report



Fuel Type	Coal Scenario (million tons oil equivalent/%)	Forced Scenario (million tons oil equivalent/%)	High-efficiency Coal and Transport plus Renewables
Oil	467 (28%)	467 (34%)	406 (29%)
Gas	114 (7%)	164 (11%)	168 (12%)
Coal	1,082 (65%)	658 (45%)	573 (42%)
Hydro	0	50 (3%)	50 (4%)
Nuclear	0	89 (6%)	89 (6%)
Other	< 1	0	89 (6%)

Source: Government of India, Planning Commission 2007

Box 12.2 Emissions from Coal and Natural Gas

Addressing coal's market share is one way to lower the emission footprint of the energy sector. The table below summarizes conventional emission standards. The carbon advantage of natural gas is plainly evident, with combined-cycle plants having just more than 33 percent of the carbon emissions of a conventional coal-fired plant (assuming the conventional coal-fired plant is efficient). The advantage of supercritical and ultrasupercritical technology versus conventional coal is also evident, given India's dependence on coal. Yet with its increasing need to import coal supplies to meet growing demand, it is easy to see why India is so keen on increasing efficiency of coal use in the power sector.[82]

Technology and fuel Combinations	Kilograms of CO_2 emissions per Megawatt-hour	Annual tons of CO_2 per 1,000 Megawatts at 70% load Factor[a]
Natural Gas		
Simple Cycle	600	3,679,200
Combined Cycle	360	2,207,520
Coal		
Conventional	1,000	6,132,000
Supercritical	900	5,518,800
Ultrasupercritical	800	4,905,600

a. Load factor: A measure of the output of a power plant compared to the maximum output it could produce.

The table suggests that low-emission "near-zero" technologies will also be very attractive and will have significant carbon advantages, even compared to efficient natural gas. These technologies or approaches include nuclear and hydro power, nonhydro renewable, reduced loss during transmission and distribution, and increased energy efficiency. In all of these cases, a kilowatt-hour that is not generated from conventional coal (for the major South Asian markets, the default technology at this time) has a carbon benefit equal to 1 ton of CO_2 per megawatt-hour of generation. It should also be stressed that most of India's installed, operating coal-fired capacity is less efficient that the conventional coal baseline shown in the table. The 1,000 kilogram per megawatt-hour standard used in the table represents an efficiency of roughly 35 percent. However, in the state electricity board, there are plants operating at efficiencies of only two-thirds of that.

Sources: International Energy Agency, Energy Information Administration (US DOE), National Thermal Power Corp. (NTPC), BP Statistical Review of World Energy June 2008, World Bank estimates

Bangladesh, Nepal, and Pakistan

Because of the cost advantage of coal and the relative security of the fuel supply streams, Bangladesh, Pakistan, and Sri Lanka will increasingly see coal emerge as the front-running fuel for incremental generation of power. Bangladesh and Pakistan have substantial, unexploited coal reserves (albeit of dubious quality and difficult to extract), and Sri Lanka has unfettered access to global coal markets. The risks around investment in coal-fired capacity are perceived as being lower than those of alternative power sources, and the overall cost of the delivered power is competitive versus other options, based on prevailing market prices for coal and competing fuels. This suggests that there is a need for more active and extensive interventions to tilt the balance in favor of cleaner technologies. To the extent that these countries can delay the next generation of coal-fired plants under consideration, the carbon savings would be substantial, perhaps as much as 3 million tons per year per 1,000 megawatts of capacity, if it is assumed that the alternative to coal is natural gas.

For Pakistan, the alternative to coal is likely to be natural gas imported from its oil-rich neighbors in the Middle East and Central Asia. Pakistan shares a land border with the world's second-largest holder of gas reserves, Iran. In Sri Lanka, the

[82] Supercritical and ultrasupercritical technologies operate at higher temperatures and pressures than conventional coal-fired technologies, increasing efficiency.

alternative source of supply would be imported liquefied natural gas. However, plans for a massive expansion of coal-fired energy are well advanced, so the prospect of reversing that decision may not be feasible, though little consideration appears to have been given to its health and environmental implications.

On the other hand, Bangladesh has significant reserves of natural gas, but exploration drilling has not kept pace with demand. Policy constraints, especially those related to pricing, are the key impediment to revitalizing exploration and production, enhancing production and reservoir management from existing fields, and reducing losses (mostly due to theft, but also to substantial amounts of leakage) from the existing gas supply network. Thus, the situation in Bangladesh is significantly different from that in Pakistan and Sri Lanka, as Bangladesh will not need large incentives from a global carbon market to inform investment decisions that choose between coal and natural gas. What it will need is simply more domestic gas development, and this remains firmly in the range of the possible, provided that the country's financial policy improves. Otherwise, the country will be forced to analyze the tradeoffs between coal and imported gas, much as Pakistan and Sri Lanka must do.

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Approaches for Reducing Emission Intensity

Options for Cleaner Coal

In the immediate future, there are three main options for lowering the emission intensity of coal that are appropriate to the Indian setting: (i) rehabilitation of old plants, (ii) replacement of inefficient plants, and (iii) adoption of cleaner-generation technologies that are economically justifiable. Each of these is considered in turn:

- **Rehabilitation:** India's state electricity boards and their successor entities own and operate plants that represent more than 50,000 megawatts of generation capacity. Some of these are old, inefficient, and highly polluting. Rehabilitation of these with energy efficiency as a priority can generate substantial emission reductions. For example, plant efficiency can increase to 35 percent from 30 percent or below, and as a result, the annual CO_2 emission reduction would be more than 1 million tons for every 1,000 megawatts for a power plant that was so renovated.

- **Replacement:** Ageing coal-fired power plants with no further rehabilitation potential could be replaced by new, more efficient plants, ideally using supercritical technology, where technically and economically feasible.

- **Cleaner generation:** A favored option in India is supercritical technology,[83] based on

[83] Given the rapid development in the sector and other factors, selecting clean coal technology options appropriate to developing countries is difficult. Two recent papers (Tavoulareas 2007; Chikkatur and Sagar 2007) have identified supercritical and ultrasupercritical technologies as appropriate choices for immediate investment focus in India, based on commercial availability, suitability for Indian and imported coal, and demonstrated track records. India is pursuing this technology actively, with licensing arrangements in place and plants (such as that at Mundra, Gujarat) under development. Other technologies, such as integrated gasification with carbon capture, offer potential to take into consideration by the World Bank. Care should be taken, however, to ensure that such technologies have been fully tested and are suitable country specific conditions.

its track record internationally, availability in India, and suitability with coal streams (domestic and imported). It is likely that many such investments will be led by private sector entities or state organizations with substantial access to market financing, such as the National Thermal Power Corporation. There is scope to expand the use of supercritical technologies to other countries in the region.

Loss Reduction, Energy Efficiency, and Pricing

For South Asia in general and India in particular, there are large gains to be had from addressing loss reduction or efficiency gains. The energy that does not have to be generated due to loss reduction or efficiency gains is attractive from both the cost and the climate-change standpoints. There are large opportunities for efficiency gains and loss reduction in South Asia (Table 12.1). Much of the industrial output in the region is from small- and medium-scale enterprises that utilize outdated and inefficient technologies and processes. Cost-effective energy efficiency opportunities exist across the entire chain of modern energy production, distribution, and consumption in all South Asian countries. However, success in capturing these benefits has been elusive; many energy efficiency projects with positive economic returns remain unimplemented.

The classic barriers to increased energy efficiency include noneconomic pricing of energy (encouraging overconsumption), imperfect information, and institutional barriers. Additionally, weight is often given to reducing up-front costs instead of considering the lower recurring lifecycle costs typically available from installation of more cost-efficient equipment and adoption of more efficient processes. Energy-efficiency projects can also face higher transaction costs due to their small average size.

Table 12.1 Energy-efficiency Opportunities and Measures in Key Consuming Sectors

Sector	Energy-efficiency Improvement Opportunities
Buildings	Integrated building design and measures such as better insulation, advanced windows, energy-efficient lighting, space conditioning, water heating, and refrigeration technologies plus energy-efficient brick manufacturing and wall paneling
Industry	Industrial processes, cogeneration, waste heat recovery, preheating, efficient drives (motor, pump, compressors)
Cities and Municipalities	District heating systems, combined heat and power, efficient street lighting, efficient water supply, pumping, and sewage removal systems, solid waste management (methane capture to generate electricity)
Agriculture	Efficient irrigation pumping and efficient water use, such as drip irrigation
Power Supply	*New thermal power plants:* Combined cycle, supercritical boilers, integrated gasification combined cycle, etc. *Existing generation facilities:* Refurbishment and repowering (including hydro), improved operation and maintenance practices, and better resource utilization (higher plant load factors and availability) *Reduced transmission and distribution losses:* High-voltage lines, better insulated conductors, capacitors, efficient and low-loss transformers, and improved metering systems and instrumentation *Intensified investigation of renewable options:* Solar and wind power, hydro-electricity (including possibility of increased regional trade)
Transport	Efficient gasoline/diesel engines, urban mass transport systems, modal shifts to inter- and intra-city rail and water transport, improved fleet usage, compressed natural gas (CNG) vehicles
Households	Efficient lighting, appliance efficiency, improved cook stoves, solar panels for heating and cooking.

Finally, capital constraints at small and medium enterprises often leads to allocation of capital toward new production capacities rather than toward investments that will reduce operating costs through energy efficiency, especially if energy costs are a small component of total production costs.

The International Energy Agency has noted that more than 60 percent of GHG reductions could come from adoption of energy-efficient policies and measures. Though contested, this conclusion highlights the importance that energy efficiency can play in reducing demand and dependence on fossil fuel use, reducing levels of power shortages by capacity-constrained electric utility companies, and improving economic competitiveness, while capturing the environmental benefits to be derived from the numerous government-led initiatives currently under way. In India, the Planning Commission estimates that improving energy efficiency in industry will have the greatest impact in reducing India's CO_2 emissions. The Government of India has demonstrated its commitment to and support for improving efficiency with the passage of the Energy Conservation Act (2001) and the formation and operation of the Bureau of Energy Efficiency. Recognizing the importance of lowering demand through energy conservation and improved efficiency, the 11th Five Year Plan seeks to improve Indian efficiency by 20 percent by 2016/7, and the recently released Climate Change Action Plan of the Government of India includes a specific mission to increase efficiency through deployment of several innovative market mechanisms. Government-supported programs for efficiency have also been launched in Afghanistan, Nepal, Pakistan, and Sri Lanka.

Hydroelectricity and Regional Trade

Though India's hydropower potential is limited relative to its needs, the hydropower sector can contribute to reductions in emissions. The Bank already has a presence in the Indian hydro sector, with one project under implementation (Rampur) and two more under preparation (Vishnugad Pipalkoti and Luhri). There are also good prospects for an increased Bank involvement in financing of hydro capacity in Nepal and Pakistan.

There are significant opportunities in energy trade between the countries with a surplus of clean renewable sources of energy—hydropower in Bhutan and Nepal, and wind energy in Sri Lanka—and the energy-deficit countries of India, Pakistan, and Bangladesh. Trading this clean energy would allow climate-change-mitigation benefits to arise from reduced operation of thermal (particularly coal-fired) power plants. The improved interconnectedness and efficiency associated with this regional trade would also yield improvements in operational performance. However, given the inadequacy of existing interconnections for trading large quantities of clean energy and current shortages of power, at the present time imported power would serve mainly to reduce load shedding, and substantial benefits would materialize only over the long term.

Other Renewable Sources

The contribution of non-hydro-renewable energy in the overall mix in South Asia is likely to be small. Even if such alternatives experience vigorous growth, their contribution to mitigation of overall carbon emissions will be limited, though individual projects will be able to attract potentially significant volumes of carbon finance. More work and research will be needed to deploy viable technologies and support emerging technologies. Recognizing this need, the Government of India has recently unveiled an ambitious approach in its National Action Plan on Climate Change to raise solar power production capacity and invest heavily in research and development in this field.

Leveraging Climate-change-related Funds

Without adequate and additional funding it is unlikely that the South Asia region can achieve the transformation needed to create low-carbon economies. Ultimately, good projects will be the key, but the long delays in obtaining carbon finance (including through clean development mechanisms) are often a hurdle. The magnitude of available funds is also inadequate for the scale of the challenges in the energy sector.

Private Sector Players

The private sector will be playing a key role across the board in investing in new, clean coal plants, gas-fired plants, and renewable energy. The Clean Development Mechanism already provides, to some extent, a signal toward future prices of carbon. However, there will still be significant risks attached to private investment in clean energy technology that is not least cost or whose potential remains unproven.

Michael Foley/World Bank