IMPROVING ENERGY EFFICIENCY IN SOUTH ASIA

Priyantha Wijayatunga and Tilak Siyambalapitiya

NO. 47

October 2016

ADB SOUTH ASIA WORKING PAPER SERIES

ASIAN DEVELOPMENT BANK

ADB South Asia Working Paper Series

Improving Energy Efficiency in South Asia

Priyantha Wijayatunga
and Tilak Siyambalapitiya

No. 47 | October 2016

Priyantha Wijayatunga, PhD, is a principal energy specialist, Sustainable Development and Climate Change Department, Asian Development Bank (ADB).

Tilak Siyambalapitiya, PhD, is a consultant to ADB.

ASIAN DEVELOPMENT BANK

ISSN 2313-5867 (Print), 2313-5875 (e-ISSN)
Publication Stock No. WPS168445-2

Cataloging-In-Publication Data

Asian Development Bank.
Improving energy efficiency in South Asia.
Mandaluyong City, Philippines: Asian Development Bank, 2016.

1. South Asia. 2. Energy. 3. Energy Efficiency. I. Asian Development Bank.

Notes:
1. In this publication, "$" refers to US dollars.
2. This report follows the convention that South Asia includes Afghanistan, Bangladesh, Bhutan, India, the Maldives, Nepal, Pakistan, and Sri Lanka.
3. ADB recognizes "Vietnam" as Viet Nam.
4. Corrigenda to ADB publications may be found at: http://www.adb.org/publications/corrigenda

CONTENTS

TABLES

ABSTRACT

Energy efficiency is considered to be the fastest way to bring additional energy to meet the increasing demand for energy services. Energy efficiency has gained attention in various parts of the world since the 1970s. Contrary to the belief among policy makers that the economic output might suffer due to energy efficiency interventions, it has been shown that higher energy efficiency improves total factor productivity. With an appropriate combination of market instruments and regulations in areas where markets tend to fail, energy efficiency interventions can be successfully implemented.

In South Asia, on the supply side of the power systems, the key energy efficiency issues are (i) the relatively lower efficiency and reliability of thermal power plants, and (ii) the significantly high losses in electricity transmission and delivery systems. On the demand side, opportunities for demand management and conservation are many. There is scope for significant improvement in coal-fired power plant efficiency improvements (2–4 percentage points) and loss reduction in transmission and distribution systems. Indirect demand control mechanisms such as time-of-use electricity tariffs and introduction of appliance standards have been used in South Asia for some time, and they can be enhanced and expanded. Similarly, direct load control through smart metering can also play an important role, with increasing attention now being paid to employment of smart grids in the region.

This paper concludes that South Asia has a significant potential for energy efficiency improvement in the power sector. These efficiency improvements can be realized with appropriate policies and programs that can be readily implemented with the existing institutional framework.

ACKNOWLEDGMENTS

The authors are grateful to Jiwan Acharya, senior energy specialist, South Asia Energy Division, Asian Development Bank for carefully reviewing the paper and providing valuable comments. The authors also wish to acknowledge the assistance extended by the respective government institutions and power sector utilities in South Asian countries by providing necessary data and information for the study.

I. INTRODUCTION

In a resource-starved developing world which is always lagging behind in the provision of basic energy services to its peoples, energy efficiency is considered the fastest and cheapest way to make available additional energy to satisfy the exponentially increasing demand for energy. At the same time, energy efficiency saves money for the users, saves economic resources of the country or the region, improves energy security, saves the environment, and even improves the quality of life of people (Alliance to Save Energy 2012).

A. Energy Efficiency Experience Worldwide

Energy efficiency caught the attention of the developed world and some of the developing countries as far back as the 1970s. Geller et al. (2006) concluded that without the energy efficiency improvements since the mid-1970s countries in the Organisation for Economic Co-operation and Development would have used 49% more energy in 1998 than what they actually used. Their study evaluated some of the specific policies and programs in the United States and countries in Western Europe and showed that they have saved about 19% of primary energy use due to those policies.

Cantorea, Calib, and te Veldec (2016) conducted a study involving 30 developing countries ranging from Bangladesh to Zambia which has shown that higher energy efficiency improves total factor productivity in a large majority of the countries contrary to the belief among some policy makers that the economic output might suffer with energy efficiency interventions. Through appropriate policies and regulations and their successful implementation, the developing world will be able to harness higher economic returns. At the same time, in countries like Viet Nam where the government has been emphasizing energy efficiency and conservation polices in recent years, the implementation of such policies on the ground has been challenging (Luong 2015). Some of the challenges include (i) lack of information and data to establish benchmarks and to measure improvements, (ii) lack of readily available expertise locally and inadequate support for international expertise, and (iii) inadequate follow-up government support, which is critical for implementation success.

In many countries, even though market instruments and economic incentives have an important role to play in energy efficiency interventions, particularly in subsectors such as building construction, regulations are increasingly used where the market tends to fail. Building codes and appliance labeling are some of the examples where regulations play a key role. Moreover, in all the countries, private sector involvement through mechanisms such as the use of energy service companies is critical to further energy efficiency interventions since government budget is always constrained by other priorities (World Energy Council 2013).

B. Supply Side versus Demand Side

The energy efficiency interventions can be both on the supply side and on the demand side of the energy services industry. On the one hand, implementation arrangements in supply-side interventions in the power sector are relatively easy to handle because such interventions involve mainly the large power utilities, which are small in number and possess adequate technical capacity. These supply-side options involve countless interventions ranging from efficiency improvements in power generation to loss reduction in transmission and distribution systems. These options are normally capital intensive on the part of the investor, but the utilities have the ability to bear such costs through various financing mechanisms including assistance from development partners such as the Asian Development Bank.

On the other hand, demand-side options such as the use of energy-efficient appliances and practices would not require large investments on the part of the users. However, if a country needs to introduce such programs, it involves many steps, ranging from developing and implementing relevant policies and regulations to arranging financing mechanisms mostly through financial intermediaries. In most cases, however, the benefits of demand-side interventions are substantial and immediate and therefore more attractive if appropriate financing mechanisms are in place.

As for South Asia,[1] the key energy efficiency issues on the supply side of the power systems are (i) the relatively lower efficiency and reliability of thermal power plants, and (ii) the significantly high losses in electricity transmission and delivery systems. On the demand side, opportunities for demand management and conservation are many, cutting across all forms of energy and consuming subsectors. We begin with the supply-side transmission and delivery systems. Later sections of the paper deal with energy efficiency aspects on the demand side.

II. EFFICIENCY OF POWER PLANTS

Power generation in South Asia as a whole is predominantly thermal, although Bhutan and Nepal are served almost exclusively with hydropower. With India leading the scene with over 298,000 megawatts (MW) of generating capacity, dominated by thermal power plants operated on coal, energy efficiency in power generation and environmental impacts have come into sharp focus over the past few decades. Table 1 shows the generation mix in countries in South Asia, indicating the continuing predominance of fossil-based generation, especially in Bangladesh, India, Pakistan, and, more recently, Sri Lanka.

Table 1: Generation Mix in South Asia (GWh)

	Afghanistan[a]	Bangladesh[b]	Bhutan[c]	India[b]	Maldives[a]	Nepal[b]	Pakistan[b]	Sri Lanka[d]
Coal		1,225	0	869,181	0	0		3,506
Oil		6,692	0	23,169	330	10		4,439
Gas		44,083	0	65,102	0	0		0
Biofuels		0	0	21,809	0	0		41
Waste		0	0	1,338	0	0		0
Nuclear		0	0	34,228	0	0		0
Hydro		894	7,164	141,637	0	3,636		4,552
Solar PV		145	0	3,433	0	0		20
Wind		4	0	33,583	0	0		272
Total		**53,043**	**7,164**	**1,193,480**	**330**	**3,646**		**12,830**
Imports		0	0	5,598	0	1,072		0
Exports		0	5,147	5	0	3		0

GWh = gigawatt-hour, PV = photovoltaic.
Sources:
[a] Data for 2013 from United States Energy Information Administration. 2016. *Independent Statistics & Analysis*. Washington, DC.
[b] Data for 2013 from International Energy Agency. 2015. *World Energy Statistics 2015,* Paris
[c] Data for 2014 from Government of Bhutan, National Statistics Bureau. 2015. *Statistical Yearbook of Bhutan 2015*. Thimphu.
[d] Data for 2014 from Government of Sri Lanka, Sri Lanka Sustainable Energy Authority. 2014. *Sri Lanka Energy Balance 2014*. Colombo.

[1] In this paper, South Asia includes Afghanistan, Bangladesh, Bhutan, India, the Maldives, Nepal, Pakistan, and Sri Lanka.

A. Power Generation Efficiencies in South Asia

In India, the cumulative installed generating capacity serving the respective grids was 298,060 MW as of March 2016. In the last financial year 2015/16, India planned to generate 1,137,500 gigawatt-hours from these power plants, indicating an effective planned capacity factor of 44% (CEA 2016).[2] For thermal power plants (210,675 MW), India planned an average capacity factor of 52%. Although power plant operations and their capacity factors are matters decided by operational economics, the capacity shortages reported in India are indicative of the need to raise the availability and efficiency of the existing power plants to the best possible extent. A coal-fired thermal power plant may achieve an availability of 90% if well designed, built, and maintained, allowing the capacity factor too to reach the same level of 90%, provided the power plant can be dispatched at all times when it is available.[3] For India's coal-fired power plants that form the basis of the generating system, dispatch throughout the year is required, as the country is short of generating capacity to meet customer demand.

India's coal-fired power plants operated at an average net efficiency of 30.1% as of 2009, with state-level averages in the range of 17.7%–34.0%. The National Thermal Power Corporation reported a group net efficiency of 33.3% in their coal-fired power plants (Piyavrat 2016). India's coal-fired power plants are issued with coal consumption norms. These norms imply a gross efficiency in the range of 31% for smaller subcritical power plants to 38.2% for larger supercritical power plants (CEA 2015). These target efficiency figures are themselves conservative, meaning they can be improved. A committee to review the size of coal-fired power plants to be built in India concluded that the next higher unit size adopted for new generation projects in India should be 800–1,000 MW, stating their higher efficiency to be the key consideration. India is on a drive to increase the size of the average generation unit, moving closer toward ultra-supercritical generating technology, especially with the ultra-mega power plant development program. For example, the 4,000 MW power plant at Mundra, Gujarat, uses 800 MW supercritical units. With significant efforts to raise the efficiency of existing power plants and to ensure the supercritical technology is implemented in new power plants, India has targeted a net efficiency of 34% by 2015 in coal-fired power plants.

With the liberalization of the power generation market in India—and more private power plants being operational—the efficiency of all types of power plants is also expected to increase. The older power plants need to be repowered to modernize with improved combustion control, improved insulation, operational optimization, and ease of maintenance. Power plants need to be retired and replaced with ones with modern, low emission, and higher efficiency designs. The Central Electricity Authority estimates that in March 2016, the peak-time capacity deficit was about 2% of installed capacity of coal- and gas-fired thermal power plants (Table 2). This means that, on average, a 2% increase in the installed capacity available to meet the peak demand is adequate to meet the peak without load shedding. It is most likely that initiatives to improve power plant efficiency will suffice to meet a significant share of this 2% additional capacity. Efficiency improvement, especially in the auxiliary power requirements of thermal power plants, can enhance their output to reduce the smaller peak-time capacity deficits India expects for 2016–2017. Hydroelectric power plants, which provide about 11% of India's electricity supply, also require refurbishment and rehabilitation at the correct time, the key improvements being turbine replacement, new control systems, and actions to reduce friction in the water conveyance systems.

[2] There is a significant amount of captive generation in India, not reported in data published in national statistics.
[3] India's nuclear power plants report an annual capacity factor in the range of 80%.

Table 2: Peak-Time Capacity Deficits in India, March 2016

Region	Peak-Time Capacity Deficit (MW)	Coal- and Gas-Fired Installed Generating Capacity (MW)	Peak Deficit as a Share of Installed Coal- and Gas-Fired Capacity (%)
Northern	1,999	50,976	4
Western	317	82,968	0
Southern	1,036	42,916	2
Eastern	172	30,813	1
Northeastern	174	2,008	9
Total (noncoincident)	3,698	209,681	2

MW = megawatt.
Source: Central Electricity Authority, India. 2016. Load Generation Balance Report 2016. New Delhi.

In Bangladesh, where the generating system is dominated by gas-fired power plants, most generation is either gas-fired open cycle combustion turbines or gas-fired reciprocating engines. These types of power plants report efficiency in the range of 30% (open cycle) to 42% (reciprocating engine), whereas the combined cycle technology, exceeding an efficiency of 50% when fired on natural gas, is well established. As Bangladesh is faced with significant shortages of generating capacity for which quick solutions have been sought over the past few decades, investments have been mostly on open cycle power plants and reciprocating engines, both by the state-owned Bangladesh Power Development Board and by independent power producers. Several projects to build heat recovery boilers and steam turbines at existing power plants as well as to build combined cycle power plants are currently under way. The potential to raise the efficiency of power generation in Bangladesh exceeds 10 percentage points.

Pakistan produces electricity using hydropower, oil, and gas—the three sources providing approximately a third of the country's electricity requirements. The Water and Power Development Authority plans to raise the share of hydropower generation from 31% (2012) to 50% by 2021, which reflects an ambitious target to raise the hydropower-generating capacity from the present 7,100 MW to about 25,000 MW. Thermal power plants using gas and oil are most likely to dominate the generating system in Pakistan, with the possibility of coal being used for reasons of cost.

Sri Lanka's electricity production during 2000–2010 has been dominated by oil-fired generation, in both reciprocating engines and combined cycle power plants. Both these technologies report a net efficiency in the 38%–45% range typical of such oil-fired power plants, although improvements are possible. Since 2011, Sri Lanka has been increasingly using coal for power generation. A total of 27% of generation from the country's first coal-fired power plant was reported in 2014, and Sri Lanka is expected to generate 50% of generation from coal by 2018. This subcritical power plant recorded a net efficiency of 31.86%, amid a larger number of starts and stops during the running-in period, which was extended due to numerous planned and unplanned outages. The relatively poor efficiency reported is expected to improve as the power plant matures and the staff gains experience for the first time on coal-fired power generation technology.

Both Bhutan and Nepal exclusively use hydropower. Opportunities do exist in hydropower plants to improve their efficiency, in particular of the old power stations, with technology interventions and operating practices. The Maldives exclusively uses diesel engines for power generation. In these island power supply systems, diesel engines generating power operate at part-load conditions most of the time, hence their operating efficiency is poor. In addition, poor maintenance has led to poor efficiencies in some of the remote islands. Afghanistan's power generation is dominated by imports from neighboring countries (78% of energy in 2013), followed by 254 MW (19% of energy) of its own hydropower capacity. The remainder of only 3% comes from small liquid-petroleum-based plants. This means the efficiency improvement in generation exists only marginally and would be mainly in hydropower plants.

B. Potential to Enhance Generation Capacity

Best practices in coal-fired generation include improved technology, equipment, and controls, as well as efficient management of power plant auxiliaries. The efficiencies of well-maintained plants in the United States reported in the literature are compared with the published figures for India and Sri Lanka in Table 3.

In summary, the bulk of generation in South Asia is coal-fired thermal, followed by gas-fired thermal and hydropower. South Asia's coal-fired power plants are operating about 2–4 percentage points below the reported efficiency in the United States (Campbell 2013). While appreciating the difference in climatic conditions in these countries, and hence their impact on operational efficiencies in the power plants, one would still agree that there is a significant potential to introduce a systematic program to build more efficient power plants and retrofit existing power plants to improve their efficiencies. Such a program will help ease the capacity enhancement requirements. An efficiency improvement of 2 percentage points may significantly assist India to minimize load shedding, as the capacity deficit to meet the peak in March 2016 was about 2%.

The efficiency gains in power plants can come in several forms. They can be achieved through retirement of old, inefficient power plants and replacing them entirely with latest designs. Or they can be improvements of some of the components and operating practices. For instance, coal-fired power plant energy efficiency can be improved through (i) optimization of combustion controls, (ii) heat loss recovery from the cooling system, (iii) heat loss recovery from the flue gas system, (iv) sootblower optimization, or (v) improved steam turbine designs. Each of these interventions can increase the efficiency of a coal-fired power plant typically by about 0.15–2.6 percentage points (Campbell 2013). Similarly, increasing the quality of coal used in the power plant, increasing the capacity of the plants, and improving the thermodynamic cycle (from subcritical to supercritical to ultra-super critical plants) also raise the efficiency of the plants significantly.

Table 3: Best Practices in Achieving Higher Power Plant Efficiency

Country	Technology	Fuel	Net Efficiency (%)
United States[a]	Steam cycle	Coal	33.9
	Combined cycle	Natural gas	44.6
	Various	Oil	34.4
India[b]	All steam	Coal (All India)	30.1
		Coal (NTPC)	33.3
Sri Lanka[c]	Steam cycle	Coal	31.9
	Combined cycle/reciprocating	Oil (utility owned)	35.6
	engines	Oil (IPPs)	40.4

IPP = independent power producer, NTPC = National Thermal Power Corporation (India).
Sources:
[a] Data for 2014 from United States Energy Information Administration. 2016. *Independent Statistics & Analysis*. Washington, DC.
[b] Data for 2012 from Central Electricity Authority India. 2016. *Load Generation Balance Report 2016*. New Delhi.
[c] Data for 2014 from Ceylon Electricity Board. 2015. *Long Term Generation Expansion Plan*. Colombo.

One issue in pursing possible interventions in this area is the limited availability of plant efficiency information not only of the private power plants but also of some of the public sector utilities. This becomes even a bigger issue with more independent power producers entering the market for a larger share of the supply. In the case of independent power producers, the capacity and price of energy are the parameters usually in the public domain, whereas commercially sensitive information such as fuel input and efficiency are not divulged by many regulators. This shows the need for the utility regulators to emphasize the information published and monitor the efficiency of plant operations.

III. LOSSES IN POWER TRANSMISSION AND DISTRIBUTION

Excessive electricity network losses in South Asia are frequently highlighted. This is not unfair, given the poor record of electricity utilities in efforts to reduce network losses to single-digit levels, which many developed systems achieved decades ago. Going by the utilities' own published statistics, in which the definition of "network losses" may not be consistent, a good share of South Asia's electricity is lost in the transmission and distribution networks. However, there are also some distribution utilities in South Asia with network losses approaching the minimum possible on the ground. Transmission and distribution losses of a selected group of utility networks are listed in Table 4. This shows the wide range of the loss values and the spectrum of definitions of "losses" used or implied.

A. Efforts by Electricity Utilities to Manage Commercial Losses

It is not that electricity utilities are not making an effort to reduce technical losses and minimize commercial losses. Historic figures show some remarkable achievements. For example, when Tata Power Delhi Distribution took over the distribution network in New Delhi in their franchise area, the combined technical and commercial loss was 51.5% (mid-2002), which has now been reduced to 10.6%, with further potential to improve and move toward a loss target of about 5%. Sri Lanka's Lanka Electricity Company took over the country's network from the municipalities in 1983 with a loss level of about 33%, a result of years of neglect and underinvestment. Lanka Electricity Company now possesses the best records of distribution losses (at 33 kilovolts [kV] and below) in Sri Lanka, matching the region's best figures reported by the Bhutan Power Corporation. Elsewhere in South Asia, loss reduction has been achieved, but not as a matter of urgency.

India and Nepal continue to report significant loss levels, exceeding 20% of electricity sent out to the distribution network. There may be certain distribution entities with loss figures as good as the good performers, but their information is not available in the public domain or such distribution units are aggregated with larger distribution entities. Absence of unbundling, unclear identification of business units, absence of accountability, and unclear definition of losses have all caused such good (and bad) performance of distribution entities to be camouflaged by statistics. However, at the national level, each country in South Asia currently reports the transmission and distribution loss levels given in Table 5, all of which (except Bhutan) may be considered "high" by various international statistics reported for other countries. Bhutan, being a large and sparsely populated country, is expected to have a larger loss percentage compared with more populated countries such as Bangladesh. However, the reality is that 82% of electricity sales in Bhutan are to bulk customers, most of whom are served at higher voltages, with minimal losses. Hence, the national average losses remain low.

Table 4: Transmission and Distribution Losses in Selected Utilities in South Asia

Country	State/Region	Utility	Loss Definition	Operational Area	Losses (%)
Bangladesh	Dhaka Metropolitan region (2014/15)	DESCO	Purchases at 33 kV and distributes	Urban and semi-urban	8.37[a]
	National (2013/14)	BPDB	Transmission 230 kV and 132 kV	National	3.11[b]
	Other cities and rural Bangladesh (2013/14)		33 kV to 400 V	Urban, semi-urban, and rural	12.00[b]
Bhutan	All country (2013)	BPC	33 kV and below	Urban and rural	4.30[c]
India	New Delhi	TPDDL	33 kV and below	Urban	10.63[d]
	Madhya Pradesh (2014)	All three DISCOMs	33 kV and below	Urban, semi-urban, rural	17.64[e]
		Intrastate transmission	132 kV and above		3.00[e]
	Maharashtra (2013)	BEST	Distribution	Urban and semi-urban	7.40[f]
	Kerala (2012)	KSEB	Transmission and distribution	Urban and semi-urban	15.65[g]
	All India (2013)		Transmission and distribution	Whole country	22.69[h]
Maldives	Service areas (2011)	STELCO	11 kV and 400 V	Service areas	7.00–8.00[i]
	Service areas (2005)	FENAKA	400 V only	Service areas	24.00[i]
Nepal	All country (2014)	NEA	All transmission and distribution	All transmission and distribution	24.44[j]
Pakistan	All country (2014)	KESC	Transmission and distribution		15.00[k]
Sri Lanka	Parts of western/ southern provinces (2014)	LECO	Distribution 11 kV and 400 V	Urban and semi-urban	4.02[l]
	All country (2014)	CEB	Transmission 132 kV and 220 kV, bulk delivery 11 kV, and distribution 33 kV to 400 V	Urban, semi-urban, and rural	10.47[m]

BEST = Brihanmumbai Electricity Supply and Transport, BPC = Bhutan Power Corporation, BPDB = Bangladesh Power Development Company, CEB = Ceylon Electricity Board, DESCO = Dhaka Electric Supply Company, DISCOM = electricity distribution company, KESC = Karachi Electric Supply Company, KSEB = Kerala State Electricity Board, kV = kilovolt, LECO = Lanka Electricity Company, NEA = Nepal Electricity Authority, STELCO = State Electric Company (Maldives), TPDDL = Tata Power Delhi Distribution, V = volt.

Sources:

[a] Dhaka Electric Supply Company. 2015. *Annual Report 2015*. Dhaka.
[b] Bangladesh Power Development Company. 2015. *Annual Report 2014*. Dhaka.
[c] Bhutan Power Corporation. 2015. *Annual Report 2015*. Thimphu.
[d] Tata Power DDL. 2015. *True-Up Petition for FY 2015–16*. Delhi.
[e] Madhya Pradesh Electricity Regulatory Commission. 2015. *Retail Supply Tariff Order FY 2015–16*. Bhopal.
[f] Brihanmumbai Electricity Supply and Transport Undertaking. 2014. *True-Up Petition for FY 2014–15*. Mumbai.
[g] Kerala State Electricity Board. 2014. True-*Up Petition for 2015–16*. Thiruvananthapuram.
[h] Planning Commission, Prayas (Energy Group). 2014. *India Electricity Security Scenarios, 2047*. Delhi.
[i] Maldives Energy Authority. 2014. Personal communication, Male.
[j] Nepal Electricity Authority. 2014. *Annual Report 2014*. Kathmandu.
[k] National Electric Power Regulatory Authority. *2015. NEPRA/TRF-133/KESC-2009/8974-8977* . Islamabad.
[l] Lanka Electricity Company. 2015. *LECO Statistical Digest 2014*. Colombo.
[m] Ceylon Electricity Board. 2015. *Statistical Digest 2014*. Colombo.

How much of these losses are technical, commercial, and administrative is difficult to estimate? Technical losses occur due to electrical properties of materials used in the conductors and transformers of transmission and distribution networks when electric current passes through them. Technical losses can be minimized by good design, investment, and maintenance of distribution networks, but such losses cannot be fully eliminated. Commercial losses are largely caused by unaccounted electricity usage, where customers and other users resort to various methods, such as tapping the distribution lines directly bypassing the meter to get electricity without paying for it. Administrative losses are generally those caused by delayed metering or total absence of any metering. Many countries simply add all the three types into aggregate technical and commercial losses, because they have no means of separating them. Others make an attempt to estimate technical losses, so that commercial and administrative losses are the remainder out of the total losses. Commercial and administrative losses can be completely eliminated in a well-managed distribution network.

With software tools for conventional analyses such as load flow studies and online measuring systems widely available, it is not difficult to accurately estimate the technical losses and to measure the total losses. The difference between the total losses and the technical losses would then be the commercial and administrative losses. However, the difficulty in most countries is that the electricity utilities do not have accurate and digital information about the power lines, their routes and lengths, and the type of wire used. In high-voltage transmission, many electricity utilities have reasonably good information on power flow, line routes, and types of wire used. However, in distribution, the information available is very limited.[4] No country has its entire distribution system fully mapped and uploaded into a geographic information system, although attempts have recently been made to prepare such information. Therefore, technical losses are almost always estimated, rather than calculated. Many utilities do not consider digitizing the distribution network and conducting load flow analysis to determine, among other things, the technical losses to be worth the effort. They continue to operate the distribution network without any technical analysis to assess energy losses as well as other parameters that indicate its performance and quality of supply, such as voltage at each point of service to customers.

Table 5: Electricity Transmission and Distribution Losses in Selected Utilities

Country	Total Transmission and Distribution Loss as a Share of Net Generation (%)	Source
Bangladesh	14.11	Bangladesh Power Development Company. 2015. *Annual Report FY 2013/14*. Dhaka
Bhutan	4.54	Bhutan Power Corporation. 2013. Data Book 2012. Thimphu.
India	23.65	For FY2012, from Central Electricity Authority. 2013. *Growth of Electricity Sector in India 1947–2013*. New Delhi.
Maldives	13.00	For State Electric Company service areas only, from United Nations Development Programme. 2007. *Energy and Poverty in the Maldives: Challenges and the Way Forward*. Bangkok.
Nepal	25.03	FY 2013, from Nepal Electricity Authority. 2015. *Annual Report FY 2013/14*. Kathmandu.
Pakistan	17.00	Estimated and stated in Tariff Decision 2013
Sri Lanka	10.30	Sri Lanka Sustainable Energy Authority. 2012. *Sri Lanka Energy Balance 2012: An Analysis of Energy Sector Performance*. Colombo.

Source: Various country utility companies as indicated in the table.

4 In the region, many countries classify lines operating at 33 kV and below as distribution.

Countries in South Asia have resorted to some extreme legal and regulatory measures to help reduce commercial losses. Nepal introduced the Electricity Theft Control Act in 2002, with limited success, and the country still reports a very high loss level of 25%, more than 12 years after the act came into force. All countries have strict laws with heavy punishments for offenders, including immediate detention, stiff penalties, and jail terms. However, the success of the legal instruments depends on how effective the utility and law enforcement agencies are in detecting theft of electricity, how effective they are in initiating legal action, and, most importantly, how effective they are in managing cases until offenders are punished. Large-scale fraud involving entire townships engaged in organized theft of electricity is not uncommon in the region. In certain towns, there are no-go areas for the utility staff for meter fixing and meter reading. In spite of all the difficulties in enforcement, some countries with state-owned utilities, such as Sri Lanka, or service areas under private utility ownership, such as New Delhi and Mumbai in India, have been able to report significant reductions in distribution losses, to below 12%.

The conventional approach in power distribution engineering is to provide ring-type or radial lines (feeders) to serve electricity to customers. In urban areas where the customer density is high, particularly in preplanned networks serving urban areas where service reliability is also important, the practice is to provide ring-type networks. These are expensive to build and maintain but would serve customers at lower loss levels and at higher reliability. In suburban and rural areas, due to lower customer density, it would not be economical to provide such ring-type feeders. The conventional approach in such areas is to serve them through radial feeders. A radial feeder, typically of medium voltage, would begin at a substation, traverse villages and farms in rural areas, and end when it reaches the end of the road or the last community in the area.[5] Some medium-voltage feeders run for more than 100 kilometers (km) in extreme cases, whereas the recommended length of such medium-voltage distribution feeders would be as low as 20 km. Long distribution feeders themselves cause excessive technical losses and poor quality of supply to customers.

B. Switching Off Lines to Control Theft and Overuse

Countries have also resorted to nonconventional solutions to resolve the problem of commercial losses, the most prominent in South Asia being the feeder separation program being implemented in several states in India such as Gujarat and Madhya Pradesh. Providing free or subsidized electricity for agricultural water pumping in several states in India and the practice of providing unmetered connections to water pumps have caused significant increases in commercial losses. This is because such pumps are excessively used beyond the approved number of hours. To control these commercial losses and to force agricultural customers to use such free (or subsidized) electricity only for the purpose of water pumping, utilities have resorted to extreme measures such as switching on the feeder as determined by the water pumping requirements (as determined by weather and agricultural authorities), thus causing household, commercial, and industrial customers served by the same feeder to be deprived of electricity.[6] An alternative measure is switching off one phase of the three-phase feeder each day in rotation during periods when water pumping is not authorized (such as in the harvesting season or when there is adequate rainfall) or to limit water pumping to a few hours each day.[7]

---

5 In South Asia, medium-voltage distribution is at 11 kV or 33 kV.

6 At other times, the feeder remains switched off, causing immense hardship to villages and townships served by the feeder.

7 The other two phases continue to provide supply to customers, but at approximately half the normal supply voltage. The lower voltage of supply usually causes equipment damage. This extreme measure causes a utility to intentionally reduce the quality of supply to force customers not to use electricity. This would mean only single-phase equipment can be used by customers and also once in 3 days.

All the above measures are hard measures that reduce the availability of electricity supply and its quality in a desperate bid by utilities to reduce commercial losses.

Utilities have resorted to harder, more organized measures, making additional investments to overcome commercial losses and to control theft. The feeder separation program implemented in several states in India implements an extreme form of separating "good" customers and "bad" customers by building separate medium-voltage feeders to serve the two groups separately.[8] Strict economic assessment would generally reject any initiative to build two distribution lines to serve the same geographical area. These are rural areas in India where the demand for electricity is low; hence, drawing two lines—one to serve household, commercial, and industrial customers, and another to serve water pumps—appears to be a strange proposition. The feeder serving the farms would traverse the farmlands in the interior, and the new feeder would traverse the villages and commercial centers. Gujarat has shown good results in the feeder separation program, helping to reduce losses.

Some utilities in India have also resorted to installing new medium-voltage distribution systems (MVDS) in rural areas, to prevent theft of electricity. MVDS are usually built in more densely populated urban areas to reduce distribution losses (technical) and to improve the quality of supply. Building MVDS in rural areas seems a wasteful investment, but if distribution is at 11 kV and if the 400-volt line length is minimized, electricity theft is expected to be minimal, because illegal connections cannot be made off 11 kV lines and even if such connections are done with the tacit support of utility employees, expensive transformers would be required to step down the illegally acquired electricity supply to a lower voltage by the party that does the illegal tapping. Along the 11 kV line, there would be shorter distribution lines, usually only a direct service line from the pole-mounted transformer to the customer's premises.

Certain utilities, without using MVDS, draw 400-volt distribution lines using insulated cables, from which illegal tapping is difficult, though not impossible if the correct tapping connector is used. As an extreme measure, some utilities in India are using armored cables for 400-volt distributors, to prevent theft of electricity.[9] These armored cables are usually laid in underground distribution systems, but when they are used to prevent theft, they are hung on poles. In addition to being expensive, they have an unpleasant appearance because they are not designed to be strung above ground.

C. Meters and Metering Systems

Prepaid metering, affixing the meter away from the customer's premises, and steady innovation in meter packaging and assembly have all been used by utilities in the region to manage commercial losses. Additionally, utilities in the region have stepped up meter calibration programs and commenced remote meter reading. All bulk customer meters in Sri Lanka are now read remotely, allowing the utility to quickly asses any discrepancies. However, frequent visits are made to the premises to check any interference with the meter. In some areas in India, distribution transformer outputs are regularly monitored online through remote metering to detect theft.

However, progress with metering the energy transfers within a utility's own service areas, including metering of distribution transformers, is still lacking in many utilities. In India, most states have now established the practice of metering all distribution transformers installed under the various projects. In Sri Lanka, Lanka Electricity Company meters all its distribution transformers and conducts a monthly

---

[8] Feeder separation has been fully implemented in Gujarat, while the states of Punjab, Karnataka, Andhra Pradesh, Maharashtra, and Madhya Pradesh are in the process of implementing the program.

[9] These cables have a steel armor, off which no connections can be made.

energy balance, enabling a rapid assessment of any sudden deviation of loss levels. Reforms being implemented in several countries in the region, particularly in India and Sri Lanka, have compelled the utilities to establish metering systems for energy transfers between different business entities of the previously vertically integrated utilities.

D. Smart Grids

Smart transmission and distribution networks have the ability to control power generation, demand, and the power flows to help the optimal operation of the power system. These grids can bring down losses with the help of smart information and communication technology including smart metering and control systems. For instance, on the supply side, smart grid devices can coordinate voltage levels in the power system in order to minimize losses (Kolenc, Papič, and Blažič 2012). On the demand side, these devices can coordinate consumption at the consumer end in the form of demand response targeting minimization of losses (Juelsgaard and Wisniewski 2014). In South Asia, smart metering is being increasingly deployed, not so much for demand response but to improve revenue collection. However, there is large scope to expand smart metering for demand response in these countries, particularly for efficient management of power generation shortages.

E. Loss Targets Established by Regulators

Although many regulators in the region have established loss targets, there is little evidence that such loss targets have been scientifically determined. In Bhutan, losses have never been an issue because the bulk of sales are at higher voltages. Hence, losses at lower voltages are not visible in aggregated statistics. However, Bhutan Power Corporation publishes distribution losses for each district, which is indicative of the presence of metering at the district level, and some districts report significant levels of losses. In India, all tariff orders over the past few years carry a "loss trajectory," basically providing a 3-year profile of aggregate technical and commercial losses that the distribution utilities are required to meet.[10] In tariff reviews conducted, regulators generally adhere to the target loss levels rather than the actual loss levels reported by utilities. This means that in determining the price, regulators have resorted to establishing energy loss targets for utilities, and then to use such targets to calculate the allowed customer tariffs. In backward adjustments, utilities also claim losses to have been more than the target, but regulators use the target loss as the actual loss. In Pakistan, studies on losses have not been reported, and the regulator continues to use a fixed transmission and distribution loss of 17% in all tariff determinations. In Sri Lanka, the Public Utilities Commission in 2011 established loss targets for the sole transmission licensee and for each distribution licensee for each year in the 5-year tariff period. Going by the declarations by the utilities, all of them have reported to have met the 2015 loss target ahead of schedule, as early as 2012. However, with no independent verification or auditing of energy flows and without financial separation of five of the six licensees, the discrepancy between the target loss and the reported loss, which would be converted into a financial loss, is not felt by the respective licensee. Table 6 shows the loss targets used by selected regulatory agencies in South Asia.

[10] For example, in the Tariff Order dated 20 June 2013, the Tamil Nadu Electricity Regulatory Commission states, "The Commission in the absence of scientific study for loss determination, has fixed the transmission and distribution loss level at 16.4% for FY2014 and has clarified that it shall assume loss percentage at 16% and 15.6% for FY2015 and FY2016, respectively, if necessary scientific study is not done by Tamil Nadu Generation and Distribution Corporation."

Table 6: Regulatory Targets for Certain Utilities in South Asia

Country	Licensee	Business	Technical Details	Regulatory Loss Target	Actual Reported	Implication on Licensee
Bangladesh	DPDC	Distribution	Total loss, FY2015	9.80%	9.46%	Financial benefit/loss owing to lower/higher energy purchased from transmission
	DESCO	Distribution	Total loss, FY2015	8.40%	8.37%	
Bhutan	BPC	Transmission and distribution	HV, technical loss, FY2013–2016 period	2.00%	4.54%, licensee reports losses in a manner different to regulator's loss definitions	If loss target is not met, revenue will be lost; licensee is still in the second year of the 3-year tariff period; hence, the actual implications are yet to be seen.
			MV, technical loss FY2013–2016 period	2.50%		
			LV, technical loss FY2013–2016 period	12.00%		
			Commercial loss for 2013	1.06%		
			Commercial loss for 2014	1.04%		
			Commercial loss for 2015	1.06%		
India	TPDDL	Distribution in New Delhi	Loss target for FY2012	13.00%	11.27%	TPDDL has formally stated a profit of Rs680 owing to exceeding the loss target in FY2012.
	DICOM-C	Distribution in Central Madhya Pradesh	Regulatory loss targets were 26%, 24%, and 22% for FY2011, FY2012, and FY2013, respectively.		29.00% for FY2012	Losses absorbed by the utility; however, owing to the lack of revenue separation applied at the time, there was no direct financial impact.
	Intrastate transmission	Madhya Pradesh	No specific target for transmission loss		3.30%	FY2013
	BEST	Distribution in Mumbai	7.50%		7.40%	FY2013, loss to licensee
	KSEB	Vertically integrated utility in Kerala	16.61%		15.65%	FY2013, gain to licensee
Sri Lanka	CEB	Transmission	220 kV and 132 kV, loss target for 2014	3.00%	10.47%	Five of the six licensees are not revenue-separated; therefore, gains or losses are not accounted to each licensee.
		Distribution licensee 1	33 kV and below, loss target for 2014	8.30%		
		Distribution licensee 2	33 kV and below, loss target for 2014	10.40%		
		Distribution licensee 3	33 kV and below, loss target for 2014	8.30%		
		Distribution licensee 4	33 kV and below, loss target for 2014	9.20%		
	LECO	Distribution licensee 5	11 kV and below, loss target for 2014	5.20%	4.02%	Direct saving to licensee

BEST = Brihanmumbai Electricity Supply and Transport, BPC = Bhutan Power Corporation, CEB = Ceylon Electricity Board, DESCO = Dhaka Electric Supply Company, DICOM-C = Madhya Pradesh Madhya Kshetra Vidyut Vita, DPDC = Dhaka Power Distribution Company, FY = financial year, HV = high voltage, KSEB = Kerala State Electricity Board, kV = kilovolt, LECO = Lanka Electricity Company, LV = low voltage, MV = medium voltage, TPDDL = Tata Power Delhi Distribution.
Note: No regulatory loss targets have been established in Afghanistan, the Maldives, Nepal, and Pakistan.
Sources: Annual reports of the respective utilities.

In Bhutan, the licensee (Bhutan Power Corporation) does not publish losses in accordance with the definition used by the regulator (Bhutan Electricity Authority). In the Maldives and Nepal, no regulatory loss targets have been defined, and whatever targets established are as a matter of either government or utility policy. In India, where licensee boundaries were fixed several years ago, metering and reporting are generally in alignment with the licensee's physical network boundaries. With almost all licensed entities now being autonomous, albeit many remaining under government ownership, rewards and penalties for loss performance are not clearly identified in company accounts. In contrast, Tata Power Delhi Distribution and the Delhi Regulatory Commission have clearly identified the benefit to the distribution company owing to the loss target being exceeded.

It is evident that South Asian utilities and regulators have much to achieve in (i) defining losses, with a clear definition of inputs and outputs as well as disaggregation into technical and commercial losses; (ii) setting loss targets in a scientific manner; (iii) aligning measurement and reporting systems with the defined boundaries of licensed entities; (iv) improving measurement and reporting systems for losses; and (v) devising methodologies and mechanisms such that a utility is financially rewarded or penalized if it performs better or worse than the loss target. Distribution network planning and engineering, generally regarded as a noncritical task, needs to be upgraded to a task in which more resources are used to plan and monitor the operations. Simple analytical tools such as load flow analysis should also be established for distribution networks.

How much can the network losses be reduced? This question does not have a straight answer because networks are different from each other, largely depending on the communities and businesses served. Unless it is for a specific network in which customer positions along the lines and their demand profiles are accurately defined and modeled, it is not fair to make estimates on the maximum allowable loss (i.e., technical losses) on a line or a network. For example, a rural customer group in a typical South Asian village was modeled as follows: Distance from the nearest 33 kV/11 kV substation is 5 km from the center of the village and customers are distributed over a length of 2 km in three directions. The maximum demand of the village is estimated as 170 kilovolt-ampere. If customers are all equal and are assumed to be uniformly distributed along the line routes, the energy losses calculated are shown in Table 7.

Table 7: Technical Losses in Distribution Lines

Standard Design

Total Input	11 kV Network Loss		Transformer Loss		LV Loss (existing bare aluminum conductors)		Total Loss		Useful Energy Delivered
kWh/day	kWh/day	%	kWh/day	%	kWh/day	%	kWh/day	%	kWh/day
1,323.5	6.8	0.5	20.4	1.5	66.6	5.0	93.8	7.1	1,229.7

Medium-Voltage Distribution System with Insulated Aerial Bundled Conductors

Total Input	11 kV Network Loss		Transformer Loss		LV Loss (larger size bundled conductors, insulated)		Total Loss		Useful Energy Delivered
kWh/day	kWh/day	%	kWh/day	%	kWh/day	%	kWh/day	%	kWh/day
1,261.9	5.5	0.4	22.9	1.8	3.9	0.3	32.2	2.6	1,229.7

kV = kilovolt, kWh = kilowatt-hour, LV = low voltage.

Notes: All percent losses are calculated as a share of the input at 11 kV. The economics of using aerial bundled conductors, which are insulated, has to be evaluated.

Source: Authors' calculations.

Therefore, the total loss in a typical rural network in this model is 7.1%, while upgrading the low-voltage conductors with a higher cross-section and establishing a new MVDS would cause the distribution losses to be as low as 2.6%. Reducing technical losses from 7.1% to 2.6% is certainly a decision that requires an economic and/or financial evaluation to weigh the incremental investment against the longer-term benefit of energy saved.

Technical loss analyses and further analyses of options steer the debate on losses toward a clear answer: Technical losses in distribution networks can never be anywhere near the 25% levels being reported in several countries, regions, and states in South Asia. Even a long-distance, medium-voltage feeder, at the end of which there would be a transformer and a few radial distribution lines of the minimum cross-section area and which serves a varying customer load with a significant peak during the evening, would have a technical loss level of less than 10% of energy sent out. A typical utility has a mix of both urban and rural customers, and with that mix, the total technical loss in a distribution network is most likely to be below 10%, even if basic conductors and equipment are used. When transmission losses are added, the national loss in transmission and distribution should remain below 12% of net generation.

The indicative savings in India, Nepal, and Pakistan, which report losses above 12%, compared with the present losses would amount to about 100 terawatt-hours a year. Valuing electrical energy at a modest $0.05 per kilowatt-hour, the potential annual savings in South Asia would be $5 billion per year.

IV. MANAGEMENT OF DEMAND AND ANCILLARY SERVICES

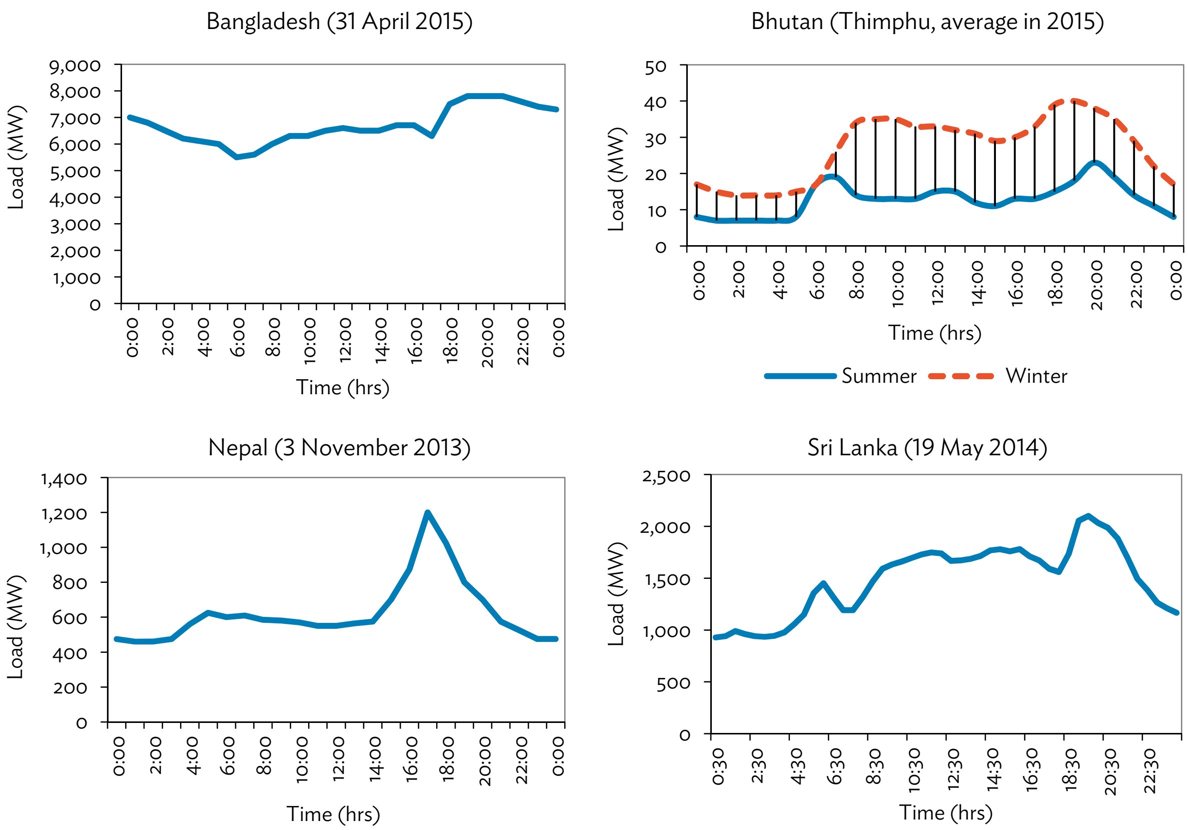
All utilities in South Asia experience relatively sharp peaks and valleys in the respective daily load profiles. Figure 1 shows a collection of load profiles in countries. All curves have a common feature: a sharp peak in the evening and very low demand in the off-peak period. The profiles indicate that all utilities need to provide assets that are used only a few hours a day. In case of power generation, storage hydropower (hydropower plants with a reservoir to store water) is an exception in that such plants can be operated for short periods over the peak time and storage hydropower can be retained in the water storage mode for the rest of the day. For countries that do not have such storage hydropower plants, the only option is to operate oil-fired or gas-fired power plants to meet the sharp peak.

Sri Lanka's daily load curve represents a daily load factor of 71%, while Nepal's is 52%. These low load factors indicate the need to manage customer demand and the existence of significant potential to impact customer demand through various means, which are generally referred to as demand-side management (DSM).[11] In general, DSM would improve asset utilization and produce savings for both the user and the supplier of electricity. Demand-management measures that include centralized or distributed generation of electricity such as pumped storage systems and renewable energy-based systems (e.g., net-metered solar photovoltaic) are not included in the following discussion.

---

[11] In this paper, DSM refers to policy and programs that are initiated and driven by state agencies or utilities, intervening either actively or in a passive sense, to alter customer demand for electricity.

Figure 1: Daily Load Profiles of Selected Countries in South Asia



hr = hour, MW = megawatt.
Source: Utilities in the respective countries.

Demand management can be achieved through indirect means or through load control. Indirect means have been more common and include (i) tariff-related measures such as time-of-use (TOU) tariffs, demand charges, and power factor and/or reactive power charges; (ii) appliance-related measures such as (a) free or concessionary provision of energy-efficient devices and appliances to customers, and (b) utility support for appliance energy performance standards, labelling, testing, and enforcement; (iii) building codes and similar initiatives supported by utilities; and (iv) customer education and advisory services.

The countries in South Asia are in various stages of implementation of these indirect measures of demand management. Some of the most common programs are those involving energy-efficient lighting such as compact fluorescent and light-emitting diode (LED) lamps as well as energy labeling of some of the commonly used appliances such as electric fans and refrigerators.

Direct load control includes the more recent approach to DSM, whereby smart metering and smart techniques are used to manage customer demand. With the integration of information technology, the demand side is now capable of providing more services to the power system and these initiatives are generally referred to as demand-side integration. Actions typically in a demand side integration program are (i) demand response, which is a mechanism to manage the demand in response to supply conditions; and (ii) demand-side participation, a set of strategies used in a competitive electricity market by end-use customers to contribute to the economy, system security, and environmental benefits. In general, such initiatives that result in direct load control, referred to as "smart techniques," may also be used to implement conventional DSM initiatives.

A. Indirect Demand-Side Management Initiatives

In keeping with the worldwide practice, TOU tariffs have been used by many utilities in the region as a tool to indirectly manage customer demand for a long time, and their implementation has now been made more convenient with the availability of programmable meters. Similarly, nearly all utilities in the region use increasing block tariffs to serve households (and also small businesses in some countries), to provide lifeline support to low users and to penalize high users. Table 8 shows a summary of the initiatives in each country and/or utility. TOU tariffs have not been reported in the Maldives. Similarly, utilities use demand charges, either fixed (based on contract demand) or variable (based on measured maximum demand over a billing period), to collect capacity revenues. Charging on the basis of measured demand is more appropriate in terms of DSM objectives, and that too on the basis of apparent power. This is because the customer power factor is reflected in the demand measured, if the measurement and charging is on the basis of apparent power. None of the utilities in the sample charge for reactive power, reactive energy, or poor power factor.

Table 8: Implementation Status of Tariff-Related Demand-Side Management Measures

Country/State	Increasing Block Tariffs	Time-of-Use Tariffs	Demand Charges	Reactive Power Charges
Bangladesh (e.g., DESCO)	Yes, for households	Yes, optional for nonhousehold customers	Yes	None
Bhutan BPC	Yes, for households	None	Yes, on measured real power demand for larger customers	None
India (e.g., MSED)	Yes, for households and smaller nonhousehold customers	Yes, mandatory for typically larger, nonhousehold customers	Yes, on measured apparent power demand for larger customers	None, but demand measured in apparent power, reflecting power factor
Maldives (MEA)	Yes, for all types of customer	None	None	None
Nepal (NEA)	Yes, for households	Mandatory, for medium and large (i.e., bulk), commercial and industrial customers	Yes, on measured apparent power demand for larger customers	None, but demand measured in apparent power, reflecting power factor
Pakistan (e.g., LESCO)	Yes, for households	Yes, mandatory for larger nonhousehold customers	On contract demand in kilowatts	None
Sri Lanka (CEB and LECO)	Yes, for households, and religious and small commercial customers	Mandatory, for medium-sized and large (i.e., bulk), commercial and industrial customers	Yes, for bulk customers, on measured apparent power demand	None, but demand measured in apparent power, reflecting power factor

BPC = Bhutan Power Corporation, CEB = Ceylon Electricity Board, DESCO = Dhaka Electric Supply Company, LECO = Lanka Electricity Company, LESCO = Lahore Electric Supply Company, MEA = Maldives Energy Authority, MSED = Maharashtra State Electricity Distribution Company, NEA = Nepal Electricity Authority.
Sources: Authors' observations.

Distribution of energy-efficient appliances free of charge or at concessionary rates has been widely implemented in the regions. Sri Lanka's compact fluorescent lighting program dates back to the 1990s. Various states in India have implemented similar programs. More recently, Nepal completed a program funded by the Asian Development Bank to distribute energy-efficient lighting devices. In most countries, such programs have now matured and market conditions determine a customer's decision to purchase such efficient appliances.

Utility-driven support to establish and operate appliance energy performance standards, though not common, are active in South Asia. Appliance energy performance standards have been established in many countries. In India, the Bureau of Energy Efficiency has introduced appliance energy performance standards, along with a performance labeling system. The labeling scheme and adherence to standards are currently mandatory for (i) frost-free refrigerators, (ii) tubular fluorescent lamps, (iii) room air conditioners, and (iv) distribution transformers. Such appliances are required to obtain "star" labels prior to sales. However, the standards are voluntary for 15 other appliances, with no compulsory requirement for sellers to obtain a "star" label. In Sri Lanka, under initiatives of the Sri Lanka Sustainable Energy Authority, energy performance standards and a mandatory labeling scheme are operational for tubular fluorescent lamps, and standards are being prepared for refrigerators, air conditioners, fans, and televisions. A standard for motors is also being prepared in Sri Lanka. In Bangladesh, Bhutan, the Maldives, and Nepal, appliance performance standards are in their early stages of preparation. Pakistan has certain initiatives active in this area.

B. Demand-Side Management through Direct Load Control

DSM through direct load control is at a very preliminary level in South Asia. Many pilot programs are in their initial stage of implementation. There are 14 smart-grid pilot projects currently operational in India, but their individual scope and the extent to which DSM can be implemented are unclear. These smart grid projects mostly establish automatic meter reading infrastructure, to be used for studies, pilot testing, and future implementation of DSM through direct load control. Clearer objectives and expected outcomes need to be established to fully harness the capability of such smart grid and smart metering initiatives. For example, a pilot project to be shortly initiated in Sri Lanka will examine the operation of a smart metering system at end users by establishing such infrastructure for about 400 customers, and implement active DSM measures including direct load control and passive DSM measures such as real-time pricing. Thus, the benefits of smart metering should be explored to secure its potential beyond a mere tool for convenient metering, to exercise active and passive control on customer demand, and to improve the overall economics of the power system operation.

V. INSTITUTIONS AND REGULATORY INITIATIVES

A government-supported institutional structure and regulatory tools are essential for the operation of DSM measures (supplier and utility initiatives) and for general energy efficiency implementation. Governments have established institutional and regulatory mechanisms in each country to deal with end users and end-use appliances, while initiatives involving energy utilities have been limited to appliance distribution, such as of compact fluorescent lamps. Implementation of DSM is weak in South Asia and has not moved beyond passive measures such as TOU tariffs.

A. Institutions to Promote and Regulate Energy Efficiency

The Government of India set up the Bureau of Energy Efficiency on 1 March 2002 under the provisions of the Energy Conservation Act, 2001.[12] The mission of the bureau is to assist in developing policies and strategies with a thrust on self-regulation and market principles, within the overall framework of the Energy Conservation Act, 2001 with the primary objective of reducing energy intensity of the Indian economy. The bureau largely works on the end-use area. The bureau has established appliance performance standards, both mandatory and voluntary, and continues to improve on the area of appliance energy efficiency. It manages the energy manager and energy auditor accreditation schemes, as well as information on energy management, for household-level users to larger users and for technical managers of energy-intensive facilities.

In Pakistan, the National Energy Conservation Centre was created in 1986. The center conducts a wide range of activities in building customer awareness, registration of energy audit firms, energy manager certification, and so on. Additionally, the center provides an advisory service to energy professionals and the general public on energy savings. It estimates the national energy conservation potential in different consuming subsectors to be between 20% and 30% of the present energy use. The center also operates the Energy Conservation Fund, which commenced with a fund of $7 million in 2005, and has conducted numerous studies and implemented projects. The center and the conservation fund extend credit for lease finance facilities (at below-market rates) for the equipment used for conservation of energy. Preference is given to those who have already obtained finance facilities from them with satisfactory repayment behavior or at least a good repayment history with other financial institution(s).

Sri Lanka has a long history of energy conservation initiatives that started with the establishment of the Energy Conservation Fund in 1985 by an act of Parliament. Currently, Sri Lanka's energy management and efficiency improvement drive is managed by the Sri Lanka Sustainable Energy Authority (SLSEA), the successor to the conservation fund. Established in 2007 by the SLSEA Act, the institution manages all the promotional and regulatory initiatives on energy efficiency on the customer end. These include appliance energy performance standards (compact fluorescent lights presently under mandatory labeling; standards and labeling schemes for other appliances have been drafted and will be implemented shortly). SLSEA manages the energy manager and energy auditor accreditation process, and it has established regulations to enforce mandatory energy reporting by large energy users. To strengthen the already ongoing work, SLSEA published the national energy management plan for 2012–2015, specifying targets to be achieved by the institution, which in turn resulted in national energy management targets.

Bangladesh recently in 2014 established the Sustainable and Renewable Energy Development Authority under its act of 2012. Its mandate includes the development and enforcement of standards for end-use appliances, energy management, and energy auditing. Bhutan, the Maldives, and Nepal, do not have agencies to specifically regulate and promote the efficient use of energy. Such work is carried out by various state agencies. In the case of Nepal, the Nepal Electricity Authority and the Water and Energy Commission Secretariat are largely involved with energy efficiency programs. The Department of Renewable Energy in Bhutan and the Maldives Energy Authority in the Maldives are responsible for activities relating to energy efficiency and conservation carried out through the power utilities. Additionally, in Nepal, the National Energy Efficiency Project, hosted by the Chamber of Commerce, has actively worked on capacity building for energy managers and energy auditors, as well as planning and implementation of energy management projects among industrial and commercial customers.

---

12 Bureau of Energy Efficiency, India. https://beeindia.gov.in/

B. Policies, Laws, and Regulatory Instruments Implemented

In Bangladesh, the National Energy Policy, 1996 contains statements related to TOU tariffs, energy-efficient lighting devices, promotion of other efficient systems and devices, energy managers and energy auditors, and promotion. However, there are no energy efficiency laws or other regulatory documents to compel suppliers and customers to be more efficient.

India's energy efficiency policy framework emanates from the Energy Conservation Act, 2001. It provides for the efficient use of energy and energy conservation. It further provides for the creation of the Bureau of Energy Efficiency at the national level, similar agencies at the state level, and a tribunal for energy conservation. The act also defines the roles and responsibilities of these institutions. It targets the following key activities: appliance standards and labeling, energy efficiency in the building sector and a building code for new buildings, energy benchmarking for designated consumers, energy efficiency in small and medium-scale industries, certification of energy managers and auditors, energy conservation awards, and other initiatives.

In Pakistan, the energy efficiency and conservation bill was passed by the Senate in June 2016 and provides for the establishment of the Pakistan Energy Efficiency and Conservation Board. The bill, once it is passed as an act, provides for a wide scope of activities and regulatory powers for the board and the National Energy Conservation Centre. These include capacity building and accreditation of energy managers and auditors, appliance-related standards and regulations, and so on.

In Sri Lanka, the National Energy Policy and Strategies, introduced in 2006, identified the demand-side energy efficiency improvements as a major strategic activity. The key initiatives of the 10-year plan to implement the strategies include the following: introduce labeling of appliances for energy efficiency by 2010, update and introduce mandatory energy efficiency building codes by 2009, and establishment of the SLSEA. The SLSEA Act 2007 provides the legal basis for institutional and regulatory initiatives. Several regulations have been issued under the act, such as the enforcement of appliance energy performance standards, mandatory energy reporting by large customers, appointment of energy managers, and energy management plans by large customers.

C. Professional Institutions Promoting Energy Efficiency

India and Sri Lanka have professional associations dedicated to the cause of energy efficiency improvement. The Society of Energy Engineers and Managers in India was established in 2005 and operates at the national level with a number of state chapters.[13] It works as a forum of professionals working on energy efficiency and is managed by a council. The society conducts a number of awareness programs and workshops at the chapter and national levels, as well as international and collaborative programs.

The Sri Lanka Energy Managers Association was founded in 1984 by a group of professionals to promote efficiency and rational use of energy in the country. In 1994, the association was incorporated by an act of Parliament but continues to operate as an independent professional organization. It regularly conducts extensive training courses, research, general awareness programs, and consultancy in energy and related fields. The association also participates in international and regional research projects on energy planning, management, and environment impacts of energy conservation. The association has

[13] Society of Energy Engineers and Managers. http://energyprofessional.in

been the pioneer organization in the energy efficiency field in Sri Lanka and the energy management professionals are linked through the organization, making it the common forum for the energy managers to share their experiences and excel in the energy efficiency field.[14]

VI. CONCLUSIONS

This paper discussed the current status of energy efficiency in the power sector, including the international experience and the experience in South Asia in particular. The paper also examined both the supply-side and demand-side opportunities for energy efficiency interventions available in South Asia.

With an appropriate combination of market instruments and regulations in areas where markets tend to fail, energy efficiency interventions can be successfully implemented. One of the key challenges that need attention is the lack of information and data to establish benchmarks and to measure improvements, particularly those involving private sector projects.

In South Asia, on the supply side, there is scope for significant improvement in coal-fired power plant efficiency improvements and loss reduction in transmission and distribution systems. By introducing a program of refurbishment and/or replacement of existing coal power plants with efficient technologies, these efficiency gains can be harnessed. Furthermore, transmission and distribution loss reduction efforts can incorporate innovative interventions, such as segregation distribution lines and managing them separately, and the installation of advanced metering systems coupled with appropriate regulatory targets for loss reduction for improving energy efficiency. On the demand side, indirect demand control mechanisms such as TOU electricity tariffs and the introduction of appliance standards have been used in South Asia for some time. Similarly, direct load control through smart metering can also play an important role, with increasing attention now being paid to employment of smart grids in the region.

South Asia has a significant potential for energy efficiency improvement in the power sector both on the supply side and on the demand side. These efficiency improvements can be realized with appropriate policies and programs that can be readily implemented. In most South Asian countries, the institutional structures for implementation of such energy efficiency improvement programs are adequate and mature.

[14] Sri Lanka Energy Managers Association. http://www.slema.org.lk

REFERENCES

Alliance to Save Energy. 2012. Top 5 Reasons to Be Energy Efficient. 20 July. http://www.ase.org/resources/top-5-reasons-be-energy-efficient

Campbell, Richard J. 2013. Increasing the Efficiency of Existing Coal-Fired Power Plants. Congressional Research Service. 20 December.

Cantorea, Nicola, Massimiliano Calìb, and Dirk Willem te Veldec. 2016. Does Energy Efficiency Improve Technological Change and Economic Growth in Developing Countries? *Energy Policy* 92: 279–285.

Central Electricity Authority (CEA), India. 2015. Norms for Coal Consumption in TPPs Issued on 15.01.2015. http://cea.nic.in/reports/others/planning/tppd/coal_cons_norms.pdf

———. 2016. *Generation Performance Report 2016*. Delhi.

Priyavrat Bhati. *Shutting Old Capacity: The 34-GW Question*. 2016. Centre for Science and Environment. New Delhi.

Juelsgaard, Morten, and R. Wisniewski. 2014. Distribution Loss Reduction by Household Consumption Coordination in Smart Grids. *IEEE Transactions on Smart Grid* 5(4): 2133–2144.

Geller, Howard, Philip Harrington, Arthur H. Rosenfeld, Satoshi Tanishima, and Fridtjof Unand. 2006. Polices for Increasing Energy Efficiency: Thirty Years of Experience in OECD Countries. *Energy Policy* 34(5): 556–573.

Kolenc, Marko, I. Papič, and B. Blažič. 2012. Minimization of Losses in Smart Grids Using Coordinated Voltage Control. *Energies* 5(10): 3768–3787.

Luong, Nguyen Duc. 2015. A Critical Review on Energy Efficiency and Conservation Policies and Programs in Vietnam. *Renewable and Sustainable Energy Reviews* 52: 623–634.

World Energy Council. 2013. *World Energy Perspective: Energy Efficiency Policies – What Works and What Does Not*. London.

Improving Energy Efficiency in South Asia

The paper examines the opportunities for energy efficiency in South Asian power systems. These opportunities exist mostly in the areas of operation of thermal power plants, electricity transmission and delivery systems and in demand management and conservation at the user-end. The paper concludes that there is scope for significant improvement in coal-fired power plant efficiency improvements and loss reduction in transmission and distribution systems. On the demand side expanded application of time-of-use electricity tariffs and appliance standards along with demand control through smart metering will improve efficiency. These improvements can be realized with appropriate policies and programs that can be readily implemented with the existing institutional framework.

About the Asian Development Bank

ADB's vision is an Asia and Pacific region free of poverty. Its mission is to help its developing member countries reduce poverty and improve the quality of life of their people. Despite the region's many successes, it remains home to half of the world's extreme poor. ADB is committed to reducing poverty through inclusive economic growth, environmentally sustainable growth, and regional integration.

Based in Manila, ADB is owned by 67 members, including 48 from the region. Its main instruments for helping its developing member countries are policy dialogue, loans, equity investments, guarantees, grants, and technical assistance.

ASIAN DEVELOPMENT BANK
6 ADB Avenue, Mandaluyong City
1550 Metro Manila, Philippines
www.adb.org