

# ENERGY TRADE IN SOUTH ASIA

## OPPORTUNITIES AND CHALLENGES

Sultan Hafeez Rahman  
Priyantha D. C. Wijayatunga  
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# Foreword

Regional cooperation provides an ideal opportunity to enhance sustainable growth by means of developing and sharing resources as a region, minimizing suboptimal development of these resources confined to national boundaries. In the context of the energy sector this is particularly applicable to the South Asia region where there is vast potential in under-exploited renewable energy sources such as hydropower, wind power, and solar power. Such cooperation in the energy sector will help countries to strengthen national energy security, reduce the costs of energy supplies, and minimize adverse impacts from energy price volatility. This will involve a wide range of actions including establishing cross-border infrastructure and promoting regional forums for sharing knowledge and experience widely available within the region.

The Asian Development Bank (ADB) has given due prominence to the importance of regional cooperation in the socioeconomic advancement of its developing member states. ADB's Strategy 2020 states that *"ADB fosters regional cooperation and integration initiatives in the region with investments in cross-border projects to accelerate growth and economic partnerships, as well as to address shared risks and challenges."* In line with Strategy 2020, the objective of ADB's Energy Policy of 2009 is to help its developing member countries provide reliable, adequate, and affordable energy for inclusive growth in a socially, economically, and environmentally sustainable manner. To achieve this objective, ADB's central role in promoting effective regional cooperation in the energy sector has been emphasized.

This publication is one of the key outcomes of an ADB-funded regional technical assistance project implemented through the South Asia Association for Regional Cooperation (SAARC). It was carried out over a period of approximately 3 years and involved national experts from each

of the SAARC member states who compiled country perspectives on energy sector development, presented the views of individual countries on regional cooperation, and discussed how to accommodate such cooperation within existing national policies and legal frameworks. Several international experts synthesized the national reports into a regional report and provided a regional perspective on energy sector cooperation. The study mainly relied on secondary data extracted from national sources and publications and other sources on regional cooperation. The study also carefully considered firsthand information provided by energy sector experts in SAARC countries and their experience in the sector. This regional report was endorsed by the 4th Meeting of SAARC Energy Ministers in Dhaka, Bangladesh in September 2011.

The final outcome of the study, in the form of a regional report, was carefully examined by the authors based on their extensive experience and knowledge of regional cooperation, not only in South Asia but also in other regions. This publication provides a carefully considered view on regional energy cooperation in South Asia. It considers the benefits of regional cooperation, provides an overview of the energy sector in South Asia, and examines the current regional trade and its prospects, with emphasis on five specific areas of intervention. It also considers opportunities for private sector participation in regional cooperation-related activities, along with a list of investment projects and feasibility studies that can be undertaken in different time frames. Considering the process undergone by the study leading to this publication, it will undoubtedly serve as a reliable reference on regional energy cooperation in South Asia and accepted by SAARC member states and energy sector professionals.

**Xiaoyu Zhao**

Vice President (Operations 1)  
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The authors gratefully acknowledge the support extended by all these individuals and institutions for their respective inputs, and the others who contributed in many ways to complete this publication.

# Abbreviations

ADB	Asian Development Bank
AEPC	Alternative Energy Promotion Centre
AFRA	average freight rate assessment
AFREC	Africa Energy Commission
AISA	Afghanistan Investment Support Agency
ANDS	Afghanistan National Development Strategy
ANSA	Afghan National Standardization Authority
APP	Asia–Pacific Partnership
APM	administered pricing mechanism
APPA	Africa Petroleum Producers Association
ATF	aviation turbine fuel
bbl	barrel
bbl/y	barrels per year
bcf/d	billion cubic feet per day
bcf/y	billion cubic feet per year
bcm	billion cubic meters
BERC	Bangladesh Energy Regulatory Commission
BEA	Bhutan Electricity Authority
BGCL	Bakhrabad Gas Systems Limited
BGFCL	Bangladesh Gas Fields Company Limited
BOGMC	Bangladesh Oil, Gas, and Minerals Corporation
BOT	build–own–transfer
BPC	Bhutan Power Corporation Limited
BPDB	Bangladesh Power Development Board
Btu	British thermal unit
CAGR	compounded annual growth rate
CAR	central Asian republic
CATS	Customers Access Terminal System
CDM	clean development mechanism
CEA	Central Electricity Authority

CEB	Ceylon Electricity Board
CIL	Coal India Limited
CNG	compressed natural gas
CPC	Ceylon Petroleum Corporation
DAE	Department of Atomic Energy
DGPC	Druk Green Power Corporation Limited
DHI	Druk Holdings and Investments Limited
DOED	Department of Electricity Development
DRC	Democratic Republic of the Congo
DRED	Department of Renewable Energy Development
EAC	Energy Advisory Committee
ECA	Economic Commission of Africa
ECT	Energy Charter Treaty
EMRD	Energy and Mineral Resources Division
EPF	Electric Power Forum
ETFC	Electricity Tariff Fixation Commission, Nepal
FOB	free on board
GDP	gross domestic product
GHG	greenhouse gas
GJ	gigajoule
GMS	Greater Mekong Subregion
GTCL	Gas Transmission Company Limited
GW	gigawatt
GWh	gigawatt-hour
HCU	hydrocarbon unit
HDI	Human Development Index
HEP	hydroelectric project
HSD	high-speed diesel
HVDC	high voltage direct current
ICE	Inter-Ministerial Commission for Energy
IDCOL	Infrastructure Development Company Limited
IOC	international oil company
IEA	International Energy Agency
IPI	Iran–Pakistan–India
IPP	independent power producer
IREDA	Indian Renewable Energy Development Agency
JGTDSL	Jalalabad Gas Transmission and Distribution System Limited
kcal	kilocalorie
KESC	Karachi Electric Supply Corporation
km	kilometer
kWh	kilowatt-hour
kV	kilovolt
Lao PDR	Lao People's Democratic Republic
LDC	load dispatch centre
LECO	Lanka Electricity Company

LNG	liquefied natural gas
LPG	liquefied petroleum gas
LDO	light diesel oil
LSHS	low sulphur heavy stock
MEA	Maldives Energy Authority
MEW	Ministry of Energy and Water
MMBTU	million British thermal units
MMPA	million metric tons per annum
MOP	Ministry of Power
MOPEMR	Ministry of Power, Energy and Mineral Resources
MOF	Ministry of Finance
MOFA	Ministry of Foreign Affairs
MOFT	Ministry of Finance and Treasury
MOWR	Ministry of Water and Resources
MNRE	Ministry of New and Renewable Energy
MMTOE	million metric tons of oil equivalent
MT	metric ton
MW	megawatt
MWh	megawatt-hour
NCL	Nepal Coal Limited
NCRE	nonconventional renewable energy
NEP	National Energy Policy
NELP	New Exploration Licensing Policy
NEEPCO	North Eastern Electric Power Corporation
NGL	natural gas liquids
NLDC	National Load Dispatch Center
NOC	Nepal Oil Corporation
NGO	nongovernment organization
NHPC	National Hydro Electric Power Corporation
NPCIL	Nuclear Power Corporation of India Limited
NSP	National Solidarity Program
OGRA	Oil and Gas Regulatory Authority
O&M	operations and maintenance
PAEC	Pakistan Atomic Energy Commission
PEEREA	Protocol on Energy Efficiency and Related Environmental Aspects
PEPP	Petroleum Exploration Promotion Project
PGCL	Paschimanchal Gas Company Limited
PFC	Power Finance Corporation
PLF	plant load factor
PTC	Power Trading Corporation Limited
PPA	power purchasing agreement
PPP	purchasing power parity
PRC	People's Republic of China
PRR	Priority Reform and Reconstruction Program

PSO	Pakistan State Oil
PTC	Power Trading Corporation
PUCSL	Public Utilities Commission of Sri Lanka
R/P	reserves-to-production
REC	Rural Electrification Corporation
RERA	Regional Electricity Regulatory Association
RETA	regional technical assistance
RET	renewable energy technology
RIPA	Regional Integrated Program of Action
RPG	regional public good
RPGCL	Rupantarita Prakritik Gas Company Limited
RPTCC	Regional Power Trading Coordination Committee
Rs	Indian rupees
SAARC	South Asian Association for Regional Cooperation
SADC	Southern African Development Community
SADF	South Asian Development Fund
SAPP	Southern African Power Pool
SDF	SAARC Development Fund
SEB	state electricity board
SERC	state electricity regulatory commission
SFRPS	SAARC Fund for Regional Projects
SGFL	Sylhet Gas Fields Limited
SHS	solar home system
SKO	superior kerosene oil
SMS	SAARC member state
SPP	small power producer
SPV	special-purpose vehicle
SRETF	SAARC Renewable Energy Task Force
SRETS	SAARC Regional Energy Trade Study
SRF	SAARC Regional Fund
SCA	Sindh Coal Authority
SNGPL	Sui Northern Gas Pipe Line Company Limited
SSGCL	Sui Southern Gas Company Limited
STEM	short-term energy market
STELCO	State Electric Company Limited
STO	state trading organization
T&D	transmission and distribution
TAPI	Turkmenistan–Afghanistan–Pakistan–India
tcf	trillion cubic feet
tcf/y	trillion cubic feet per year
TERI	The Energy and Resources Institute
TGTDCL	Titans Gas Transmission and Distribution Company Limited
toe	ton of oil equivalent
TSO	transmission system operator



UNDP	United Nations Development Programme
US	United States
USAID	United States Agency for International Development
WEC	World Energy Council
WTO	World Trade Organization

# Energy Conversion Factors

## Basic Energy Units

1 joule = 0.2388 calories

1 calorie = 4.1868 joules

1 British thermal unit (Btu) = 1.055 kilojoules = 0.252 kilocalories (kcal)

## WEC Standard Energy Units

1 metric ton of oil<sup>1</sup> equivalent (toe) = 42 gigajoules (GJ) (net calorific value) = 10,034 million calories

1 ton of coal equivalent = 29.3 GJ (net calorific value) = 7,000 million calories

## Volumetric Equivalents

1 barrel = 42 US gallons = approximately 159 liters

1 cubic meter = 35.315 cubic feet = 6.2898 barrels

## Electricity

1 kilowatt-hour (kWh) of electricity output = 3.6 megajoules = approximately 860 kcal

## Representative Average Conversion Factors

1 ton of crude oil = approximately 7.3 barrels

1 ton of natural gas liquids = 45 GJ (net calorific value)

1,000 standard cubic meters of natural gas = 36 GJ (net calorific value)

1 ton of uranium (light-water reactors, open cycle) = 10,000–16,000 tons of oil equivalent (toe)

1 ton of peat = 0.2275 toe

1 ton of fuel wood = 0.3215 toe

1 kWh (primary energy equivalent) = 9.36 megajoules = approximately 2.236 million calories

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<sup>1</sup> The ton of oil equivalent currently employed by the International Energy Agency and the United Nations Statistics Division is defined as 107 kilocalories, net calorific value (equivalent to 41.868 GJ).

# Executive Summary

**R**egional cooperation provides a major opportunity for individual countries to address barriers to sustainable inclusive economic growth, especially in the energy sector. Examples of successful cooperation in pursuing sound energy policies can be found in different parts of the world, particularly in sharing electricity generation through cross-border transmission interconnections. Estimates suggest that in Europe, electricity system interconnection has resulted in a 7%–10% reduction in generation capacity costs. Similar cooperation within the United States has been estimated to bring benefits in the order of \$20 billion. A study of the Greater Mekong Subregion in Southeast Asia suggests that regional cooperation in energy could reduce energy costs by nearly 20%, for a saving of \$200 billion during 2005–2025.

To examine benefits of regional energy cooperation in South Asia, the South Asian Association for Regional Cooperation (SAARC) requested the Asian Development Bank (ADB) to conduct the SAARC Regional Energy Trade Study (SRETS). The effort was the main component of a Regional Technical Assistance (RETA) project to promote energy sector cooperation in the SAARC region. The study focused on the potential for regional energy trade and the preliminary feasibility of developing transnational electricity, gas, and oil projects. The SRETS is based on secondary data from SAARC member states (SMSs), reviews of earlier studies on regional energy trade, and consultations with the relevant stakeholders across the region.

## SAARC Energy Sector

The SAARC region is home to 23% of the total world population, and a large proportion of the population is living below the poverty line. There is a wide variation in the energy resource endowments among the SMSs, particularly

in relation to hydropower, natural gas, and coal resources. The SAARC region is well endowed in other renewable energy sources such as biomass, wind, and solar with biomass meeting a large portion of household energy demand across the region. The energy demand in the region is expected to grow at an annual rate of 5%, with the household and industry sectors as main contributors.

Key challenges faced by the energy sector include increasing energy deficits, single fuel dominance in the energy mix, rising import dependence, and lack of requisite energy infrastructure. Augmenting the energy supply and diversifying the fuel basket requires inter- and intra-regional energy trade. In this regard, apart from existing initiatives on intra-regional energy transfer, a few interregional trade proposals have also been under discussion.

## **Current Intra-Regional Energy Trade**

The existing intra-regional energy trade among SMSs is limited to electricity trade between India and Bhutan, and India and Nepal, and trade in petroleum products between India and Bangladesh, Bhutan, Nepal, and Sri Lanka. While the electricity traded is based on indigenous hydropower resources, the petroleum trade is based on India importing and refining crude oil and exporting petroleum products to Bhutan, Nepal, and Sri Lanka. India is also exporting diesel to Bangladesh. India and Nepal have recently agreed to construct a 40-kilometer (km) pipeline to transport petroleum products from India to Nepal.

## **Intra-Regional Energy Trade Expansion Prospects**

An electricity transmission interconnection of 500 megawatt (MW) capacity between Bangladesh and India is also currently under implementation with assistance from ADB. The feasibility study for an India–Sri Lanka power transmission interconnection is also being carried out. Given the severe power shortages in Pakistan and the open access power transmission possibilities in India, it may be possible to reconsider the power transmission interconnection between Dinanath (near Lahore, Pakistan) and Patti (Punjab, India).

## Current and Proposed Interregional Energy Trade

The current interregional energy trade between South Asia and other regions includes petroleum, coal, and limited electricity. The interregional electricity trade is limited to Afghanistan importing power from central Asian republics (CARs) and Pakistan from Iran. But the volume of this trade is insignificant in comparison to its potential and is constrained by the infrastructure available. In the meantime work on the Central Asia–South Asia (CASA) 1000 power link, the Iran–Pakistan–India (IPI) natural gas pipeline and the Turkmenistan–Afghanistan–Pakistan–India (TAPI) natural gas pipeline have also progressed significantly.

India is developing the Tamanti hydropower project (1200 MW) in Myanmar for export to India. Also, India proposes to bring in natural gas from Myanmar through a pipeline passing through Bangladesh, and has sought a mutually beneficial agreement on the use of the right-of-way.

## Additional Energy Trade Options

The SRETS recommends further intra-regional energy trade options that would bring in substantial additional energy to SMSs as follows:

- **Regional Power Market.** An option available for the region to reduce electricity shortages is to promote enhanced electricity trade in any surpluses. The current initiatives and existing and proposed bilateral trading arrangements provide an ideal environment for a regional power market. The present bilateral trade arrangements can graduate to multilateral trade arrangements. The interconnections necessary to expand the regional power market would need to be established in a phased manner.
- **Regional Refinery.** Although there would be an increase in the demand for petroleum products, opportunities for refinery capacity expansion in the region are limited. Given this background, interested SMSs could consider cooperating to set up a state-of-the-art large-scale regional refinery, with adequate flexibility to accommodate a range of crude oils, to meet the petroleum products demand of the region. This will allow SMSs to benefit from economies of scale in refinery operations as well as in crude oil procurement.
- **Regional Liquefied Natural Gas Terminal.** In the context of energy security concerns and the need to use cleaner forms of energy, there has been an increased focus on natural gas to augment energy supplies. Given that India is already a liquefied natural gas

(LNG) importing country, and that Bangladesh and Pakistan are also considering LNG imports, the region could benefit from embarking on a bulk regional LNG terminal to capture the benefits of economies of scale from terminal size and bulk LNG procurement. Development of the incremental natural gas distribution infrastructure needed would be a parallel requirement. The ownership and financing of the LNG terminal can be appropriately structured as a joint venture of the interested SMSs and the private sector.

- **Regional Power Plant.** Part of this LNG-based power generation presently being considered by India could be in the form of a bulk regional power plant invested in by interested SMSs, with adequate power interconnections. This would bring the benefits of economies of scale in power plant operations and in natural gas procurement, preferably through the proposed regional LNG terminal. Imported coal-based mega power generating plants of the order of 4000 MW can also yield similar economies of scale, and one or more could be considered for development as a regional power plant.
- **Nonconventional Renewable Energy.** The SMSs are in the process of strengthening institutional arrangements, including tariff setting and technological innovations, to vigorously pursue nonconventional renewable energy (NCRE) utilization. These best practices of NCRE deployment can be shared among the SMSs and cross-border private sector investment in NCRE can be encouraged.

## Scope for Private Sector Participation

It emerges from the foregoing that clear opportunities exist for specific roles for the private sector in pursuing the intra- and interregional energy trade options including the four additional options identified to bring in further energy access to the SMSs. In the case of the intra-regional energy trade, potential for the private sector lies in the development of hydropower resources and associated power transmission. The proposed expansion of that regional power market would open up opportunities for wheeling power through cross-border interconnections. In the case of the interregional energy trade, private sector activity would be associated with providing the long distance cross-border bulk natural gas or electric power transmission. The four additional regional energy trade options proposed also offer major opportunities for private sector participation.

## Conclusion

The SMSs need to cooperate to improve regional cross-border energy exchange by facilitating integration of their energy markets through electricity and gas interconnections. In this regard, transparent open access to transmission infrastructure and agreeing to common protocol and harmonious legal, regulatory, and economic rules would be essential. This requires SMSs to develop an SAARC Regional Energy Trade and Cooperation Agreement and consider adopting a regional trade treaty. It would also be necessary for the SMSs to carry out more detailed study of the intra- and interregional energy access augmentation options discussed. Clear identification of the opportunities for private sector participation in these options is also required.

Energy infrastructure projects that can be considered for implementation within a 5-year period include (i) an India–Nepal oil product pipeline, (ii) an India–Nepal power interconnection from Dhalkebar to Muzaffarpur (preparation for implementation is already at an advanced stage), and (iii) an India–Pakistan power interconnection from Patti to Dinanath. Improvement of the enabling environment for enhanced NCRE development is also an important short-term activity.

Those that can be possibly implemented in a 5–15 year period include the following:

- (i) India–Sri Lanka power interconnection (feasibility study is being carried out jointly by the governments of India and Sri Lanka),
- (ii) India–Nepal power interconnection from Gorakhpur to Butwal,
- (iii) Central Asia–Afghanistan–Pakistan power transmission interconnection,
- (iv) Iran–Pakistan–India gas pipeline,
- (v) Myanmar–Bangladesh–India gas pipeline,
- (vi) Turkmenistan–Afghanistan–Pakistan–India gas pipeline,
- (vii) Expansion of the regional power market,
- (viii) Establishment of a regional crude oil refining facility and creation of an SAARC strategic petroleum reserve,
- (ix) Establishment of an LNG terminal for the region and associated natural gas distribution facilities, and
- (x) Establishment of bulk power generation for regional consumption.

## Chapter 1

# Introduction

## Context

The South Asian Association for Regional Cooperation (SAARC), comprising Afghanistan, Bangladesh, Bhutan, India, the Maldives, Nepal, Pakistan, and Sri Lanka, is characterized by stark contrasts. The region has a population of approximately 1.5 billion, which is nearly 23% of the total world population, living on 5% of the world's land mass. The total gross domestic product (GDP) of the region amounted to \$3,860 billion in 2009,<sup>1</sup> but was less than 3% of the world's total GDP. On the other hand, it is one of the fastest growing regions in the world. It experienced an average annual GDP per capita real growth rate of 5.2% from 2000 to 2009.<sup>2</sup> Countries such as Bhutan and India have developed at even higher per capita GDP growth rates of 6.8% and 5.6%, respectively. This economic growth is expected to facilitate the alleviation of widespread poverty in the region.

One of the key inputs needed to sustain and accelerate economic growth in the region is increasing access to energy, as there is a strong direct relationship between economic growth and energy demand. Upward social mobility associated with faster economic growth further accentuates the demand for energy. This puts pressure on all SAARC member states (SMSs) to ensure a continuous and reliable supply of energy in its various forms. Although the region as a whole is well endowed with diverse energy resources, including renewable energy, a large part of these resources remains to be tapped, for various reasons. Limited availability of indigenous energy supplies, coupled with the large population base, makes the region significantly dependent on

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<sup>1</sup> The GDP is in purchasing power parity basis.

<sup>2</sup> ADB (2010a). The country average per capita GDP growth rates, where available, were weighted by 2005 population.



energy imports. The diversity of energy resource endowment between South Asia and its neighboring energy-resource-rich regions provides opportunities for interregional energy trade to reap the optimum benefits from available resources. Several of these opportunities have been identified in earlier studies. However, the geopolitics involved and competition from alternative-energy markets makes interregional energy trade a challenging proposition.

Recognizing the importance of intraregional and interregional energy trade and at the request of the SMSs for a study on that trade, the Asian Development Bank (ADB) approved a Regional Technical Assistance (RETA) project in December 2006 to promote energy sector trade and cooperation in the SAARC region and also strengthen the SAARC Energy Centre.<sup>3</sup> The major component of the RETA project is an SAARC Regional Energy Trade Study (SRETS). The study focuses on the opportunities and challenges associated with energy trade in South Asia. It reviews the prevailing trade regimes and the regulatory and legal frameworks of the SMSs; examines the international and regional best practices and their relevance as well as applicability to the region; and assesses the various technological, financial, and commercial options for promoting trade and related projects. The study is an effort to augment the efforts of the SMSs to find the most appropriate and economically feasible solutions to help meet their growing energy needs, to the extent possible through national resources and through regional energy trade. It is based on data provided in the eight country reports prepared by the national country experts (national consultants), reviews of earlier studies done by national and international organizations related to regional energy trade, and discussions held with the concerned stakeholders across the region.

### Message

The message conveyed by the study highlights the importance of regional participation of the SMSs within an accepted legal and regulatory framework to establish public and private regional energy trade mechanisms that would facilitate the SMSs to meet their future energy demands, while recognizing the welfare gains of collective action in comparison to unilateral actions by individual member states. Considering the increasing regional demand for natural gas, mainly for more environmentally acceptable electricity generation, and the limited indigenous natural gas resources of the region as well as access to piped natural gas from outside the region, the study underlines the economy of scale advantages that can be gained through bulk liquefied natural gas (LNG) import and gasification in association with bulk natural gas-based electricity generation for regional use. Increased natural

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<sup>3</sup> ADB (2006b).

gas connectivity of the region, facilitated by the planned integration of the natural gas systems in India, would enable diversification of LNG-based natural gas into other uses within the region. The study also brings out the economy of scale benefits that can be obtained through bulk regional crude oil refining with the harmonization of the regulatory policies to facilitate regional distribution of the petroleum products. The importance of tariff incentives in particular to achieve greater penetration of the large renewable energy potential in the region is also addressed in the study.

## Chapter 2

# Regional Cooperation and Energy Trade

Regional cooperation can complement national programs and projects to enhance growth and energy security. Across the region, poverty is still widespread, but rapid growth in some countries shows that policy environments can be *pro-growth* and that historic problems can be overcome. Within the broader set of economic policies, energy policies must play an essential role in sustaining the economic growth in the South Asian region. SAARC member states (SMSs) need to ensure energy security, reduce the costs of energy supplies, and cushion themselves from possible oil price shocks. This will involve a wide range of actions, including providing public goods and for cross-border infrastructure.

## Regional Cooperation

Regional cooperation refers to countries coming together in joint efforts to address common problems or to make use of the opportunities. Regional cooperation produces results and incurs costs that are typically unevenly spread across the group of countries—thus considerable negotiation is required in any regional effort to ensure that all perceive that the effort merits the expense. Examples of regional cooperation initiatives include: (i) cross-border infrastructure such as transborder bridges or roads, and transmission lines; (ii) free trade agreements that jointly set the policy environment governing trade in goods or services between countries; (iii) cooperation to reduce the spread or impact of pandemics such as avian influenza; and (iv) collective efforts to contain transborder pollution such as acid rain.

As suggested by the above examples, regional cooperation can come in many forms, depending on the particular group of countries and the purpose for their collective action. ADB classifies these types of activities in four different classes or pillars of ADB's Regional and Subregional Economic Cooperation Programs:<sup>4</sup>

- **Pillar 1.** Cross-border Infrastructure and Related Software
- **Pillar 2.** Trade and Investment Cooperation and Integration
- **Pillar 3.** Monetary and Financial Cooperation and Integration
- **Pillar 4.** Cooperation in Regional Public Goods

Three of these pillars encompass energy sector activities. For instance, Pillar 1 includes cross-border electricity transmission systems and pipelines, and Pillar 2 covers the development of regional trade in electricity, petroleum, or natural gas. Joint capacity building and research on subjects such as solar technology, reducing climate change impacts, and technical standards, which enable interconnections of gas pipes, transmission lines, etc., are parts of Pillar 4.

Regional cooperation is a tool, complementary to purely national programs and policies, in pursuing national goals. Here, the issue of regional institutions becomes relevant. The word "regional" carries the suggestion of a supranational initiative, and there are many examples of supranational institutions, such as the United Nations, to support mutual cooperation. Supranational institutions can ease cooperation by reducing the transaction costs of negotiation, and supporting research and consultations. However, not all transborder projects require transborder institutions. The Greater Mekong Subregion (GMS)<sup>5</sup> program, for example, has an impressive track record since 1990 of coordinating more than \$10 billion of investments in cross-border infrastructure including airports, bridges, electricity transmission lines, railroads, and roads. In spite of this impressive record, GMS runs without a headquarters institution, but is coordinated through ADB staff working as a secretariat.

## Regional Public Goods

An optimal mix of public and private actions are necessary for a successful regional program. The concept of public good helps in understanding the role of the governments in a regional program. A public good is *non-rival* (consumption by one person does not diminish the availability for other

<sup>4</sup> See ADB (2007).

<sup>5</sup> The GMS includes five mainland Southeast Asian countries (Cambodia, the Lao People's Democratic Republic, Myanmar, Thailand, and Viet Nam) and the People's Republic of China.

people) and *non-excludable* (if offered to one person, the good becomes available to others) as opposed to normal private goods, the consumption of which can be controlled by suppliers. These two characteristics allow free riding, and markets fail to supply public goods at optimal levels. This justifies government interventions in the provision of public goods. One familiar class of goods or services that has some aspects of public goods is a *club good*.<sup>6</sup> Club goods are those goods or services that are characterized by excludability, but at certain levels of service provision show non-rivalry in consumption. The classic example would be a swimming pool in a small community. It is fairly easy to exclude people from enjoying the service—a fence and a gate are all that is required. But at low levels of use, one additional person does not cost anyone anything: consumption exhibits non-rivalry. Electricity or natural gas transmission systems have some aspects of club goods: as distinct from the supply costs of electricity or natural gas, the incremental operational costs of transmission are small for an additional user, up to some level of usage.

Conversely, there are goods that show some features of non-excludability, but show rivalry in consumption—these are called *local public goods*. Examples include a local highway system that is congested from high usage. Excludability is difficult or prohibitively expensive, yet additional users impose costs upon everyone.

These examples are important in that they help set the context to discuss an increasingly important set of issues—the provision of *regional public goods* (RPGs). In theory, RPGs exhibit characteristics of public goods and are shared by two or more countries.<sup>7</sup> In practice RPGs are often *impure public goods*—they do not share every characteristic of a public good completely—and need to be approached from an understanding of their specific conditions of supply and consumption. Most importantly, these goods and services require the intervention of two or more governments to ensure that needs and opportunities for growth are met.

ADB has identified six categories of RPGs that affect inclusive growth in Asia and the Pacific, two of which are also focal areas for energy policy: (i) clean energy and energy efficiency, and (ii) the environment—especially in

<sup>6</sup> The discussion on club goods and local public goods draws on David M. Nowlan (n.d.), University of Toronto.

<sup>7</sup> ADB (2007), p. vii. The terminology can vary. For instance, the United Nations Millennium Project website includes energy infrastructure in regional public goods, stressing the need for public or governmental involvement in the funding and legal arrangements of these very costly projects in developing countries. Ferroni (2002) is an example of the literature that is closer to the ADB usage.

transborder areas.<sup>8</sup> The category of clean energy and energy efficiency especially calls attention to the need for research on solutions to common problems. This research is expensive, the results need to be shared to have impact and there is little or no cost to having more people learn of the work once it is done. Thus it would be inefficient to rely upon private firms to supply the research needed, capturing the benefits of the research through user fees. Clean energy and energy efficiency research initiatives have public good elements and there is a clear need for governments to become involved in supporting this work. Similarly, in reducing the impact of economic growth on the environment, research into improving waste management, mitigating climate change, finding ways to reduce air and water pollution, improving soil management techniques, and similar efforts all have elements of public goods and require government support.

The second category, the protection of transborder environments (for instance the reduction of cross-border pollution) is equally important, and also calls for cooperative international action. Air and water pollution do not respect borders. Industrial production and agricultural practices, such as clearing forests by burning, can create pollution that can impact on people in other countries. Pollution generally is considered an economic *externality*—a cost imposed on people outside of those directly involved in the economic activity that generated the pollution. Externalities are not reflected in a private company's supply costs and thus, like public goods, require the intervention of governments to bring an efficient allocation of resources. Regional externalities extend this concept further; one country's action can affect the neighboring countries, requiring common solutions. The use of various sources of energy for power generation, transport, and industries generates various pollutants, some of which become trans-boundary pollution issues. Hydropower generation in trans-boundary rivers can cause regional environmental issues, whose resolution requires cooperation among countries involved.

Externalities are present in many cross-border activities. The provision of electricity or commercial energy in a border area that helps spark development can have "spill-over" effects on both sides of a border, encouraging faster growth in neighboring regions. Conversely, the commercial energy shortages in a given border area can contribute to deforestation throughout the cross-border neighborhoods. This is an example of a negative externality. All governments have an interest in border area development and joint programs have proven a necessary component of this broader action. A common understanding of benefits and mutual trust are also quasi-public goods and without concerted efforts by the countries involved, together

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<sup>8</sup> The other four areas are (i) disaster management, (ii) communicable diseases, (iii) governance, and (iv) human and drug trafficking. ADB (2007).

with a regional facilitator such as ADB, the necessary enabling environment for regional energy infrastructure would not be developed.

### **The Benefits of Regional Energy Trade**

The previous discussion sets the stage for understanding the role of governments and development partners in promoting regional cooperation. How can governments in a region that have had conflicts, wars, and a lack of mutual trust be convinced to work together to reap the benefits of regional cooperation? The enormous potential economic benefits of regional cooperation realized by other regions can be used as a motivating factor for regional cooperation in energy. The following sections describe the benefits of regional cooperation in energy and provide convincing examples of such benefits.

### **Diversity in Supply amid Narrow Comparative Advantage**

Developing nations require a wide range of energy goods and services. As communities move away from traditional agriculture and develop industrial and service sectors, the demand for commercial energy increases. Transport fuels and electricity become particularly important inputs. Few countries have domestic energy resources that mirror their domestic demand. The international trade in energy allows countries to balance this important demand and supply, exploiting their own unique comparative advantage while meeting increasingly diverse energy requirements. Cross-border collaborative investments in energy infrastructure can lower supply costs and ease the financing constraints for these enormously expensive projects.

### **Sustainable Growth Opportunities for Small Exporting Economies**

Trade, especially in energy goods and services, can be particularly important for small economies. Small economies are unlikely to have the wide range of natural resources that could match evolving patterns of demand for energy. The Maldives and Sri Lanka, for example, have very limited domestic energy resources, especially relative to the needs of a rapidly developing economy. Nepal, despite its vast hydropower resources, still falls into this category since its resources are largely untapped. Indeed it is only through trade that these economies are able to grow: exporting resources in which they have a relative comparative advantage, and importing a wide range of other goods and services. From the standpoint of energy resources, Bhutan has moved to develop its hydroelectric power resources, exchanging electricity exports for other imports, including petroleum products, while Nepal is also striving

toward a similar hydropower trading environment. This type of international trade, especially when based on cross-border project financing, allows for a win–win rationalization of resource costs and project benefits.

## Relief for Energy Constraints to Rapid Economic Growth

The need to rebalance energy supply and demand is evidenced by the stark energy shortages that are present across South Asia, particularly of electricity. Electricity shortages discourage investment and hobble growth. They impose enormous costs, often ignored or underestimated. A study by the United States Agency for International Development (USAID) estimated that planned outages in Sri Lanka and Bangladesh in the past used to cost their economies the equivalent of one-half percentage point of GDP in the respective years.<sup>9</sup>

Table 1 provides figures on the scale of electricity shortages experienced in the larger South Asian countries. The figures are derived from government sources and generally refer to estimates of the gaps between supply and peak demand. These are only illustrative, as there is no unambiguous way to measure the gap between the supply and demand for a utility service. Electricity shortages are a function of demand, which changes over the course of the day and the season; of changing tariffs and economic growth; and on supply, which can vary with rainfall-generated hydropower and maintenance schedules for facilities. In spite of this uncertainty, the data paint a picture of a serious lack of capacity to meet existing demand.

These estimates can be supplemented with anecdotal evidence of the extent of shortages. In India, for instance, small enterprises in Maharashtra

**Table 1 Estimated Capacity Shortages**

Country	Estimated Capacity Shortage (megawatts)	Percentage of total Installed Capacity (%)
Bangladesh	1,900	31.7
India	10,296	12.0
Nepal	336	43.6
Pakistan	5,230	44.5

Sources: Annual Reports of Bangladesh Power Development Board; Central Electricity Authority, India; Nepal Electricity Authority; and National Electric Power Regulatory Authority of Pakistan.

<sup>9</sup> Wijayatunga and Jayalath (2004) and Wijayatunga and Jayalath (2008) discuss the impact of power shortages in Sri Lanka and Bangladesh.



faced 1–2 days without power each week in 2007. Small firms neither have recourse to alternative power sources, as some large industries do, nor the financial resources to easily withstand extended periods of closure. Similarly, in Pakistan in 2008, steel mills, textile mills, businesses, and retail centers were shuttered to ease power demand, with economic losses projected to run into billions of dollars (Anthony 2008). Similar examples can be found for the other countries.<sup>10</sup>

Regional cooperation and regional energy trade can be means by which SMSs better align supply and demand for specific forms of energy and combat energy shortages. Bhutan and Nepal, for instance, have significant hydropower resources. Bhutan exports to India approximately 5,620 gigawatt-hours (GWh) each year, and Nepal intends to do the same in the future. Exports of hydropower ease India's electricity supply constraints and finance imports, including petroleum products, for the smaller nations.

### Supply Cost Reduction

Cross-border infrastructure development can also ease the huge burden of energy infrastructure investment required in South Asia. Gas and oil pipelines, electricity transmission lines, and hydropower facilities are enormously expensive. If the costs and benefits of the projects can be shared, it can reduce immediate financing burdens, smooth cash flows, and lower project risks for individual countries.<sup>11</sup> Given the combination of big and small economies in the region and different income levels, some countries invest more on regional energy infrastructure, easing the burden on less developed, smaller countries. Cross-border electricity distribution can be the only cost-effective way to bring poor border areas within a reliable distribution grid. The cross-border interconnection of electricity grids can also help balance the needs of national markets, which may have different demand and supply patterns.

Similarly, cross-border trade in petroleum products lowers overall resource costs by allowing for regional refinery centers to achieve larger economies of scale. A regional refinery can serve a wider market than if it were confined to any given national market base. Currently, India exports refined petroleum products to Bangladesh, Bhutan, Nepal, and Sri Lanka. The dependency of the region on imported natural gas may similarly provide scope for regional

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<sup>10</sup> On Bangladesh, Energy Bangla (2008) titled its story, "Bangladesh: No Respite from Electricity Shortage." Gopal Sharma (2008) characterizes the situation in Nepal as "Nepalis face 16-hour daily power cuts."

<sup>11</sup> Across all sectors, ADB studies suggest that South Asian countries require infrastructure investment to the order of \$94 billion per year, but actual investment is only about one-half this total.

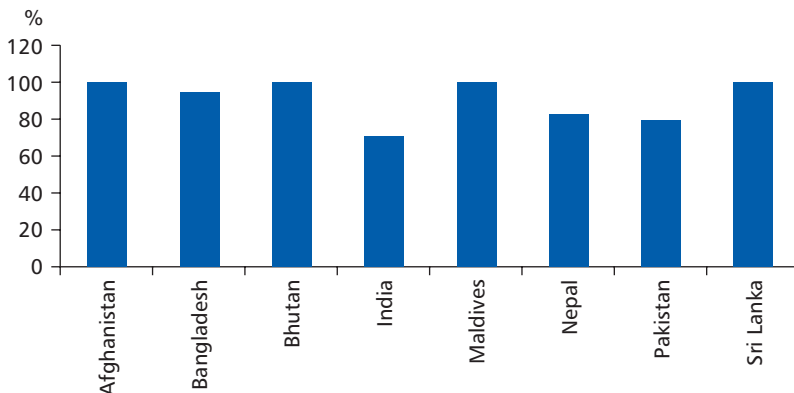
infrastructure to share the financing and project risk for gas pipelines or liquefied natural gas (LNG) terminals.

## Energy Security—Oil Price Shocks

Cooperation in energy policy can ease supply constraints and lower energy costs. The need for this is heightened by the likelihood that world oil prices will spike higher in the coming decades. Oil price increases in the 1970s twice destabilized economies across the globe. While there is no certain method of forecasting oil prices, current world trends suggest that demand will rise faster than supply, resulting in increased potential for sharply higher oil prices. South Asian countries are heavily dependent upon imported petroleum (Figure 1) and higher oil prices could reverse some of the economic gains seen in the past few decades.

Concerns over the possibility of a renewed round of oil price shocks emerged in the last decade when growth in developing countries, particularly the People's Republic of China (PRC) and India, raised fears of heightened competition for commodities to meet raising standards of living. The International Energy Agency (IEA 2008) has projected global primary energy demand to grow 36% from 2008 to 2035. Developing countries such as the PRC and India are expected to account for more than 90% of the increase. This puts pressure on energy supplies, especially oil—pressure which is projected to push oil prices up by 50%–100% by 2030.

**Figure 1 Net Petroleum Imports against Total Consumption in South Asia, 2007**



Source: United States Energy Information Administration.

## Climate Change Mitigation

A final issue to be examined in the context of regional cooperation in energy in South Asia is that of climate change—the results of the buildup of greenhouse gases (GHGs) in the atmosphere. Associated with global warming, GHG-induced climate change can bring higher sea levels and flooding of coastal areas; increased frequency and intensity of storms; and changing patterns of rainfall, affecting agriculture.

One set of efforts would be to mitigate climate change by reducing GHG emissions through improvements in energy efficiency and promotion of renewable energy. Raising energy efficiency, reducing the use of petroleum-based fuels for a given unit of economic activity, requires a wide range of efforts—from pricing policies to research initiatives. The SAARC provides a unique platform in which countries can work together and jointly consult, to understand what efforts would be most relevant to regional conditions. Regional projects offer unique opportunities for climate change mitigation and receiving clean development mechanism (CDM) benefits. Bhutan–India hydropower trade, for example, reduces coal power generation in India and helps to mitigate climate change. The first-ever regional CDM benefits were realized by Bhutan–India hydropower trade in 2010.

## Examples of Benefits of Cooperation in Energy

Box 1 discusses an example of cross-border natural gas provision in archipelagic Southeast Asia. The European Commission counts seven regional cooperation initiatives in electricity and three in natural gas among its member states (EKEM n.d.). Similarly, the Economic and Social Commission for Western Asia (ESCWA 2010) is working on four geographically different cross-border electricity interconnection initiatives. The Southern African Power Pool (SAPP) also provide an example of good practice in regional cooperation on energy (Annex 2). There is a particularly rich history, across the globe, in cross-border electricity supply.

Estimating and quantifying benefits from regional cooperation can be extraordinarily difficult. The analysis must be over a period of 2 decades or more, energy prices must be forecast, and demand and construction costs projected. These types of analyses can be challenging because of oil price fluctuation. For this reason, many formal models of the benefits of regional energy cooperation focus on cross-border electricity network interconnections. Here, standardized construction techniques and supply technologies reduce somewhat the challenges of modeling, and benefits can be identified through savings in supply costs. A report by Castalia (2008), for

### Box 1 **Indonesia–Malaysia–Singapore Natural Gas Pipeline**

Natural gas pipelines from Indonesia's gas fields to Malaysia and Singapore—extension of the Sumatran, Grissik-Duri pipeline, through Batam Island to Singapore—provided for balancing natural gas demand between nations. In the wake of the 1997–1998 financial crisis, Indonesian energy demand grew slower than earlier forecast, allowing natural gas supplies to be shared internationally with Singapore—a small nation with no significant domestic energy resources. Each country benefited; Singapore enhanced its energy security and Indonesia grew its exports.

example, cites studies by the United Nations that found regional cooperation in Western Europe, through electricity system interconnection, has resulted in a 7%–10% reduction in generation capacity costs—lowering the capital costs of supplying reliable energy. Similarly, the study cites benefits from cooperation within the US in the order of \$20 billion per year.

Regional energy cooperation is particularly active and important in Southeast Asia. On the mainland, there have been important programs to encourage cross-border electricity trade, by which two or more countries can exploit complementarities in supply and demand. Through a large number of specific investment projects, institutional capacity building, and policy reforms, the Greater Mekong Subregion (GMS) has encouraged the cross-border development of hydroelectricity resources to meet rapidly growing regional demand.

One salient GMS project is the Nam Theun 2 Hydroelectric Project, a 1,070-megawatt power plant built on the Nam Theun River in the Lao People's Democratic Republic (Lao PDR), financed by international financial institutions and private companies. The project is expected to export 5,354 gigawatt-hours (GWh) of electricity to Thailand, provide 200–300 GWh of electricity in Lao PDR, and yield \$1.9 billion of revenue for the government over the life of the project. The economy of Lao PDR received financing to develop a domestic resource for export; the economy of Thailand invested in a resource in a neighboring country to ensure electricity supply. Looked at narrowly from a project-financing standpoint, World Bank (2005, 23) studies estimated that Nam Theun 2 would yield a 16.3% real economic rate of return to the funds invested.

From the broader standpoint of the impact on development, Nam Theun 2 is one of a number of hydroelectric projects being planned or brought on line. Using somewhat conservative estimates, the World Bank country report for Lao PDR projected that the natural resource sector would become

an important driver of growth. The sector was anticipated to move from accounting for less than 2% of GDP during 1999–2002, to between 21% and 29% over 2006–2015, with GDP growth itself rising from 6.2% to between 7.1% and 8.0%.

The Nam Theun 2 project is only one example of a long-running program, under the auspices of the GMS, to realize the benefits of regional cooperation in the energy sector. Under this broad-based initiative, all countries stand to benefit. The quantification of such a diverse program is difficult, but some estimates are illustrative. A Japan Bank for International Cooperation study by Kawaguchi and Seki (2003) looked somewhat narrowly at the potential benefits from interconnecting the power systems in four countries—Cambodia, Lao PDR, Thailand, and Viet Nam. Even this somewhat restricted set of activities yielded estimates of benefits through regional cooperation of \$97 million annually, especially from “system reliability improvement and reduction in fuel cost.” This compares with an estimate solely for opening electricity trade, over the period 2001–2020, of \$10.4 billion (United Nations 2006, 86) as part of the study on electricity grid issues.

A broader modeling effort (Castilia 2008, 7) shows that regional cooperation on energy in the GMS could reduce energy costs by nearly 20%, for a savings of \$200 billion over 2005–2025. Thus Southeast Asia, with a population smaller than Western Europe, could potentially reap comparable benefits from a wide-ranging set of regional programs and projects in the energy sector. The benefits come particularly in view of the expected strong growth in energy demand and the ability to reduce energy costs in any given country by accessing energy resources in neighboring countries.

These examples, though not exhaustive, provide adequate justification for regional cooperation efforts on energy in any region. Given the vast diversity of resources and the economic growth potential in South Asia, regional cooperation on energy provides opportunities to accelerate economic growth and to sustain the growth momentum. This report describes potential avenues for energy trade and related regional cooperation.

## Chapter 3

# The SAARC Energy Sector: An Overview

## Social and Economic Indicators

There is a wide variation in the social and economic profile of the South Asian Association for Regional Cooperation (SAARC) member states (SMSs). For instance, the population in the Maldives is only approximately 315,000 people, while in India the population is more than 1 billion. Given the difference in land areas of the countries, a relevant social indicator is the density of population, i.e., the number of persons per square kilometer of land. The density of population varies from a low of 14 persons per square kilometer in Bhutan to as high as 997 in the Maldives.

Increased population density highlights the increasing pressure on land and national resources of the SMSs concerned. The per capita gross domestic product (GDP) of the SMSs (on a purchasing power parity [PPP] basis) also varies significantly and ranges from \$733 in Afghanistan to over \$4,862 in Bhutan. The Human Development Index (HDI) of the SMSs is somewhat similar, except for the Maldives and Sri Lanka, which are higher in ranking than the other states. The socioeconomic profile for the region is summarized in Table 2.

## Energy Reserves in the SAARC Region

Table 3 indicates the potential total energy reserves of various energy forms in the region.

**Table 2 Key Socioeconomic Indicators for the SAARC Region**

	Mid-Year Population 2009	Urban Population	Density of Population (2009)	HDI Ranking (2007)	HDI Index (2007)	GDP per Unit of Energy Use	GDP per Capita at PPP
Member States	Million (mid-year population)	% of Total Population	Persons per km <sup>2</sup>			toe/capita	PPP (\$)
Afghanistan	25.5	21.6	40.21	181	0.352	NA	NA
Bangladesh	144.2	25.4	988.68	146	0.543	7.2	1,585
Bhutan	0.7	30.9	15.08	132	0.619	NA	NA
India	1,165.9	29.4	354.57	134	0.612	4.9	3,287
Maldives	0.3	35.0	997.00	95	0.771	NA	NA
Nepal	27.2	17.2	199.47	144	0.553	2.9	1,236
Pakistan	165.2	35.8	204.68	141	0.572	4.6	2,666
Sri Lanka	20.5	15.1	323.79	102	0.759	8.6	4,713

GDP = gross domestic product, HDI = Human Development Index, km<sup>2</sup> = square kilometer, NA = not available, PPP = purchasing power parity, SAARC = South Asian Association for Regional Cooperation, toe = ton of oil equivalent.

Sources: Country Reports (2008).

**Table 3 Energy Reserves of SAARC Member States**

Country	Coal (million tons)	Oil (million barrels)	Natural Gas (trillion cubic feet)	Hydropower (megawatts)	Biomass (million tons)
Afghanistan	440	NA	15	25,000	18–27
Bhutan	2	0	0	30,000	26.60
Bangladesh	884	12	8	330	0.08
India	90,085	5,700	39	150,000	139
Maldives	0	0	0	0	0.06
Nepal	NA	0	0	42,000	27.04
Pakistan	17,550	324	33	45,000	NA
Sri Lanka	NA	150	0	2,000	12
<b>Total</b>	<b>108,961</b>	<b>5,906</b>	<b>95</b>	<b>294,330</b>	<b>223</b>

NA = not available, SAARC = South Asian Association for Regional Cooperation.

Sources: Country Reports (2008).

Table 4 indicates the 2007 reserves-to-production (R/P) ratio of hydrocarbon fuels for some of the SMSs. The R/P ratio shows the time period for which the reserves will last at the current production rate.

**Table 4 Reserves to Production Ratio, 2007**

Country	Reserves to Production Ratio (as estimated in 2007)		
	Coal	Oil	Natural Gas
Bangladesh	NA	NA	16
India	45	24	35
Pakistan	NA	NA	21

NA = not available.

Sources: Country Reports (2008).

The R/P ratio is necessarily a dynamic ratio that varies with changes in the estimation of reserves, resulting either from increased investments or improved technologies, or with changes in production patterns. With robust economic growth of the region, there is increased demand for energy that could result in the energy reserves being exploited at a faster rate. The R/P ratio of energy reserves in the region has been falling over the years with increased exploitation of resources at an exponential rate and inadequate new findings of reserves. In comparison, the R/P ratios of some of the western and central Asian countries are in the range of 60–90 years for oil and gas. In coal, Kazakhstan has an R/P ratio higher than 300 years and Uzbekistan has one of more than 142 years.<sup>12</sup>

The limitation of hydrocarbon reserves in the SAARC region can, to a certain extent, be overcome by promoting renewable energy resources such as hydropower, solar, wind, and biomass. The SMSs are rich in renewable resources and there is good potential for their utilization. The region has a total of 223 million tons of biomass, with member states such as India having the largest share. Regional cooperation in the field of technology development and the sharing of technical expertise to develop these energy forms can have a direct and large impact on the poorer segments of society, thereby having the potential to stimulate the social and economic development of the region.

<sup>12</sup> World Bank (2007a).



## Current Energy Scenario in the SAARC Region

As in the case of energy resource endowments, there is a wide disparity in energy demand and its consumption patterns among the SMSs. Total energy consumption in absolute terms ranges from as low as 0.17 million metric tons of oil equivalent (MMTOE) in the Maldives to 423.20 MMTOE in India.<sup>13</sup> In per capita terms, significant variations also exist, albeit in different forms, as shown in Figure 2, based on the country reports data.

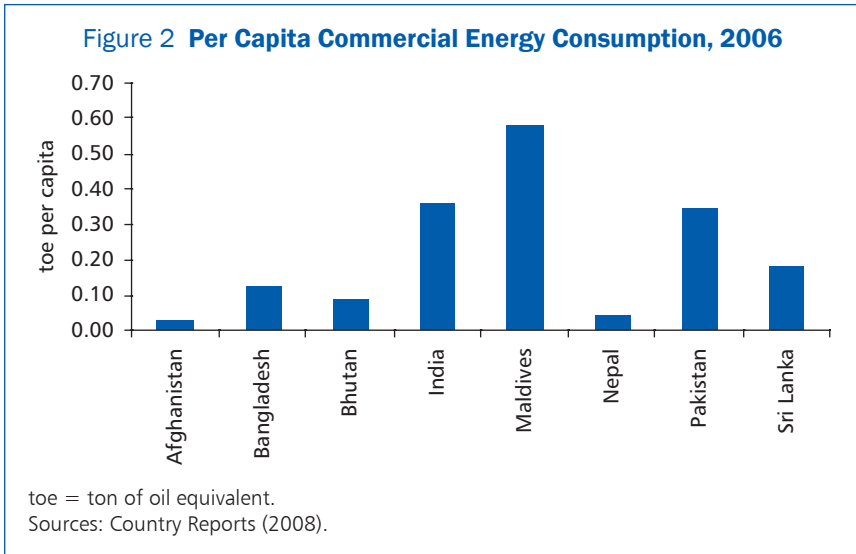
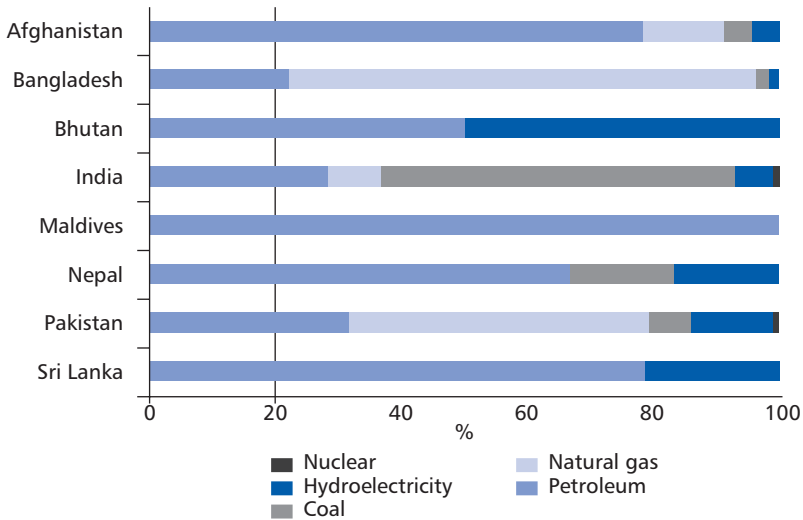


Figure 3 highlights the relative share of various energy forms in the total energy consumption mix in the SAARC region. Most countries, with the exception of India and Pakistan, have a predominant dependence on a single commercial energy form. These are oil for Afghanistan (78%), Maldives (100%), Nepal (67%), and Sri Lanka (79%); hydropower for Bhutan (50%); and natural gas for Bangladesh (74%). Such a large dependence on a single energy source not only limits the options of meeting diverse energy needs but also increases energy security concerns. It is also relevant to note that despite substantial coal resources available in the region, particularly in India, some of the SMSs are importing coal. India, for example, imported 28 million tons of coal in 2006. This is due mainly to the poor quality of domestic coal and technical constraints.

<sup>13</sup> Country reports (2008).

**Figure 3 Relative Contribution of Sources to National Energy Consumption**



Sources: Country Reports (2008).

The energy security concerns associated with crude oil and product imports are stark. In recent years, crude oil prices have risen and are anticipated to remain in the next decade at levels well above those in the recent past.<sup>14</sup> While all energy prices can be expected to move in similar directions over the long term, in any given period, diversification of energy sources protects consumers from unpredictable short-term movements in any particular price. Crude oil, in particular, is quite susceptible to sudden changes in prices.

A further problem is that most SMSs have limited refining capacity—the exception being India. Bangladesh has a refining capacity of 1.5 million metric tons per annum (MMTPA), Pakistan at 12.85 MMTPA, and Sri Lanka at 2.5 MMTPA. Bangladesh and Sri Lanka have one refinery each, while Pakistan has seven. These refineries meet approximately 40%, 85%, and 80%, respectively, of the petroleum product demand in these countries, with imports providing the balance. India, on the other hand, has about a 30% excess of modern refining capacity. Of the total product consumption across the region, diesel constitutes the largest component. The share of diesel in

<sup>14</sup> The World Bank website shows that crude oil prices in 2010 were 132% above the level in 2000. The price projection for 2020 shows a further, albeit very small increase. <http://www.worldbank.org>

the total product profile ranges from 37% (India) to 95% (Maldives). Energy security concerns increase with the increase of imported petroleum products rather than imported crude, with their greater price volatility compared to crude oil due to refinery interventions to cover operational risks.

An alternative fuel that is being used in the region is natural gas. However, its availability and consumption across the region is skewed. While Bhutan, the Maldives, Nepal, and Sri Lanka do not use natural gas at all, Bangladesh and India face supply deficits (Table 5). The excess of supply over demand in 2006 for Pakistan, based on the country reports, has now turned negative and intensive efforts are being made to accelerate production and also acquire additional supplies of natural gas from outside the region through pipelines and in the form of liquefied natural gas (LNG). Bangladesh is also considering the import of LNG.

**Table 5 Natural Gas Demand Supply Position, 2006**  
(million metric tons of oil equivalent)

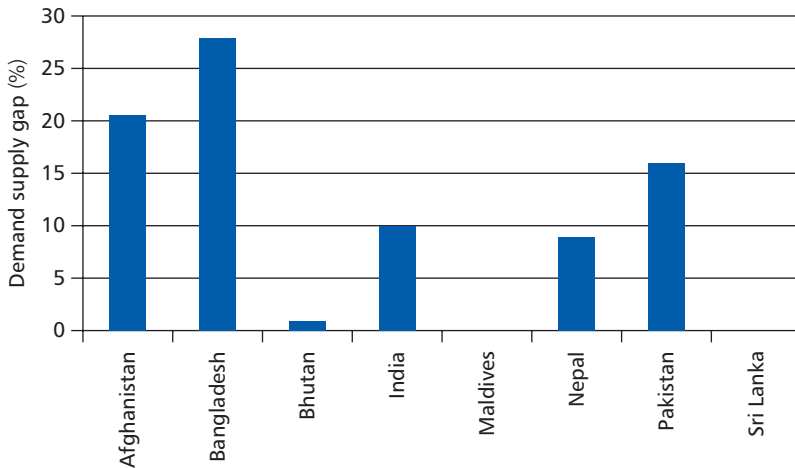
Country	Demand	Supply	Deficit/Surplus
Bhutan	0.00	0.00	0.00
Bangladesh	13.70	12.78	(0.92)
India	35.80	28.60	(7.20)
Maldives	0.00	0.00	0.00
Nepal	0.00	0.00	0.00
Pakistan	13.33	29.19	15.86
Sri Lanka	0.00	0.00	0.00
<b>Total</b>	<b>62.83</b>	<b>70.57</b>	<b>7.47</b>

( ) = negative.

Sources: Country Reports (2008).

The major consumer of natural gas is the power sector. In Bangladesh, 82% of the total electricity generation capacity is natural gas-based, while in Pakistan it is around 64%. Afghanistan is expected to have substantial gas reserves. However, lack of infrastructure and poor security are the main hindrances to the development of natural gas markets in the country. India has natural gas infrastructure, with major trunk natural gas pipelines (the Hazira-Bijaipur-Jagdishpur, Dahej-Vijaipur, Dahej-Uran, and East-West pipelines) connecting domestic and imported supplies. At present, the total trunk natural gas pipeline network is more than 9,000 kilometers (km) and the country is going to add another 9,000 km in the next 5 years.

The demand for electricity is steadily rising with continued economic development in the region. However, most member states have not been

**Figure 4 Electricity Shortages in SAARC Countries, 2006**

Note: Data for Afghanistan are from 2005.

Sources: Country Reports (2008).

able to augment the electricity supply to keep pace with increasing demand. Figure 4 shows the 2006 level of electricity shortages in the region.

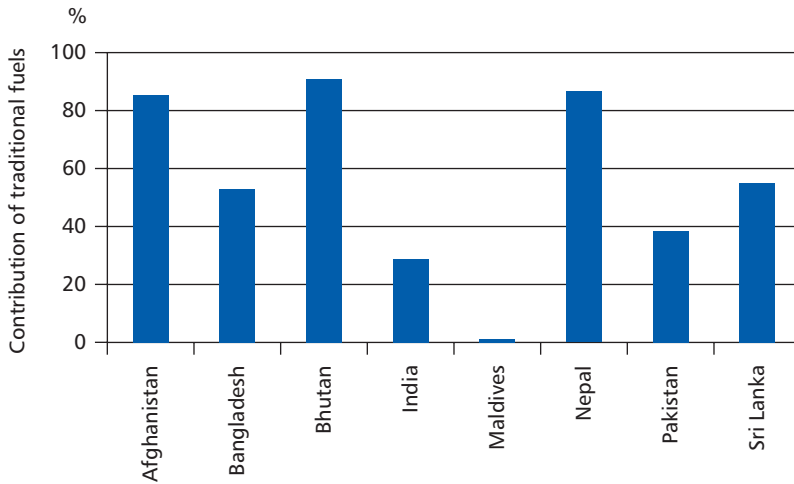
The electricity shortages have been calculated either based on the amount of electricity imported or on the load shedding experienced in the country. Access to electricity across the various member states is still low and ranges from approximately 20% in Afghanistan to 80% in Sri Lanka. On the supply side, the electricity generation mix in the region also varies widely across nations. Around 65% of the total installed capacity of India is based on thermal resources, whereas Bhutan and Nepal are largely hydro-based.

An important characteristic of the SMSs is their heavy dependence on traditional fuels (wood, agricultural residues, and animal dung) in meeting total energy consumption (Figure 5).

In India, around 90% of cooking energy needs in rural areas are met through traditional sources of energy.<sup>15</sup> In Bhutan and Nepal, more than 85% of the domestic energy needs are met through traditional fuels. However, as the SMSs develop, it is expected that their dependence on traditional fuels will

<sup>15</sup> Misra et al. (2005).

Figure 5 **Dependence on Traditional Fuels**



Sources: Country Reports (2008).

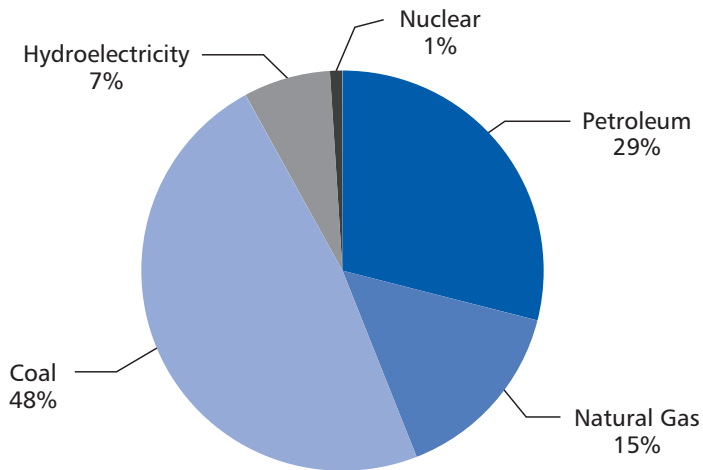
decrease and consumption of commercial fuels will increase. This implies increased pressure on the already constrained commercial energy supplies.

## Commercial Energy Supply Features

A brief sector-wise energy demand analysis for the SMSs, based on the information available in the country reports, is provided below, focusing on commercial energy utilization in the region. Figure 6 and Table 6 show the commercial energy supply mix in 2006. The three larger SMSs (Bangladesh, India, and Pakistan) accounted for more than 98% of the total energy supply of 507.9 MMT0E in the SMSs.

Energy supply in the region is clearly led by India with coal (237.7 MMT0E) and oil (120.3 MMT0E) dominating the country's 423.2 MMT0E equivalent of commercial energy supply in 2006 (Figure 7). As a region, the total energy supply from petroleum products has been leveling off during recent years, with natural gas increasing steadily from 17.5 MMT0E in 1995 to 35.8 MMT0E in 2006. India commenced LNG imports in 2004 and imported 7.2 MMT0E of LNG in 2006.

Natural gas is the main commercial fuel consumed in Pakistan (Figure 8), increasing from 13.1 MMT0E in 1995 to 27.6 MMT0E in 2006. Natural gas accounted for 48% of the total commercial energy supply of 58.0 MMT0E

**Figure 6 Commercial Energy Supply Mix of SAARC Region, 2006**

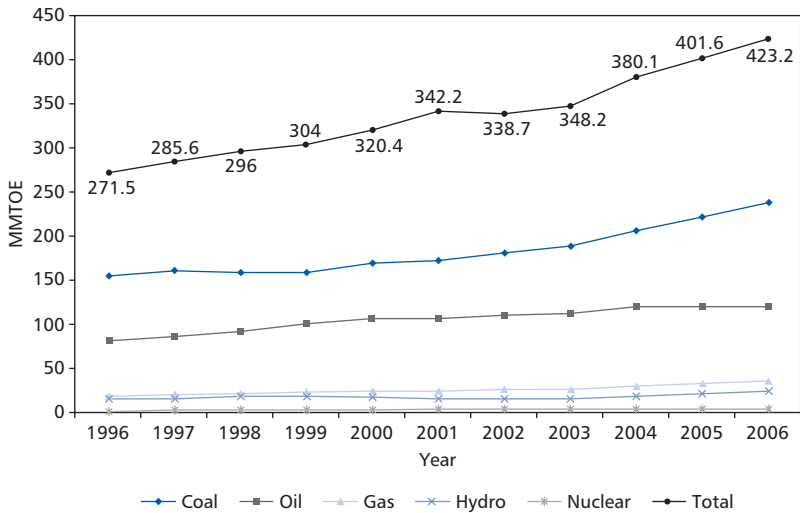
Sources: Country Reports (2008).

**Table 6 Commercial Energy Supply of SAARC Member States, 2006**  
(million metric tons of oil equivalent)

Country	Petroleum	Natural Gas	Coal	Hydro-electricity	Nuclear	Total
Afghanistan	1.8	0.3	0.1	0.1	0.0	2.3
Bangladesh	4.1	13.7	0.4	0.3	0.0	18.5
Bhutan	0.1	0	0	0.1	0.0	0.2
India	120.3	35.8	237.7	25.4	4.0	423.2
Maldives	0.3	0	0	0	0.0	0.3
Nepal	0.8	0	0.2	0.2	0.0	1.2
Pakistan	18.4	27.6	4	7.4	0.6	58
Sri Lanka	3.3	0	0	0.9	0.0	4.2
<b>Total</b>	<b>149.1</b>	<b>77.4</b>	<b>242.4</b>	<b>34.4</b>	<b>4.6</b>	<b>507.9</b>

Sources: Country Reports (2008).

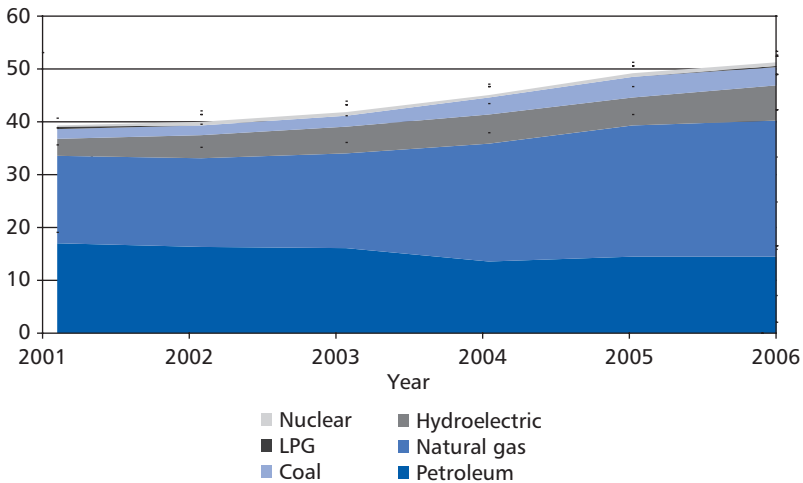
**Figure 7 Commercial Energy Demand Growth in India**  
(million metric tons of oil equivalent)



MMTOE = million metric tons of oil equivalent.

Source: Country Report for India (2008).

**Figure 8 Commercial Energy Supply Growth in Pakistan**  
(million metric tons of oil equivalent)



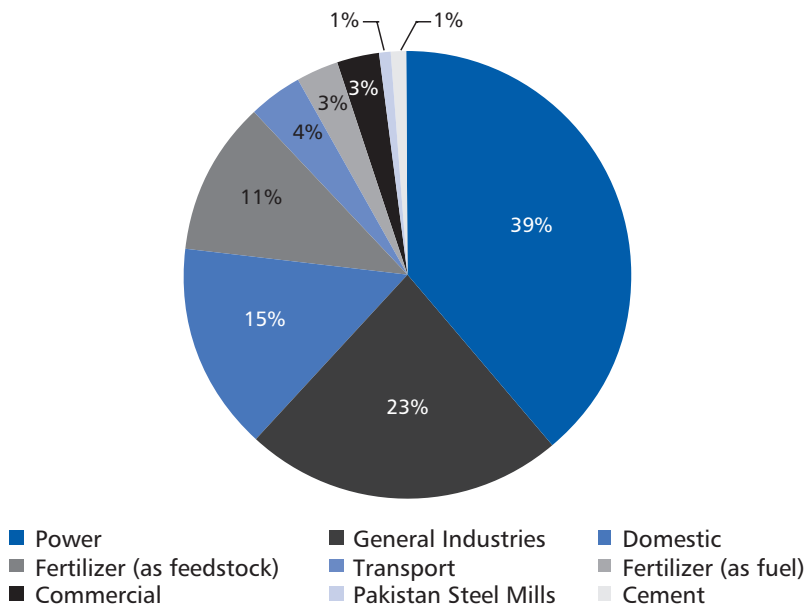
LPG = liquefied petroleum gas.

Source: Country Report for Pakistan (2008).

in 2006, while petroleum products at 18.4 MMTOE accounted for 32%. Figure 9 indicates the consumption of natural gas by sector in 2006. The power sector was the largest user of natural gas in 2006 with a consumption of 9.98 MMTOE, followed by industry with 6.16 MMTOE, the domestic or household sector with 4.00 MMTOE, and fertilizer (as feedstock) with 3.03 MMTOE. The other natural gas users include transport, as compressed natural gas (CNG) with 0.91 MMTOE; fertilizer, as fuel, with 0.84 MMTOE; commercial enterprises with 0.69 MMTOE; steel firms with 0.36 MMTOE; and the cement industry with 0.36 MMTOE.

Natural gas is the main source of commercial energy in Bangladesh, increasing from 6.7 MMTOE in 1995 to 13.7 MMTOE in 2006 (Figure 10). Natural gas accounted for 74% of the total commercial energy supply of 18.5 MMTOE in 2006, while petroleum products at 4.1 MMTOE accounted for 22%. Figure 11 shows the sector breakdown in natural gas consumption. The power (41%) and fertilizer (17%) sectors are the major consumers of natural gas, with the household or domestic sector and the captive power sectors each consuming 12% of the total natural gas supply. The dominant role played by natural gas in the power sector is illustrated in Figure 12, showing the fuel mix of the total electricity generation in 2006 of 22,741 GWh.

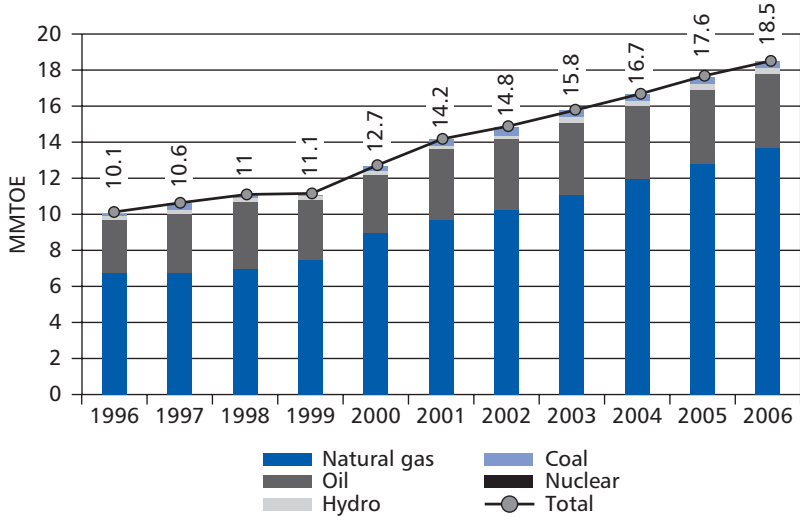
**Figure 9 Consumption of Natural Gas in Pakistan, 2006**



Source: Country Report for Pakistan (2008).

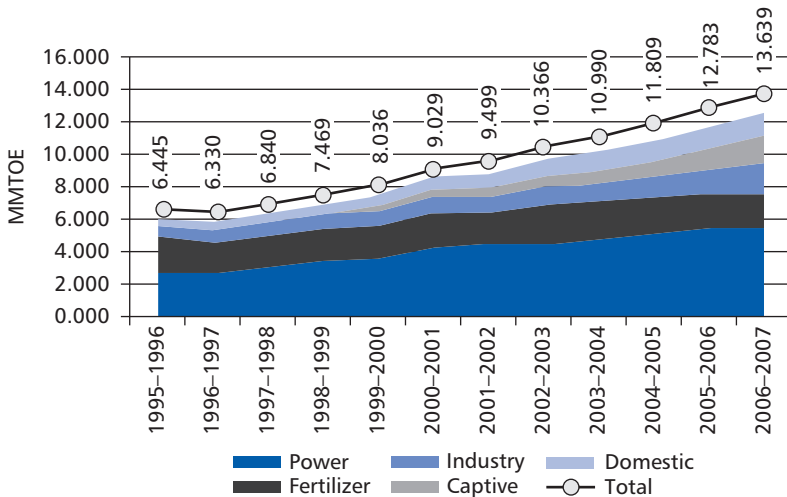


**Figure 10 Commercial Energy Supply in Bangladesh**



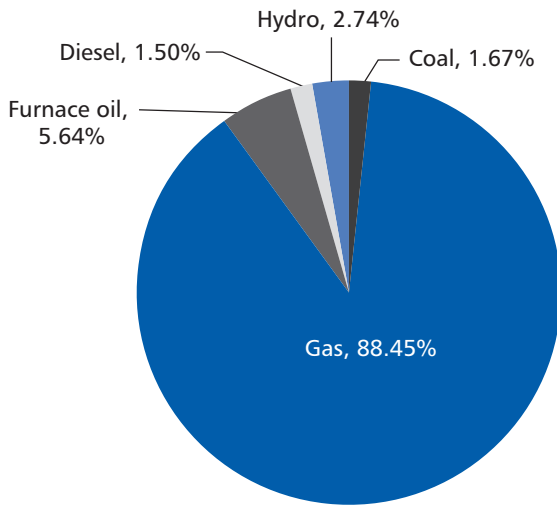
MMTOE = million metric tons of oil equivalent.  
Source: Country Report for Bangladesh (2008).

**Figure 11 Sector Consumption of Natural Gas in Bangladesh**  
(million metric tons of oil equivalent)



MMTOE = million metric tons of oil equivalent.  
Source: Country Report for Bangladesh (2008).

**Figure 12 Fuel Mix in Bangladesh Electricity Generation, 2006**



Source: Country Report for Bangladesh (2008).

The steadily increasing dependence of the region's major energy consumers on natural gas, particularly for electricity generation in the case of Bangladesh and Pakistan, is evident from the analysis given above. This development points to the need for seeking economically advantageous opportunities for bulk natural gas trade as well as bulk electricity trade, given the rapidly depleting access to indigenous natural gas.

## Key Challenges and Issues Faced by the SAARC Energy Sector

### Increasing Energy Deficit

All member states of the SAARC region faced electricity supply shortages ranging from approximately 9% in Nepal to 28% in Bangladesh in 2006. Crude oil refining capacity in the region, except in India, is outdated and inadequate and therefore constraining the domestic supply of petroleum products. Bangladesh and India are currently natural gas-deficient while Pakistan is also facing a similar situation.

## **Dominance of Single Fuels for Electricity Generation**

In India 65% of the total electricity generation capacity is thermal-based, Bhutan and Nepal are almost completely dependent upon hydroelectricity to meet their electricity requirements, the Maldives produces all its electricity from diesel, while natural gas dominates the generation mix in Bangladesh and Pakistan. Such excessive dependence on one energy resource raises concerns related to energy security. The concerns are aggravated by limited domestic supply of these fuels and the necessity to import. For instance, India has already started to experience a shortage of non-coking coal and within a decade non-coking coal imports have shot up from a nearly negligible level to around 25 million tons in 2007–2008. Some member states also experience short-term shortages. For instance, Bhutan faces a short-term shortage of electricity in the winter, needing electricity imports from India despite the large-scale exports to India in the summer.

## **Limited Utilization of Nonconventional Renewable Energy Potential**

SMSs are making increasing efforts to enhance the share of nonconventional renewable energy (NCRE, which excludes large hydroelectricity facilities) in total electricity generation. However, despite large resource endowments, they are currently not used to their full potential due to a lack of technology including modern control systems, commercial incentives, and infrastructure and financial resources. Another concern creating a hindrance to the development of renewable energy sources is the timely availability of wind power equipment, and the availability and high cost of solar energy equipment. While solar and wind mapping has been conducted for Afghanistan, the Maldives, Pakistan, and Sri Lanka under the South Asia Regional Energy Program funded by the United States Agency for International Development (USAID), this exercise is yet to be undertaken for Bhutan, Bangladesh, and Nepal. India, with its established database, is rapidly moving toward mainstreaming NCRE development. Chapter 9 of this report is devoted to further discussing NCRE development.

## **High Dependence on Traditional Fuels**

Member states such as Afghanistan, Bhutan, and Nepal use traditional fuels to meet about 85% of the total energy requirements. The main traditional energy resource is biomass, which under its current usage pattern is utilized inefficiently and with significant negative health impacts due to indoor air pollution. A high dependence on traditional sources of energy has also led to negative gender-related issues impacting female family members. Continued promotion of efficient biomass utilization technologies, and the

shifting of households from traditional sources of energy to commercial and cleaner sources of energy such as natural gas, where economically feasible, are necessary to address this situation.

## **Rising Import Dependence**

Bangladesh, Bhutan, the Maldives, Nepal, and Sri Lanka are dependent on imports to meet petroleum products demand, to varying degrees. India has sufficient refining capacity and imports 75% of its total crude requirement. In effect the entire region has an energy deficit and thus imports a large amount of crude oil or petroleum products. Such import dependence raises energy security concerns as it increases the vulnerability of a nation both in terms of availability of the energy supply and price hikes. Moreover, importing fuels in large quantities also has financial implications for the country's economy. For instance, in the case of Bhutan, in 2007, the entire electricity export earnings of the country were spent on procuring petroleum products. In a situation of volatile international crude oil markets, such high dependence on imported fuel can have an inflationary impact on the economy. A related concern in the case of petroleum products is that the current refining capacity of the member states, excluding India, is insufficient to meet their respective demand while the technology employed in these refineries is not state-of-the-art. Hence, the region may consider enhancing its aggregate refining capacity by setting up a state-of-the-art refinery to meet the region's petroleum product demand. Under such an arrangement the region would also be able to reap the benefits of joint fuel procurement.

## **Lack of Energy Infrastructure**

Energy sector infrastructure is required in the form of electricity transmission lines, natural gas pipelines, and crude oil and petroleum product pipelines to support the increasing levels of in-country energy flows, and the regional energy trade envisaged to meet energy requirements needs substantial improvements in infrastructure. As of 2010, in the region only India has LNG terminals, but India does not have a well-developed natural gas pipeline network. This has hampered the development of a natural gas market in the country, since the demand and supply centers are not adequately connected.

Many feasible hydropower projects are located in remote and mountainous areas, where infrastructure, such as accessible roads and high-voltage transmission lines, does not exist. This necessitates the development of this type of infrastructure with the associated costs being added to the overall cost of the hydropower project. This ultimately leads to higher costs for those projects, which adversely affect their competitiveness. Allocating the

supporting infrastructure development cost between the project and the broader country infrastructure development in a transparent manner would make electricity generated from these projects more competitive. Moreover, the benefits of avoiding carbon emissions should provide additional justification for hydropower developments in the region. The region should actively pursue global transfer mechanisms such as the Clean Development Mechanism, in promoting hydropower development.

## **Future Energy Demand and Supply in the SAARC Region**

Table 7 shows the projected commercial energy supply (other than from hydro and nuclear sources) along with best estimates for all energy forms in Afghanistan, and for oil in Bangladesh. Table 8 shows the projected electricity generation demand as indicated in those reports, and with best estimates for Afghanistan. Hydropower and nuclear power would continue to make significant contributions to meet this electricity demand in India and in Pakistan. In India, the hydroelectricity contribution is estimated to grow from 130 billion kilowatt-hour (kWh) (31.2 MMTOE) to 250 billion kWh (60.0 MMTOE) over the period 2010–2020, while the corresponding figures for nuclear electricity contribution are 60 billion kWh (14.4 MMTOE) and 160 billion kWh (38.4 MMTOE). In Pakistan, the hydroelectricity contribution is estimated to grow from 130 billion kWh (31.2 MMTOE) to 250 billion kWh (60.0 MMTOE) over the period 2010–2020, while the corresponding figures for nuclear electricity are 60 billion kWh (14.4 MMTOE) and 160 billion kWh (38.4 MMTOE).

The total energy resources in the SMSs as depicted in Table 7 are equivalent to 803 MMTOE for crude oil; 73,004 MMTOE for coal; and 2,280 MMTOE for natural gas. India dominates in these resources with coal accounting for 60,357 MMTOE equivalent, but India itself is importing coal to supplement its domestic coal production capability. The natural gas resources are mainly in India and Pakistan, and while India is already importing natural gas (as LNG) to supplement domestic natural gas production, Pakistan is planning to do the same, with Bangladesh also moving toward that objective. A comparison of the region's commercial energy resource utilization and the projected commercial energy needs shows that while a substantial part of these commercial energy needs can be met from regional resources, significant levels of interregional energy imports would also be required (Table 8).

Very large amount of investments would be required to expand regional energy production, access necessary interregional energy imports, and

Table 7 **Projected Commercial Energy Supply**

Country	Crude Oil/Petroleum Products			Coal			Natural Gas		
	2010 (MMTOE)	2020 (MMTOE)	CAGR (%)	2010 (MMTOE)	2020 (MMTOE)	CAGR (%)	2010 (MMTOE)	2020 (MMTOE)	CAGR (%)
Afghanistan	1.57	3.48	8.28	0.00	0.00	0.00	0.33	0.92	10.79
Bangladesh	5.70	11.6	7.36	0.37	6.58	33.35	16.79	33.95	7.29
Bhutan	0.09	0.18	7.18	0.17	0.17	0.00	0.00	0.00	0.00
India	147	267	6.15	426.94	599.95	3.46	43.95	81.68	6.39
Maldives	0.50	0.83	5.20	0.00	0.00	0.00	0.00	0.00	0.00
Nepal	0.85	1.23	3.74	0.27	0.32	1.94	0.00	0.00	0.00
Pakistan	20.60	30.70	4.07	5.80	15.10	10.04	35.60	62.50	5.79
Sri Lanka	5.19	6.34	2.01	0.00	7.30	0.00	0.00	0.00	0.00
<b>Total</b>	<b>174.23</b>	<b>306.28</b>	<b>5.80</b>	<b>433.55</b>	<b>629.42</b>	<b>3.80</b>	<b>96.34</b>	<b>178.13</b>	<b>6.34</b>

CAGR = compounded annual growth rate, MMTOE = million metric tons of oil equivalent.

Sources: Country Reports (2008).

**Table 8 Projected Electricity Demand**

Country	2010 (gigawatt-hours)	2020 (gigawatt-hours)	Compounded Annual Growth Rate (%)
Afghanistan	1,132	3,877	13.10
Bangladesh	33,716	71,990	7.88
Bhutan	2,260	3,703	5.06
India	1,077,000	2,550,000	9.00
Maldives	1,923	2,447	2.44
Nepal	3,731	8,990	9.91
Pakistan	14,4711	261,523	6.10
Sri Lanka	10,327	22,040	7.88
<b>Total</b>	<b>1,274,800</b>	<b>2,924,570</b>	<b>8.66</b>

Sources: Country Reports (2008).

provide the associated transmission and distribution networks. For example, India is estimated to require approximately \$30 billion per year during the period 2007–2012 to meet the projected increase in power generating capacity and associated power transmission and distribution. Significant among the challenges to meet the regional energy needs would be the ability to create the enabling environment to attract large energy infrastructure investments and the complementary regional energy trade.

## Likely Gains from Energy Trade Arrangements

The power generating capacity in a power system is normally provided to meet the peak power demand. So, during off-peak hours, surplus capacity is available for transfer to some other areas if economically attractive. If there is a difference in the time of the peak power demand between two power systems, the surplus power available in one system during its off-peak hours can be supplied to the other system. This results in optimized utilization of generation capacity in both power systems.

Electricity can be traded through power transmission networks with relative ease compared to other sources of energy. With the availability of adequate transmission capacity, coal and natural gas-fired power generating stations can be used to meet the base load of interconnected countries and hydrogenerating plants can be used to meet the peak load. This would promote the operation of more efficient power plants as far as possible, to achieve overall economic efficiency in systems operations. Larger and

more economic power generating plants could also allow access to a larger market. Economies of scale in investment in power generating plants can also be achieved as an added benefit.

Increased interconnectivity of power systems also increases their reliability and the expectation with which the demand can be met through continuity in supply. Sometimes the geography of two countries is such that the loads of one country are in closer proximity to generation facilities of the other country than to its own generation facilities. It would then be easier and more economical to meet such loads from neighboring countries. Such arrangements result in reduced line length, lower system losses, and smaller capital costs.

Enhanced cross-border interconnections can also help reduce adverse energy sector greenhouse gas (GHG) impact on the environment by expanding the market for larger scale hydropower projects and thereby also increasing their economic viability and financing prospects. For instance, by setting up more export-oriented hydropower projects, Bhutan and Nepal can further help the region in reducing its dependence on fossil fuels and consequently reduce GHG emissions. Also, increased natural gas use through natural gas interconnections would result in cleaner production in the power and industrial sectors.

## **Need for Harmonization of Legal and Regulatory Frameworks**

Energy markets in the individual SMSs are governed by individual legal, regulatory, and policy frameworks, and there is wide diversity among them. The existing legal and regulatory framework in each of the individual member countries is discussed in Annex 1. In some SMSs, energy falls under the purview of a single ministry. In others, there are multiple ministries handling energy-related and energy subsector issues. These differences add complexity to regional energy trade as it is difficult to draw one-to-one relationships across member states.

Differences also exist in the structure and mandate of the regulators. Their roles range from multi-sector regulation and overall energy sector regulation to energy subsector regulation. India and Pakistan have separate sector regulators, while Bangladesh has one energy regulator. In the case of Sri Lanka, there is a Public Utilities Commission, which is not restricted to only the energy sector. Such divergence in the mandate of regulators across the region can impede the development of energy trade. As a first step, these regulators need to work together to develop a road map for harmonizing the relevant regulations.



There are also variations in terms of the pace of reforms in the different SMSs and the associated unbundling of energy utilities. This is an important issue as unbundling of utilities creates an enabling environment for promoting regional energy trade.

Table 9 shows the key features of the legal and regulatory frameworks in the SMSs.

## Conclusion

The per capita national income of the South Asian countries varies significantly, as much as population and its density. There is also a wide variation in resource endowments in the Asian region both in fossil fuels, such as coal oil and natural gas, as well as hydropower and biomass. The reserves-to-production ratio of the fossil fuels, which has been falling over the years, is relatively low in the region compared to other regions rich in these resources. The per capita energy consumption also varies considerably with Afghanistan and Nepal recording the lowest levels, while the level in the Maldives is almost 20 times that of Afghanistan. The total commercial energy supply in the region is mainly contributed by coal and petroleum. The dominance of traditional fuels in the national energy supply is high in all of the countries except India and the Maldives. With the exception of India and Pakistan, all of the countries experience single fuel dominance in their national energy supplies. All of the countries are heavily dependent on oil imports and have limited refining capacity, except India.

One of the main challenges faced by the energy sector in the region is the increasing energy deficit. Electricity shortages are a common phenomenon, at least at certain periods of the year, except in the Maldives and Sri Lanka. All of the countries lack the required energy infrastructure to serve the ever-increasing demand for energy services that has resulted from the fast economic growth experienced by the region in the recent past.

These factors pose serious challenges to efforts by all of the countries to provide for the basic energy needs to their populations, and also impact on energy security in the respective countries and that of the whole region. A comparison of the projected demand with the region's commercial energy resource utilization shows that a substantial part of these needs can be met from regional resources, while significant levels of interregional energy imports would also be required. A strong regional energy cooperation program will ensure that the efforts of the individual countries in providing for energy needs are supported through optimal development and utilization of regional resources and energy infrastructure with increased

**Table 9 Key Features of the Legal and Regulatory Frameworks in SAARC Member States**

Country	Unbundling of Utilities	Energy Regulator	Private Sector Participation in Energy Sector	Provisions for Promoting Regional Energy Trade
Afghanistan	No	No	No policy promoting private sector participation, but it has been included in the energy strategy	Regional energy trade has been recognized as an option for increasing energy availability
Bangladesh	Yes Unbundling of BPDB is not complete	Yes BERC for downstream oil and gas sector and electricity sector	Private sector participation is present in upstream oil and gas sector and electricity sector	Regional energy trade recognized as an option for increasing energy availability
Bhutan	Yes Partially unbundled	Yes BEA for electricity sector	Private sector participation is encouraged especially in hydropower generation	No particular mention of regional energy trade in the policy, however, regulations are in place for promoting open access
India	Yes	Yes Central and state regulators for electricity and a central regulatory for oil and gas	Private sector present in most sections of the energy value chain	No particular provision in the Indian legislative framework, however, regulations for open access and third party access are in place
Maldives	No	Yes MEA for Electricity Sector	Limited private sector participation in the energy sector	No particular mention of regional energy trade
Nepal	No But new legislation for unbundling is under consideration by the parliament	Yes ETFC only to fix tariffs Legislation to establish NERC is under consideration	Private sector participation is already in electricity generation	Hydro Policy 2001 recognizes scope of regional energy trade (bilateral and multilateral) to harness the hydro potential in the country
Pakistan	Yes	Yes NEPRA for Electricity sector OGRA for oil and gas sector	Private sector participation is in the electricity sector	Recognizes scope of regional energy trade
Sri Lanka	No	Yes PUSCL for electricity and petroleum	Private sector is in petroleum distribution and in electricity generation	Regional energy trade recognized as a measure for enhancing energy security

BEA = Bhutan Electricity Authority; BERC = Bangladesh Energy Regulatory Commission; BPDB = Bangladesh Power Development Board; ETFC = Electricity Tariff Fixation Commission, Nepal; MEA = Maldives Electricity Authority; NERC = National Electricity Regulatory Commission, Nepal; NEPRA = National Electric Power Regulatory Authority of Pakistan; OGRA = Oil and Gas Regulatory Authority of Pakistan; PUSCL = Public Utilities Commission of Sri Lanka.

Source: Authors.

reliability and efficiency. Such cooperation will also provide countries with ample and low-cost opportunities for GHG mitigation as a region. In this regard, one of the key factors that needs immediate attention is the harmonization of regional integration policies and legal and regulatory environments.

## Chapter 4

# Current Regional Energy Trade and Its Prospects

## Introduction

In 2010, total intra-regional trade in energy was less than 5% of the total trade taking place among the SAARC member states (SMSs). This indicates larger untapped potential for energy trade within the region. The successful example of electricity trade between Bhutan and India and the resultant benefits to both economies are well appreciated and could be emulated by other countries in the region. Discussions are underway to develop additional electricity transmission interconnections within the region and with neighboring regions. The first ever transmission interconnection between Bangladesh and India is being constructed and this project should provide additional impetus for other, similar interconnections. Some of the prominent projects proceeding to implementation at this stage are the additional power transmission interconnections from Bhutan and Nepal to India, between India and Sri Lanka, and between Bangladesh and India. A brief discussion on intra-regional energy trade prospects and existing and past initiatives being taken is given below.

## Existing Trade of Petroleum Products

India supplies the entire demand of petroleum products in Nepal and Bhutan. The governments of India and Nepal have recently agreed to proceed with the construction of an approximately 40 kilometer (km)-long pipeline to transport petroleum products from India to Nepal (about 20,000 barrels a day are transported by road in tankers). India also exports petroleum

products to Bangladesh. Lanka IOC, Indian Oil's subsidiary in Sri Lanka, is the only private oil company other than the state-owned Ceylon Petroleum Corporation (CPC) that operates retail outlets in Sri Lanka. Lanka IOC has been incorporated in Sri Lanka to (i) carry out retail marketing of petroleum products, (ii) provide bulk supply to industrial consumers, and (iii) build and operate storage facilities at the Trincomalee Tank Farm, thereby not only providing energy security and supply stability for Sri Lanka but also upgrading the overall standards of service, particularly in petroleum retailing in the nation. As a result, the smaller economies benefit from existing trade infrastructure in India, broadening their energy supply options at lower resource costs than would be possible if they operated independently. India benefits from the expanded economies of scale in its petroleum operations, enjoying access to the markets of the smaller economies in addition to its own domestic market.

## India–Bhutan Electricity Trade

The first major initiative for collaboration on large hydropower development in Bhutan was the bilateral agreement signed in 1974 for the construction of the Chukha Hydroelectric Project (HEP) with 336 megawatts (MW) installed capacity, as a joint venture. The Government of India agreed to finance the total cost of the project on the basis of 60% grant and 40% loan funding. The first 84 MW unit was commissioned in 1986 and by 1988 the remaining three units were commissioned. The Royal Government of Bhutan agreed to sell the surplus power generated by the project to India after meeting its internal requirement. Power is sent to India through three 220-kilovolt (kV) transmission lines, one single-circuit 220 kV Chukha (Bhutan)–Birpara (India) line and one double-circuit 220 kV Chukha–Birpara line. The successful completion of the Chukha HEP, coupled with its sustained performance after commissioning, gave added confidence to the governments of Bhutan and India to construct similar large hydroelectric projects as joint ventures. This led to the construction of the 60 MW Kurichhu HEP and the 1020 MW Tala HEP. This regional cooperation in electric power generation and transmission provides additional electricity supply to SMSs that are experiencing costly electricity shortages—cooperatively expanding regional energy supplies. Further, the crucial element of financing by India of projects in neighboring countries allows relatively small economies, such as Bhutan and Nepal, to undertake otherwise prohibitively expensive projects: the financing cost is thus borne by India, appropriately sharing the costs, risks, and benefits from a cross-border project.

The Tala HEP, a run-of-the-river scheme downstream of the Chukha HEP, was conceived as a joint venture with Government of India funding (60% grant and 40% loan). It was commissioned on 30 March 2007 and has an

underground powerhouse with six 170 MW power generating units. Two 400 kV direct current (DC) transmission lines carry power from the Tala HEP to India through two different locations on the India–Bhutan border. The project will generate 3,900 gigawatt-hours (GWh) of electricity in an average year and fetch a revenue of approximately \$120 million. The Power Trading Corporation (PTC) of India signed a 35-year power purchase agreement (PPA) with the Government of Bhutan in 2006. The total expected annual electricity export to India from Bhutan from the three projects mentioned above is 5,620 GWh (3,900 GWh from Tala, 1,470 GWh from Chukha, and 250 GWh from Kurichu).

On future development, the governments of Bhutan and India signed an agreement in 2006 to further facilitate the development and construction of hydropower projects in Bhutan and associated transmission systems, as well as trade in electricity between the two countries, through public and private sector participation. The Government of India has agreed to a minimum import of 10,000 MW from Bhutan by 2020. One of the important features of the agreement is that the two countries would be cooperating to develop projects under the Clean Development Mechanism (CDM) of the Kyoto Protocol, using India's carbon emission baseline. In this context, it is relevant to note that the \$200 million Dagachhu HEP (114 MW) funded with loans from Asian Development Bank (ADB), Japan, and Austria is expected to reduce carbon dioxide emissions in India by about 500,000 tons per year.

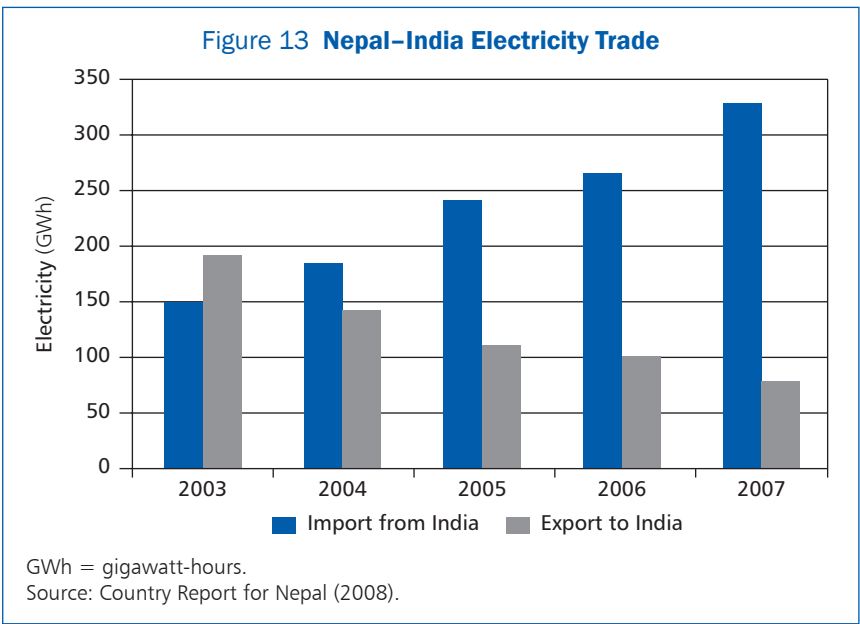
The governments of Bhutan and India signed an agreement in 2007 to implement the Punatsangchhu-I HEP (1,095 MW) in Bhutan. The two parties have also agreed to cooperate on the Punatsangchhu-II (1,000 MW) and the Mangdechhu (720 MW) HEPs. The Detailed Project Reports are being prepared. In addition, investigations and Detailed Project Reports for the Bunakha (180 MW) and Wangchu (900 MW) projects have been completed. To move to full operation of these plants, the present power transfer capacity between the two countries of approximately 2,500 MW would have to be suitably augmented or new capacity created. Technological and economic feasibility is being examined for high-voltage interconnection at voltages up to 765 kilovolts (kV). Although due to environmental concerns and the need for sustainable development, the hydropower projects developed in Bhutan so far have been run-of-river schemes, there could be the possibility of the development of two major storage-based HEPs—the Sankosh Dam (4,600 MW) and the Manas Dam (2,800 MW). These projects have the potential to significantly contribute toward meeting the energy demand in the region and beneficiary member states could consider participating in the promotion and development of these projects with the view to wheeling the power through the Indian power system. The collective participation in regional infrastructure, such as power transmission systems, benefits all, reducing project risks and costs, and expanding regional energy supply.

The present power transfer capacity between Bhutan and India is around 2,500 MW. Expansion of this capacity to serve the future development of hydroprojects in Bhutan is being planned and developed, including investment in transmission along the right-of-way in the *chicken-neck* area in India, providing jointly for the evacuation of power from future projects in Sikkim and the northeastern region of India. It is envisaged that connectivity with the power generation projects in Bhutan could be through high-capacity 400 kV lines up to pooling points in India. Onward power transmission from those pooling points would be through a hybrid transmission line system.

## Nepal–India Electricity Trade

India–Nepal power exchange began in 1971 with about 5 MW, and by 2001–2002 the trade had grown to about 150 MW. Figure 13 gives the details of electricity trade in the recent past. At present, power exchange is taking place at 21 interconnections through 11 kV, 33 kV, and 132 kV transmission lines, but these are not adequate to accommodate the transfer of summer surplus power generating capacity from Nepal to India.

Nepal has a hydropower potential of 83,000 MW, of which about 42,000 MW is considered economically feasible to develop. Projects totaling approximately 23,000 MW have been studied in varying detail by domestic and international agencies. Nepal's existing installed generation capacity



is about 600 MW and its annual electricity demand growth rate is about 10%. (Some estimates put the growth closer to 8%–8.5% per annum.) Even at 10% growth, domestic demand will reach only 3,500 MW by 2025 and its large undeveloped hydropotential presents Nepal with a major commercial opportunity to develop hydropower for export to India and to other SMSs. The experience of Bhutan provides a clear indication that the benefits accruing to Nepal from hydropower exports can be substantial—cooperatively expanding regional energy supplies, enabling a small economy to finance extremely expensive projects, and sharing both the costs and the benefits.

The development of export-oriented hydropower projects in Nepal, principally for consumption by India, is potentially the biggest area for cooperation. The 750 MW West Seti storage HEP exemplifies a project being developed under this model. It is already underway through an independent power producer (IPP) arrangement in Nepal with an initialed PPA. The focus on private sector participation, through IPP structures, recognizes that private sector financing can greatly ease the demands on limited public sector financial resources.<sup>16</sup> In addition, private sector design and management can bring to a sector international best practices, improving implementation and operational efficiency. The Government of Nepal is also pursuing with developers other export-oriented hydropower projects including the Budhi Gandaki (600 MW), Upper Karnali (400 MW), Kali Gandaki (660 MW), Arun-III (800 MW), and Tamakoshi (880MW).

In terms of present operations, Nepal has a hydro-dominated power system whereas India's is primarily thermal. Nepal's power generation comprises mainly of run-of-river schemes. With reduced local demand during the wet season (April–October) these hydroprojects have to reduce generation and spill energy. This spill energy could potentially be exported to India, which faces acute power shortages during this period. During the dry season (October–March), Nepal faces shortages of power in excess of 100 MW, which could partly be met by import from India. However, this trade of power is currently constrained due to a lack of adequate interconnection between the two countries. There is a clear need for strong interconnections between the countries to deal with this problem, and more importantly, to export the large amount of power from the export-oriented hydropower projects under development. The joint, intercountry provision of transmission facilities to allow seasonal trade in power would reduce the overall need to finance and build generation capacity—optimizing country-specific systems within a regional market.

<sup>16</sup> Private Power & Infrastructure Board. <http://www.ppib.gov.pk/index.htm>



Four alternatives have been considered for enhancing India–Nepal power exchange: interconnections between Butwal (Nepal) and Gorakpur (India), Duhabi and Purnea, Dhalkebar and Muzaffarpur, and Anarmani and Siliguri. Of these links, considering the level of power transfer, only the Dhalkebar–Muzaffarpur link has been identified and finalized at this stage for construction as a 400 kV DC line initially charged at 220 kV. The PTC has been identified as the nodal agency for trade of power between Indian utilities to the Nepal Electricity Authority. The Anarmani–Siliguri link has been rejected by India as it passes through the *chicken-neck* area in Indian territory, which is reserved for bulk evacuation of power from projects in the northeastern region of India and in Bhutan.

The Infrastructure Leasing & Financial Services in India has taken the initiative to develop the India–Nepal transmission projects. Two joint venture companies—Cross Border Power Transmission Company Private Ltd. and Power Transmission Company Nepal Ltd.—were incorporated for the implementation of the projects. In what may be called as a breakthrough in transborder cooperation between India and Nepal, in November 2009, the stakeholders of the Dhalkebar–Muzaffarpur 140 km, 400 kV, double-circuit, cross-border transmission line project set a deadline of mid-2010 for the completion of a PPA and financial closure for the project. The project would be completed within 18–24 months at an estimated cost of around \$60 million (100 km in India costing around \$40 million, and 45 km in Nepal costing around \$20 million). The Power Grid Corporation of India Limited is taking responsibility for the engineering of this project.

## India–Bangladesh Electricity Trade

Bangladesh has a predominantly gas-based electricity generation while India has substantial amounts of coal and hydro-based electricity generation. There is daily and seasonal diversity in electricity demand between the two countries. The difference in weekly and festival holidays and the 30-minute time difference can also provide opportunities for exchanging power. In this context, Bangladesh and India are examining the modalities for mutually beneficial mechanisms to share the benefits from their respective generation assets, considering also the importance of the energy security of both countries. The possible routes for the exchange of power are between (i) the eastern region of India and the Western Grid of Bangladesh, and (ii) the northeastern region of India and the Eastern Grid of Bangladesh.

The detailed analysis done so far shows that interconnection between the northeastern region of India and the Eastern Grid of Bangladesh would have limited attractiveness since any power transmitted would exacerbate the critically overloaded East–West power interconnector of Bangladesh.

Development of the 750 MW gas-fired power plant at Tripura, close to Agartala in India, adds to the case for reconsidering possible cross-border interconnections. The most attractive interconnection between Bangladesh and India in the near term is through the route between the Western Grid of Bangladesh and the eastern region of India. This can take place with a high voltage direct current (HVDC) back-to-back asynchronous power link between the two countries. Power transfer can be controlled in either direction up to the capacity of the HVDC unit, depending upon the availability and demand on either side. Any fluctuations or disturbances of one grid would not affect the other side.

The proposal to connect Bangladesh and India (on the western side) through an HVDC back-to-back link of 500 MW capacity has been approved, and construction will commence shortly. It is expected that this interconnection will be upgraded to around 1,000 MW in the longer term. For the establishment of this asynchronous interconnection between the eastern region of India and the Western Grid of Bangladesh, the interconnecting terminal alternating current (AC) substations need to meet the local technical requirements. On the Bangladesh side, the substation identified for this purpose is Bheramara, close to Ishurdi in the Western Grid of Bangladesh, and an appropriate facility needs to be established. On the Indian side, one 400 kV substation is to be created at Baharampur using one circuit of the Farakka–Jeerat 400 kV line. The back-to-back HVDC converter will be located at Bheramara to complete a Baharampur–Bheramara 400 kV AC double circuit line.<sup>17</sup>

## India–Pakistan Electricity Trade

There is a dense power transmission grid on the Pakistani side along the northwestern border of the Indian Punjab. The nearest grid substation on the Indian side of Punjab is Patti, located close to the Lahore Ring in Pakistan. In the late 1990s, when Pakistan had surplus power generation, mainly in the form of IPP take-or-pay power generation, there was a proposal to erect a 50 km HVDC double circuit transmission line to carry power from the Dinanath substation near Lahore to the Patti substation in Indian Punjab. However, this proposal was not realized due to the relatively wide gap between the price offered by the Indian side (approximately \$0.023 per kWh) and the price sought by the Pakistani side (approximately \$0.072 per kWh). Given the severe power shortages in Pakistan, and the open access power transmission possibilities in India, there is now renewed interest in pursuing mutually beneficial cross-border power transfer between the two countries.

<sup>17</sup> Power Grid Company of Bangladesh documentation (March 2010).

## India–Sri Lanka Electricity Trade

Electricity generation in Sri Lanka is currently dominated by oil-fired sources supplementing hydropower, but serious efforts are being made to meet the electricity demand growing at about 7% per year, with greater diversification of fuel resources. The average cost of electricity supply is as high as \$0.15 per kWh, although the average selling price is around \$0.10 per kWh. Accordingly, the Ceylon Electricity Board has entered into a memorandum of understanding with the National Thermal Power Corporation of India to set up a 2x500 MW coal-fired thermal power station in northeast Sri Lanka. This would be in addition to the 900 MW of generating capacity now under construction in the west of Sri Lanka with assistance from the People's Republic of China (PRC). The use of coal, helping to diversify the energy resource base of the country, would reduce the heavy dependency upon petroleum fuels. As noted above, this would improve the general energy security and also reduce the cost of generation.

In this context, another possibility that is being evaluated between India and Sri Lanka is a transmission interconnection between the two countries through a 50 km long HVDC submarine cable and 335 km of HVDC overhead transmission (185 km in India and 150 km in Sri Lanka). An HVDC connection needs strong electrical terminal stations, and Madurai on the Indian side and New Anuradhapura on the Sri Lankan side have been identified as strong substations for this purpose. Technically, the best option would be an interconnection with double circuit HVDC overhead transmission and a double circuit HVDC submarine cable with 500 MW of power planned for exchange in the short term and 1,000 MW in the longer term. In view of the difficulty in laying the transmission system it would be technologically and economically advantageous to build the transmission system for the ultimate capacity of 1,000 MW. An inter-governmental agreement is in place to proceed with this interconnection.

The project is estimated to cost \$430 million (\$248 million for the HVDC transmission and \$182 million for the HVDC terminal stations). In the short term, if required, the HVDC line could be operated as a mono-polar HVDC line with ground return for the transfer of 500 MW power. In this case, there would be no saving in the HVDC transmission, but the system would provide for revenue savings of \$90 million with provision for doubling capacity to 1000 MW.<sup>18</sup> A high-capacity HVDC link would later open the possibility for Sri Lanka to gain access to hydropower generation in Bhutan and in Nepal through the Indian power system, and also to bulk liquefied natural gas (LNG)-based power generation planned for installation in India.

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<sup>18</sup> Power Grid Corporation, India (2006).

## Potential Areas for Cooperation in Regional Energy Trade

Improving regional cross-border energy exchange requires integrating local energy markets, including developing regional energy markets through adequate electricity or gas interconnections. Transparent open access to transmission infrastructure and agreeing to common protocol and harmonized legal, regulatory, and economic rules are essential. Member countries need to work toward this by standardizing the rules and procedures and simplifying of transaction mechanisms to reduce costs. Some of the SMSs have put in place regulatory mechanisms and regulators are discharging their responsibilities effectively. Others have yet to proceed to this stage.

SMSs can also cooperate among themselves in developing projects under the clean development mechanism (CDM). By 2010, India was one of the leading CDM destinations, and CDM activity in India is second only to that of the PRC. India's carbon base line is such that prospective hydropower projects in the neighboring countries can become viable by supplying power to India to replace some of its thermal base generation and help in greenhouse gas (GHG) mitigation. Bhutan and India are already cooperating in this respect. This is, again, an example of a regional (if not global) public good, which requires cooperative, governmental initiatives to achieve the goal of slowing climate change due to GHG emission. In this case, the CDM provides some short-term incentives, but still requires considerable efforts by the governments of participating countries in any specific project.

The member countries may also jointly promote strategic reserves of crude oil and petroleum products and encourage joint stock holdings with partner countries, where appropriate. India is in the process of establishing a strategic oil reserve to insulate itself against disruption of supplies and international oil price fluctuations. Creating such infrastructure requires huge investment and since Bhutan and Nepal are heavily dependent on India for the supply of petroleum products, they too could become part of this venture. Other neighboring countries like Bangladesh, Pakistan, and Sri Lanka, which are heavily dependent on the Middle East for crude oil, could join such a project to address short-term market fluctuations. However, the costs involved, including those for crude oil storage facilities, are large at about \$2,500 million for a strategic crude oil storage of around 5 million tons.

## Interregional Energy Trade Opportunities

The current interregional energy trade regimes between South Asia and other parts of the world primarily cover the importation of petroleum and its products, liquid natural gas, coal, and limited electricity imports (by Afghanistan and Pakistan from central Asian republics and Iran, respectively). However, additional interregional energy trade options are being explored by the SMSs to procure energy supplies from outside the region. Significant among them are the opportunities discussed below to establish interregional gas and power transmission.

### Iran–Pakistan–India Natural Gas Pipeline

Iran, has the potential to be a large-scale energy exporter to the SMSs, with oil reserves of 132 billion barrels (bbl), producing 4.2 million bbl per year (bbl/y); natural gas reserves of 971 trillion cubic feet (tcf), producing 3.5 tcf per year (tcf/y); and hydropower potential of 42,000 MW, with 2,000 MW developed. Pakistan is already importing 39 MW of electricity from Iran to Balochistan and intends to increase power imports from Iran to 1,100 MW to meet demand in the port city of Gwadar. The Iran–Pakistan–India (IPI) pipeline project has been under discussion for the past couple of decades. The 800 km pipeline under this project was originally designed to supply 55 billion cubic meters per year (5.2 billion cubic feet per day) of natural gas for use by both India and Pakistan, and the estimated project cost was of the order of \$7 billion. However, the natural gas volume to be supplied has recently been revised down to 21 billion cubic meters per year (2.0 billion cubic feet per day), to be shared equally between India and Pakistan in the first phase of the project. The respective sections of the natural gas pipeline falling within the territory of each country are to be built and operated by the concerned country. The Inter State Gas Systems of Pakistan and the National Iranian Oil Company of Iran initialed a gas sale and purchase agreement on 24 May 2009 and was signed bilaterally on 5 June 2009 at Istanbul in Turkey, leaving room for India to join the project at a later stage.<sup>19</sup>

Pakistan is planning to lay a 42-inch natural gas pipeline to transport gas volumes of up to 1.0 billion cubic feet per day, while another section of the same size can be added later if and when India decides to join the project. The pipeline cost based on current steel prices is estimated at \$1.3 billion to supply the gas up to Nawabshah, which is about 800 km from the Iran–Pakistan border (the natural gas will be made available up to the border by Iran). The model proposed for funding the project is fundamentally

<sup>19</sup> Noor Ul Huq (2010).

based on an integrated project structure with the Government of Pakistan or a strategic investor taking a lead role in implementing the project. The natural gas transit charge cash flow would come from the major natural gas purchasers including the Pakistan State Oil, Oil and Gas Development Company Limited, Pakistan Petroleum, Sui Northern Gas Pipelines, and Sui Southern Gas Company.

The success of the project would depend on ensuring

- (i) the availability of adequate natural gas reserves and the commitment and authority of the producer to feed the pipeline capacity for 15–20 years (reserve and production risk),
- (ii) the construction costs and schedule considering the authorizations required and the ability of the pipeline operator to keep it functioning for a 15–20 year period (construction and operation risk),
- (iii) the commitment of the market or buyers to take all the natural gas over this period and pay for it in currencies matching the gas supply costs (market and payment risk),
- (iv) no political unrest and influence (political risk), and
- (v) the ability to obtain timely financial closure for the project (financing risk).

Among these, the construction and operation risk, the payment risk, and the financing risk are most significant and are best handled through proven project implementation and operation arrangements, maximizing the local currency share of the construction costs, and using international financial institution risk mitigation instruments in the financing arrangement. A smaller scale project would pose substantially less overall risk. Given the expensive electricity shortages in Pakistan at nearly 16% of peak capacity in 2006 (Figure 4) and the likely shift of the country from experiencing surpluses of natural gas to a deficit situation, obtaining additional supplies of natural gas will be important to enhancing the country's capacity to grow.

## Opportunities for Energy Imports from Myanmar

With oil reserves of 3.2 billion bbl, producing 7.3 million bbl/y; natural gas reserves of 18 tcf, producing about 4 bcf/y; and hydropower potential of 39,720 MW, with 747 MW developed, Myanmar is another energy resource-rich neighbor of South Asia. Hydropower projects with an installed capacity of 10,398 MW are reported to be under construction, with about 2,000 MW scheduled for completion in 2010. However, several of the hydropower projects are being developed as joint venture projects with foreign partners who are likely to take most of the electricity from such projects to their own

countries. India is developing the Tamanti multipurpose project, close to the India–Myanmar border, with an installed capacity of 1,200 MW in the first stage and 400 MW and 700 MW in the second and third stages, with most of the electricity generated from this project intended for sale within India. In this context, with transmission expansion in Myanmar, the possibility is open for the SMSs to negotiate additional access to electricity generated.

Myanmar has also invited foreign direct investment for the exploration and development of oil and gas fields. Indian energy companies from both the public and the private sector have taken equity stakes for the development of gas and oil fields in Myanmar. The Oil and Natural Gas Corporation and the Gas Authority of India have a nearly 30% equity stake in the A-1 and A-4 blocks, with reserves in the order of 5.7 tcf to 10–13 tcf gas, off the coast of Myanmar.<sup>20</sup> In 2007, India was planning to bring its equity gas from the A-4 block through a pipeline passing 290 km through Bangladesh. Although the annual transit fee alone was estimated to be around \$125 million, the right-of-way through Bangladesh could not be resolved. However, fresh initiatives were taken in November 2009 in the face of exacerbated natural gas constraints faced by the SMSs, particularly Bangladesh, and it is expected that the right-of-way through Bangladesh will be resolved. However, natural gas availability in Myanmar for the project is now an issue given Myanmar's natural gas commitments to the PRC. It would, nevertheless, be advantageous for the SMSs seeking access to gas reserves in Myanmar to develop the necessary pipeline infrastructure. These plans need to be made consistent with plans by the SMSs to bring in natural gas in the form of LNG—for instance, pipeline infrastructure to evacuate the natural gas to load centers from the LNG regasification terminals would be needed.

The above discussion highlights the need for regional energy strategies to be developed to ensure consistency with national programs. Such strategies can provide guidelines for regional project planning and implementation. Regional strategies are regional public goods that require collaborative efforts and return rewards greater than obtainable from individual country efforts.

## **Central Asia–South Asia Power Transmission Project**

The Central Asia Republics (CAR), including Kazakhstan, the Kyrgyz Republic, Tajikistan, Turkmenistan, and Uzbekistan, is well endowed with energy resources, including hydropower and natural gas, and formed a strong

<sup>20</sup> Shwe Gas Movement (2010).

electricity trading group in the past via interconnection through a common 500 kV power transmission ring. With the demise of the Soviet Union, much of this trade disappeared due to decreased electricity demand and drive for self-sufficiency in the CAR, but a significant interdependence still existed among them. For example, Tajikistan depended on Uzbekistan as a source of electricity supply during the winter months but exported hydroelectricity to Uzbekistan in the summer months, and also released water for agriculture in the Fergana Valley in Uzbekistan during that time. However, Tajikistan has now sought to further develop its hydropower (both run-of-river and storage type plants) for export to third parties. This Tajikistan initiative is viewed with serious concern by Uzbekistan due to the possible impact on water releases for its agriculture. The Kyrgyz Republic also has hydropower generating capacity to supply exports.

At a regional conference on electricity trade, organized by the Government of Pakistan in Islamabad in May 2006, Afghanistan, the Kyrgyz Republic, Pakistan, and Tajikistan created a joint Multi-Country Working Group to pursue a project for constructing a transmission line to export about 1,000 MW of electricity from the Kyrgyz Republic and Tajikistan to Pakistan via Afghanistan (with a possibility to off-load some electricity in Afghanistan). Subsequently, at the second regional conference in Dushanbe in October 2006, these countries signed a memorandum of understanding for the development of the Central Asia–South Asia (CASA-1000) Project, and created a ministerial committee to oversee the effort. They also formally requested the World Bank and ADB to assist in conducting the necessary analytical work for project preparation.

The CASA-1000 Project, primarily involves (i) construction of a 500 kV power transmission line from Tajikistan to Pakistan via Afghanistan, and strengthening of transmission infrastructure with the Kyrgyz Republic; and (ii) development of the associated electricity trading arrangements. The analytical work in support of the CASA-1000 Project consisted of a Technical and Economic Assessment and a Commercial Assessment of the project. The Technical and Economic Assessment examined the technical and economic merits of the project and its environmental, social, and other safeguard implications, while the Commercial Assessment examined options for implementing the project through public–private partnership arrangements and the institutional, financial, risk, and legal structures of the project.

The country delegations and their advisors, the international financial institutions and the consulting teams, and representatives of the Government of the United States (US) met in 31 July–2 August, 2008 to discuss the CASA-1000 project and recommended that the concession company to be selected would develop, construct, and operate the Tajikistan–Afghanistan–Pakistan



transmission system and also construct the Kyrgyz Republic–Tajikistan link. It was also recommended in principle that Barki Tajik (the Tajikistan power utility) should be the consolidator of power with the Kyrgyz Republic generating plants selling power to Barki Tajik through the Kyrgyz Republic–Tajikistan link, and Barki Tajik signing a single PPA with the power purchasers. The Kyrgyz Republic and Tajikistan are together expected to commit firm power flows. Meantime, Uzbekistan has raised objections to the further control that would be imposed on water releases to the Amudarya river supplying water to the Fergana Valley as a result of further hydropower developments in Tajikistan, particularly the 3,600 MW Rogun hydropower project on the Vakhsh river, which is a major tributary of the Amudarya. In fact, in December 2009, Uzbekistan isolated itself from the aforementioned 500 kV power transmission ring, imposing winter power supply constraints on Tajikistan. This development has added further complexities to the CASA-1000 Project.

This project highlights the need for consensus in international cooperation—potential benefits and costs must be apportioned so that all participants view the results as fair. Regional public goods, regional infrastructure projects thus have an additional element of complexity that purely national projects do not have. This is one reason why there is often the need for support for these projects by international finance institutions that can help provide technical studies supporting the necessary negotiations among participating countries.

## **Turkmenistan–Afghanistan–Pakistan–India Natural Gas Pipeline**

Turkmenistan, with reserves estimated at 14 trillion cubic meters, has the world's fourth largest natural gas reserves after the Russian Federation, Iran, Qatar, and the US. Most of the Turkmenistan natural gas is sold to the Russian Federation for transport and sale to Europe. A pipeline is also currently operating to transport natural gas from Turkmenistan to the PRC through the central Asian states. The Turkmenistan–Afghanistan–Pakistan–India (TAPI) Natural Gas Pipeline project was proposed to bring natural gas from the South Yolatan –Osman in Turkmenistan to Afghanistan, Pakistan, and India. ADB was requested by the respective governments to be the secretariat for the project and ADB provided continuous support including the funding for the feasibility study of the project, conducted by the British consulting firm Penspen in 2004 (updated in 2008). That study envisages a 3.2 bcf/d, 56-inch diameter pipeline from Turkmenistan, through Herat and Kandahar in Afghanistan, crossing the Pakistan border near Chaman, and passing through Multan to Fazilka near the Pakistan–India border. The length

of the pipeline would be 1,680 km. The capital cost of the project, originally estimated at \$3.3 billion, has since been revised to \$7.6 billion. The project would take between 4 and 5 years to complete after the signing of all the contracts.

The project development is being supervised by an inter-ministerial steering committee of the petroleum ministers of the participating countries, i.e., Afghanistan, India, Pakistan, and Turkmenistan. A Gas Pipeline Framework Agreement (GPFA) initialed in April 2008 was signed in December 2010 by the respective ministers along with an intergovernmental agreement. A Heads of Agreement document outlining the key principles of a Gas Sales and Purchase Agreement was successfully negotiated in May 2008 and later signed in September 2009.

The success of this project would depend on the factors mentioned in section 4.10 in the IPI pipeline. In the TAPI case, the gas availability has been confirmed, but the continued commitment could be an issue given other possibly more lucrative markets, particularly in Europe. The TAPI route is in extremely challenging terrain and 830 km of the pipeline will be in Afghanistan, posing possible operational constraints. Consequently, the financing risk would be higher than in the case of the IPI pipeline, although the market and payment risk would be similar to that pipeline.

A Qatar–Pakistan–India pipeline through the United Arab Emirates and Karachi has also been considered for a long time, but its chances of materializing are dependent upon whether Qatar can commit to supplying 2.6 bcf/d of gas through the pipeline, given its existing LNG commitments.

## **Additional Energy Trade Options**

It is evident from the degree of maturity of the regional energy trade initiatives identified above that the volume of supplementary energy that can be accessed by the SMSs through these initiatives and the likely pace at which that supplementary energy can be accessed would not be adequate to address the key energy sector issues faced by the SMSs. This judgment considers the likely energy demand growth together with the country-based energy expansion options available to the individual SMSs. The SAARC Regional Energy Trade Study (SRETS), therefore, recommends further regional energy trade options that would bring in substantial additional energy to the SMSs. These options include the development of a regional power market, a regional refinery, a regional LNG terminal, and a regional power plant (Chapters 5–8).

## Conclusion

The current intra-regional energy trade, which is limited to petroleum product and electricity, is only 5% of the total trade in the South Asia region. Even this low level of energy trade is limited to a few countries. The trading of petroleum is limited to India supplying petroleum products to Bhutan, Nepal, and Sri Lanka. Large-scale electricity trade exists only between Bhutan and India, while India–Nepal electricity trade is limited to about 60 MW–100 MW. The ongoing efforts to increase power transmission capacity between India and Nepal will materialize with the establishment of the first large-scale cross-border line from Dhalkebar to Muzzafarpur of 1000 MW capacity. The 500 MW transmission link between Bangladesh and India is likely to be operational by 2012 or 2013. The strong understanding between India and Sri Lanka on the development of their submarine electricity transmission interconnection of 1000 MW capacity is expected to lead to its implementation in two stages, starting from 2013. In the meantime, there will be unhindered development and enhancement of cross-border transmission capacity between Bhutan and India to accommodate increased export-oriented power generation capacity in Bhutan. Although there is a significant level of interest in establishing power transmission interconnections between India and Pakistan, given the present geopolitical environment, this is likely to be a reality only in the long term.

The discussions on interregional energy trade have been confined to the Iran–Pakistan–India (IPI) and Turkmenistan–Afghanistan–Pakistan–India (TAPI) natural gas pipelines and the Central Asia–South Asia (CASA-1000) power transmission project. The development of natural gas resources in Myanmar for electricity generation and transmission to Bangladesh and India are also being discussed. While the IPI pipeline project has advanced with a reduced transmission capacity, other projects are unlikely to make headway in the short and medium term.

## Chapter 5

# Regional Power Market

## Introduction

Given the high opportunity cost of electricity shortages in the region, any effort to reduce these shortages would have significant economic benefits. According to a 2007 study by The Energy and Resources Institute (TERI), the economic value created by electricity consumption in India was estimated at Rs81.2 per kilowatt-hour (kWh).<sup>21</sup> An option available for the region to reduce electricity shortages is to promote enhanced electricity trade in any surpluses that the SAARC member states (SMSs) may have either over the course of the day or seasonally. In this context, it is important to note that Bhutan has agreed to export around 10,000 megawatts (MW) of hydropower to India by 2020, Sri Lanka is in the process of implementing nearly 2,000 MW of coal-fired power plants together with a 500 MW or 1,000 MW high voltage direct current (HVDC) link with India (see Chapter 4), while India itself is progressing with the implementation of its 2,000 MW–4,000 MW power plants with coal or liquefied natural gas (LNG) firing (see Chapter 8). On the other hand, Bangladesh, which is predominantly dependent upon natural gas for power generation, is looking toward an early power interconnection with India to ease its power shortages, which are approximately 30% in 2010, and Pakistan is also seeking power trade opportunities to ease its power shortages. The present regional trade, which is now bilateral in nature and taking place between India and Nepal, and India and Bhutan, can be enhanced to cover much larger power volumes, involving most of the SMSs.

Such enhanced electricity trade can be facilitated by a regional power exchange that would provide centralized control to increase opportunities

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<sup>21</sup> TERI (2007).

for cross-border electricity trade among the SMSs, which are already interconnected or likely to have interconnections. A regional power market for the SMSs is a regional public good that offers many technical and economic benefits, including better exploitation of energy resources, a reduction in generation reserve requirements, lower overall costs of supply from competition in generation, improved power system reliability, reduced environmental impacts, and added incentives to resource-rich countries to accelerate power development. As such, the private sector will likely not provide the resources needed to undertake the development of these exchanges; there is need for the concerned governments to collectively and cooperatively undertake this initiative.

Bilateral trade arrangements can graduate to multilateral trade arrangements within a regional framework. India already has two working national level electricity exchanges, India Energy Exchange and Power Exchange India Limited, through which bilateral as well as competitive electricity trade is taking place. Interested power producers and buyers in the SMSs that are already connected or to be connected to the Indian electricity grid can consider participating in enhanced regional electricity trade through a regional power exchange linked to these Indian electricity exchanges. The SMSs could then, as a first step, participate in the Indian power market through bilateral contracts facilitated by this regional power exchange, and then proceed to transfer power to third parties where feasible.

## Indian Power Market

India has an important role to play in building a regional electricity market because of its size and its central location. All trade except that between Afghanistan and Pakistan would involve India as the conduit for electricity transmission. India's experience of linking various regional grids to move to a national grid may be emulated for building the proposed regional power market. India has five regional transmission grids: Northern, Western, Southern, Eastern, and North Eastern. In India, as is generally the case in the SAARC, resources are unevenly distributed with select regions such as Bihar/Jharkhand, Orissa, and West Bengal in the east having abundant coal, and north and northeast India having abundant hydro resources. The demand centers in the north, west, and south do not have adequate natural resources for setting up power plants to meet their requirements. Therefore, the regions were interlinked for better utilization of generating resources for sustainable development. At present four regions, the Northern, Western, Eastern, and North Eastern regions are synchronously interconnected through high capacity 400 kV AC lines. HVDC back-to-back interconnections are also available between the Eastern and Northern regions and between the Western and Northern regions. These supplement the alternating

current (AC) synchronous links. The Southern region, now connected with the remaining all-India power grid through asynchronous HVDC and radial AC links, is expected to be synchronously connected to the other regions by 2013–2014.

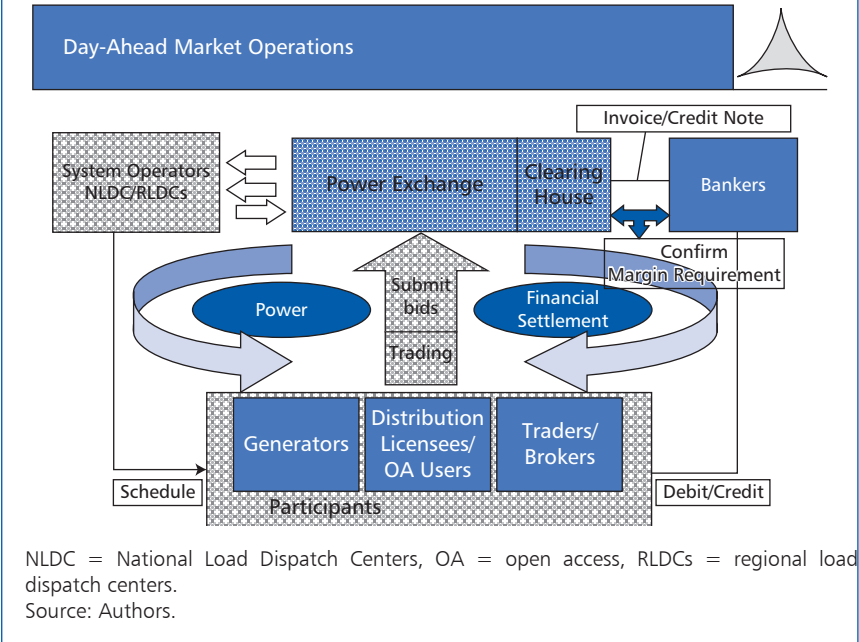
The Indian power exchanges referred to above, the India Energy Exchange and Power Exchange India Limited, are day-ahead markets. In the process of carrying out market operations (Figure 14), they make a first estimate of the marginal clearing price and the marginal clearing volume of power, based on the bids received from sellers and buyers for each hour over the next day. The exchanges then check the required transmission capacity with the national load dispatch center (NLDC) and regional load dispatch centers, and do a recalculation of the marginal clearing price and marginal clearing volume, considering any transmission constraints. Thereafter, the exchanges issue day-ahead power generation and dispatch schedules for implementation the next day and follow with the issuance of financial statements for the settlement of payments.

In 2006, India's power grid operator, the Power Grid Corporation, had 74,300 circuit-km of power transmission lines that also provided an interregional power transfer capacity of approximately 20,800 MW within India. This is expected to increase to 32,000 MW by 2012. At the end of its fiscal year 2009 (ending 31 March 2010), India was generating about 2,000 million kWh per day of electricity using an installed power generating capacity of 141 gigawatts (GW). However, due to the unavailability of the full generating capacity, peak demand shortages of up to 15% resulted. The day-ahead market of the two power exchanges nevertheless account for only around 1.2% of the daily electricity traded nationally due to market clearing electricity prices at the exchanges (averaging approximately \$0.054 per kWh at high voltage) being in excess of the cost of bilaterally traded electricity. Most of the facilitation offered by the two power exchanges at this stage is for bilaterally traded power between generators and major consumers. However, given the continuing power shortages, there is strong interest in the further development of merchant power plants in India. These typically tie up about 70% of their generating capacity through long-term bilateral contracts with major consumers, trading only the balance on a competitive basis. Given this background, there is scope for expanded cross-border bilateral electricity trade facilitated by a regional power exchange.

## Developing a Regional Power Market

Looking at international experience, it emerges that a regional power market can be set up by adopting a building block approach. Regional electricity

Figure 14 Typical Indian Power Exchange Day-Ahead Market Operation



markets need to evolve over time for a variety of reasons—technical, regulatory, and policy related. The evolutionary path for this market would depend on the pace at which the regional resource potential is exploited, the demand–supply balance in the foreseeable future, the structure of the power supply industry (including the network characteristics and the legal and regulatory framework), government policies and, not least, the surpluses that the countries involved can identify over the different seasons and over the course of a day. The first and foremost requirement for moving toward a regional power market would be a broad agreement at the governmental level, between the participating member states, to facilitate bilateral power exchanges followed by multilateral power exchanges. This has been an initiating point for a number of power pools currently operating across the world. This is well illustrated by the development of the Southern African Power Pool (Annex 2). Power system studies for different scenarios in the short, medium, and long term would then identify the possible quantity of power exchanges and transmission system requirements including the associated costs and benefits.

The interconnections necessary to support a regional power market would need to be established between various SMSs in a phased manner, starting

with the most feasible bilateral ones and then gradually expanding to accommodate multilateral power flow opportunities. The cost of electricity transfer through these interconnections would depend upon a number of variables such as power transfer capacity, length of the line, power flow, and hours of supply. These costs could be levied as wheeling charges on the base tariff charged for the electricity as in the case of bilateral contracts for power transfer. The SMS governments could consider building some of these interconnections as public goods to reap long-term economic benefits from increased regional electricity trade. The evolutionary path of a regional electricity market would depend on the pace at which the regional resource potential, together with interregional energy imports, is exploited and the structure of the power supply industry that would emerge in the region in terms of legal and regulatory frameworks.

Along with the setting up of interconnections, regulatory provisions, including grid codes to ensure reliable interconnected operation, National Load Dispatch Centers (NLDCs) of the participating countries, together with control and communication mechanisms to coordinate the regional power exchange, would have to be set up. In the case of contract-based bilateral power exchanges between SMSs, a country NLDC can evaluate the net feasible power exchange (based on data from generators, traders, or aggregators) along with the points of power export or import for each scheduling period from that country's perspective and communicate this to the designated regional power exchange for implementation. In the case of market-based power transactions, the power available for export in excess of bilateral commitments can also be marketed through the regional power exchange given proposed hourly power injection quantities and the points of injection and price, for subsequent finalization and implementation to the extent accepted by the sellers and buyers of power.

An important decision while interconnecting a number of power systems would be the mode of interconnection (synchronous or asynchronous) and a scheme for grid-level protection. The radial (asynchronous) AC link is normally used for small blocks of power exchange (up to 150 MW). Synchronous AC links could be used if it were technically possible to operate the two grids in synchronous mode, which is determined on the basis of relevant technical studies. HVDC back-to-back links could be used for interconnecting two adjacent grids for regulated power transfer or for those that need to be operated in asynchronous manner due to operational reasons. HVDC bi-pole lines are used for transferring large amounts of power over longer distances. All investments, however, need to be justified considering economic and technical analysis. The establishment of a comprehensive and reliable regional base as proposed in Chapter 11 would support such analysis.



## Implementation Approach

Considering the importance of an enhanced regional power market, a SAARC task force is already carrying out the analysis to develop a common template on the technical and commercial aspects for electricity grid interconnections among the SMSs. This analysis can be supplemented to the extent necessary by regional technical assistance, comprehensively covering the issues to make an enhanced regional power market a reality, facilitated by a regional power exchange, and linked to the existing Indian power exchanges. These issues are as follows:

- (i) A study of regional power system structures, including the legal and regulatory aspects, and the power transmission system security and stability standards in the participating countries and their compatibility from a regional power trading perspective.
- (ii) A study of power generation scheduling and dispatch procedures, energy accounting systems, and financial settlement systems for electricity transactions in the individual countries; identification of measures for their harmonization to allow feasible cross-border power trade; and analysis of the institutional, regulatory, and commercial requirements for cross-border power trade.
- (iii) Identification of possible cross-border power transmission interconnections and scenarios for different regionally interconnected power systems and the development of a regional database required to carry out power system studies.
- (iv) Development of scenarios for nodal point supply and demand in the region covered or to be covered by interconnected power systems, and conducting power system studies for different regional participation scenarios to determine the technical potential for cross-border power exchanges; the additional power transmission required; and the institutional, regulatory, and commercial principles and procedures to be followed in formalized cross-border power trade.
- (v) Carrying out of economic and financial analyses of different power trade options quantitatively examining the possibilities to optimize resources at the regional level, and the extent to which environmental benefits of such options can be captured.
- (vi) Development of the structure for a regional power exchange that can link with the existing Indian power exchanges, with operational modifications necessary, and centrally facilitate the extension of the Indian power market to cater to regional power trade.

## Chapter 6

# Regional Refinery

## Introduction

Given the current high dependence of the entire South Asia region on petroleum products, most of which are imported, the SAARC member states (SMSs) may consider setting up a state-of-the-art large-scale regional refinery designed to yield the petroleum product mix required, with economies of scale in refinery operations as well as in crude oil procurement, and with reduced petroleum product transport distances compared to procurements from outside the region. The regional refinery would lead to reduced petroleum product prices and an increase in the energy security of the region by reducing imports of petroleum products, although it would increase imports of crude oil. The best practice adopted here is drawn from a similar approach taken by the African refinery sector to capture economies of scale from integrated large-scale joint refining and associated bulk crude oil procurement.

## Regional Refinery Justification

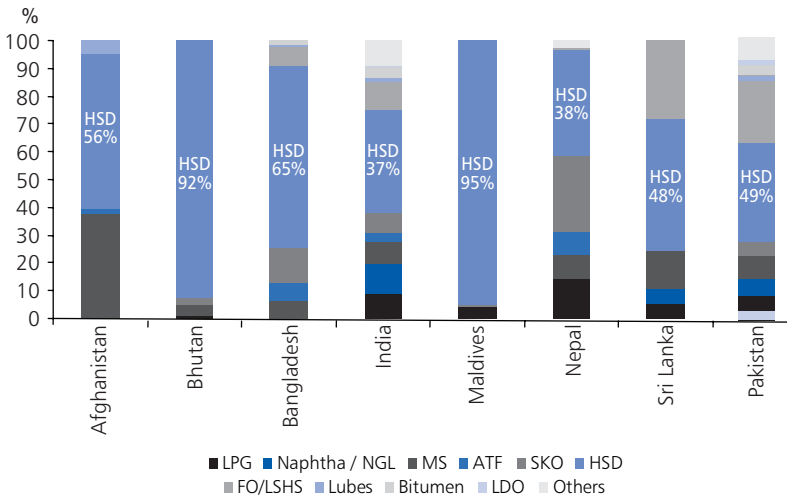
As highlighted in Chapter 3, the region is heavily dependent on imports to meet its crude oil and petroleum product demand. The import of petroleum products poses deeper energy security concerns compared to those associated with the import of crude oil. SMSs such as Afghanistan, Bhutan, the Maldives, and Nepal are nearly 100% dependent upon imports. Bangladesh and Sri Lanka, with limited refining capacities of 1.5 million metric tons per annum (MMTPA) and 2.5 MMTPA, respectively, are dependent on the import of petroleum products by about 50%. A current refining capacity of 12.9 MMTPA meets around 68% of Pakistan's petroleum product demand

and Pakistan is pursuing three new refinery projects to reduce imported petroleum product dependency. Current refining technology employed in most of the refineries across the region, except in India, is outdated and needs modernization. India, on an aggregate basis has a surplus refining capacity, but it is still unable to meet the demand for all its petroleum products and therefore partly imports some petroleum products such as liquefied petroleum gas (LPG).

Although an increase in the demand for petroleum products is expected with annual growth rates ranging from 3% in India to 20% in the Maldives, plans for refinery capacity expansion are limited and high import dependence on petroleum products will continue. An analysis of the current petroleum product consumption pattern of the SMSs reveals that high-speed diesel (HSD, or simply diesel), constitutes the majority of total consumption (Figure 15). In some member states such as Bhutan and the Maldives, HSD accounts for more than 90% of petroleum product consumption.

Transport requirements in India will dominate the region's long-term diesel requirements, and the present diesel share in India is projected to grow to 50% by 2020.<sup>22</sup> Given this background, interested SMSs could consider

**Figure 15 Petroleum Product Consumption Profile**



ATF = aviation turbine fuel, FO = fuel oil, HSD = high-speed diesel, LPG = liquefied petroleum gas, LDO = light diesel oil, LSHS = low sulphur heavy stock, MS = motor spirit, NGL = natural gas liquids, SKO = superior kerosene oil.

Source: Authors.

<sup>22</sup> International Energy Agency (2008).

cooperating to set up a state-of-the-art large-scale regional refinery, with adequate flexibility to accommodate a range of crude oils, to meet the petroleum product demand with economies of scale in refinery operations as well as in crude oil procurement. The refinery would be aimed at enhancing the energy security of the region by decreasing its dependence on imports of petroleum products and configuring it to maximize diesel production, with 50% diesel output. The greater energy security risk associated with petroleum products is the operational and price risk due to intermediary refining operations.

Regional cooperation efforts—collaborative partnerships—will reduce project risks for the refinery by providing multi-country markets. This is especially important for the smaller economies. Bhutan, the Maldives, and Nepal cannot support, with their domestic markets, a large-scale, efficient petroleum refinery. By co-sponsoring such a facility on a collaborative basis, with the partnership of other SMSs, these smaller economies can realize economies of scale. In this fashion, regional cooperation can improve energy security for the smaller economies.

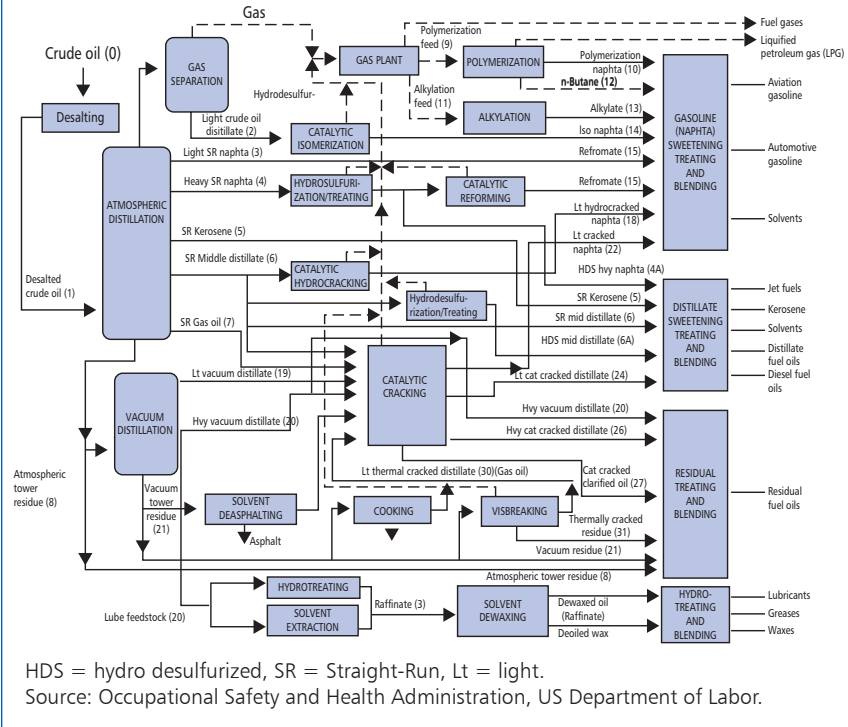
The net refinery margin from such a refinery, after accounting for sales (valuing petroleum product prices at the refinery gate) and all costs (including crude oil, operating, and financing) would benefit SMSs taking an equity stake in that refinery and could be used to provide a return to those states or provide a discount on the refinery gate petroleum prices. Regional distribution of the petroleum products from the refinery can be facilitated through regional seaports and the available land-based oil transport infrastructure.

## Expected Refinery Performance

India's 27 MMTPA Jamnagar refinery in Gujarat, owned by Reliance Industries Limited and commissioned in 2008, is one of the largest in the world and is an example of a large state-of-the-art refinery. A refinery of this magnitude can be considered for a regional refinery. In this context, a 23 MMTPA regional refinery, including thermal and catalytic cracking in addition to atmospheric and vacuum distillation (Figure 16), is considered appropriate to meet the medium-term petroleum product demand of the region together with other sources of such products.

The total investment required for the 23 MMTPA regional refinery considered is expected to be around \$8.1 billion. If the refinery is configured to produce 50% diesel, then production of diesel (also referred to as distillates and gas oil) would be 11.5 MMTPA. The other refinery petroleum products would include LPG, naphtha, motor spirit (gasoline), kerosene, aviation fuel, and by-products for industrial use. Foreign exchange would

**Figure 16 Typical Large-Scale Refinery Flow**



be incurred on feedstock in the form of crude oil for the refinery, valued at \$100 per barrel (bbl).

Table 10 shows the gross refinery margin obtained on a per bbl basis by deducting the crude oil cost and the refinery operating cost from the total value of refinery products including industrial by-products. Table 11 shows the gross annual revenue accruing to the refinery. Table 12 shows the net annual revenue generated from the refinery. Meaningful variations to the basic parameters used in this analysis can be examined with information obtainable from the regional energy database proposed in Chapter 11.

## Refinery Implementation

The regional refinery can be set up through a special-purpose vehicle (SPV) owned by interested SMSs with the specific objective of setting up a large-scale state-of-the-art refining capacity that would be available to more than one country. The refinery will be expected to operate on commercial

Table 10 **Gross Refinery Margin**

Refinery Margin Calculations			
Product	Share (%)	Price (\$/bbl)	Value (\$)
LPG	3	119.37	3.58
Naphtha	10	124.97	12.50
Motor spirit	15	124.97	18.74
Kerosene/Aviation fuel	10	120.05	12.01
Diesel	50	114.60	57.30
Furnace oil	5	69.99	3.50
By-products			5.00
<b>Total Value (\$/bbl)</b>			<b>112.63</b>
Crude oil cost (\$/bbl)			100.00
Refinery margin (\$/bbl)			12.63
Refinery operating cost (\$/bbl)			5.00
<b>Gross Refinery Margin (\$/bbl)</b>			<b>7.63</b>

bbl = barrel, LPG = liquefied petroleum gas.

Source: Authors.

Table 11 **Gross Annual Revenue Accruing to Refinery**

Product	Produce (million MT)	Price (\$/MT)	Revenue (\$ million)
LPG	0.7	875	604
Naphtha	2.3	916	2,107
Motor spirit	3.4	916	3,160
Kerosene/Aviation fuel	2.3	880	2,024
Diesel	11.5	840	9,660
Furnace oil	1.15	513	590
By-products			840
<b>Total Revenue</b>	<b>\$million</b>		<b>18,985</b>
	<b>\$billion</b>		<b>18.98</b>

LPG = liquefied petroleum gas, MT = metric ton.

Source: Authors.

principles with import parity pricing at the refinery gate. It could be set up as a grassroots refinery or in the form of additional refining capacity in an existing refinery. However, it takes 3–4 years to commission a new refinery and 2–3 years to expand an existing one. In the interim period, petroleum products can be procured on commercial terms from existing

**Table 12 Net Annual Revenue Generated from Refinery**

	Amount	Unit
Regional refinery size	23	MMTPA
Capital investment @ \$357/MMTPA	8.21	\$billion
Share of diesel	11.5	MMTPA
Refinery total revenue	18.98	\$billion
Cost of procurement of crude @ \$100/bbl	16.79	\$billion
Refinery operating cost	0.84	\$billion
Financing costs	0.82	\$billion
Net revenue to region	0.53	\$billion

bbl = barrel, MMTPA = million metric tons per annum.

Source: Authors.

Indian refineries that have capacity and located close to SMS country borders. Procuring Indian petroleum products might allow these countries to source such products at a lower cost than importing them over longer distances from outside the region. Sri Lanka, for example, is procuring half of its petroleum product requirement from India. Common crude procurement by interested SMSs for refining at an existing Indian refinery with capacity can also be considered. By virtue of their ownership share in the refinery, participating SMSs would obtain an additional source of income.

In the case of a grassroots refinery, the SPV would be required to carry out a detailed analysis of the petroleum product needs of participating SMSs and optimize the technology, size, and location of the refinery to gain the maximum benefit from economies of scale in refinery size and crude oil import arrangements. Since there are a number of refinery capacity expansion projects that are planned in the region (especially in India), as an alternative interim approach, the SPV can be tasked with the responsibility of negotiating incremental capacities to meet the needs of other SMSs, individually or collectively. The interest of participating countries in such incremental capacities will depend on the specific locations where such projects are planned.

The region could also benefit by allowing swap arrangements for the supply of petroleum products across existing refineries to help in limiting transport costs for petroleum products. Some domestic refineries have an advantage in that they are located in close proximity to the border of the adjoining SMSs. The regional refinery can therefore have swap arrangements with these domestic refineries, under which it could supply markets of the domestic refineries located closer to it and in turn the domestic refineries can supply the regional refinery markets closer to them.

The SMSs may also jointly promote a strategic reserve stock of energy (particularly crude oil and petroleum products) and encourage joint stock holdings by partner countries, where appropriate. To mitigate the risks of short-term supply disruptions, the Government of India decided in early 2004 to build a strategic stockpile of crude oil to supplement those already held by Indian oil refiners. The stockpile is expected to eventually reach 15 million tons (110 million bbl) in 2016, to be accumulated in three phases of 5 million tons, with each phase covering 19 days of net oil imports at 2006 levels. The total cost of the first phase was estimated in 2006 at \$2.6 billion, including the construction of storage facilities (\$600 million) and oil purchases (at \$55 per bbl). Other SMSs dependent on India for petroleum products could also become part of this venture to address short-term market risks.



## Chapter 7

# Regional Liquefied Natural Gas Terminal

## Introduction

In the context of energy supply augmentation and energy security concerns, and the need to use cleaner forms of energy, there has been increased focus on natural gas—an interest in increasing its supply in some SAARC member states (SMSs) and as an attractive option to diversify the current fuel mix in other SMSs. Natural gas is an economically attractive substitute for diesel-based power generation. Moreover, increasing the energy mix by providing for natural gas can reduce the dependency upon petroleum, insulating an economy, to some extent, from oil price shocks. Natural gas, in contrast especially to coal, is a cleaner burning fuel, producing less greenhouse gas (GHG),<sup>23</sup> and fewer particulates for each unit of energy produced. Natural gas thus tends to contribute less to climate change problems and to local air pollution than either oil or coal. The internalization of environmental costs, through for example the use of the clean development mechanism (CDM) or a similar mechanism, would increase the competitiveness of natural gas-based power generation with imported coal-based power generation. Natural gas-based electricity generation for localized use and for bulk transmission through intra-regional power interconnections is an important electricity supply option.

The long-distance transport of natural gas (beyond 2,000 km) over oceans is most economically carried out in the form of liquefied natural gas (LNG)—

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<sup>23</sup> As noted in the discussion of a regional power station, an LGP-fueled power plant would emit less than one-half the amount of carbon dioxide that a comparable sized coal-fired plant would.

natural gas cooled to minus 160 degrees centigrade and occupying 1/600th the gaseous volume. Some significant LNG production and export points, which can be easily accessed by the region, are Ras Laffan in Qatar, Arun in Indonesia, and Bintulu in Malaysia. The larger SMSs (Bangladesh, India, and Pakistan) may consider developing a large-scale regional LNG importation and regasification terminal at a suitable point on their seaboard and enjoy the benefit of economies of scale in transport and regasification coupled with LNG procurement advantages. An important parallel activity needed with the establishment of such an LNG terminal is the provision of the required natural gas transport infrastructure. Extending such infrastructure to the smaller SMSs such as Sri Lanka would not be economical, given the limited natural gas demand that can be served and the costs associated with the necessary pipelines. However, they can access LNG-based bulk power generation, for example in India, through regional power infrastructure including cross-border power interconnections. As in the case of a regional refinery (Chapter 6), the participation of more than one country in LNG importing, either directly or through electricity production, can reduce project risk—minimizing the potential losses to any one country—and widen the potential market for the project outputs.

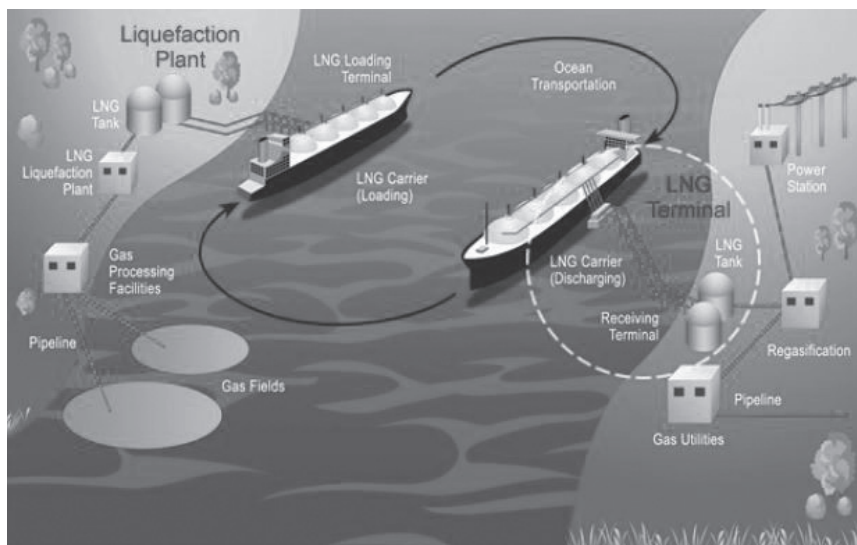
There are many examples of LNG import-based natural gas distribution and power generation in the world. A relevant example of best practice is the recently commissioned, private sector-funded \$1,000 million LNG receiving and regasification terminal, with a capacity of 7.9 million metric tons per annum (MMTPA) at Baja California in Mexico, with natural gas storage capacity (available for users on a common carrier basis) and the associated distribution infrastructure.<sup>24</sup>

## Liquefied Natural Gas Value Chain

The global LNG business depends on a value chain containing four components: (i) exploration and production; (ii) liquefaction; (iii) shipping; and (iv) storage and regasification, providing natural gas for delivery to end-users (Figure 17). To attract investors to an LNG project, the price of a unit volume of natural gas delivered into a bulk distribution pipeline must at least equal the combined costs of producing, liquefying, transporting, storing, and regasification of the gas, plus the costs of the capital needed to build the necessary infrastructure—and a reasonable return to investors. About 40% of the total cost of the LNG value chain is usually in the liquefaction plant, while the production, shipping, and regasification components account for nearly equal portions of the remaining costs. Technology improvements have reduced costs in all components of the LNG value chain during the last

<sup>24</sup> Energia Costa Azul (2004).

Figure 17 Elements of the Liquefied Natural Gas Value Chain



Source: PTT LNG Company Ltd., <http://www.pttlng.com/>.

20 years. Several factors—improved efficiency through design innovations, economies of scale through larger natural gas liquefaction train sizes, and competition among manufacturers—have led to a drop in capital costs for liquefaction plants.

A new 8 MMTPA (10.5 billion cubic meters per year) liquefaction plant could cost \$1,500 million—50% for construction-related costs and 50% for equipment and materials related costs. The cost of building and operating an LNG receiving terminal would vary by site. New onshore terminals built on existing designs are expected to cost \$100 million per MMTPA, with a new 5 MMTPA LNG receiving and regasification terminal costing \$500 million. Figure 18 shows the Sodeguara 4.8 MMTPA LNG terminal in Japan as an example of a typical LNG receiving terminal. LNG companies build most LNG ships for a specific project, then own and operate them. A typical 138,000 cubic meter capacity LNG ship would cost \$150 million. LNG shipping costs vary, depending on the ship's operating and amortization costs, the size of the cargo, and the distance transported.

## Relevance of Liquefied Natural Gas to the SAARC Region

A common issue across the region is the deficit of natural gas. Bangladesh, India, and Pakistan, using natural gas in their energy mix, are facing a deficit

**Figure 18 Typical Liquefied Natural Gas Receiving Terminal**

LNG receiving terminal, South Hook, Milford Haven, UK.  
 Source: Meyts Structural Consulting Limited, UK.

situation. For instance, Bangladesh is currently experiencing a natural gas deficit of 300 million standard cubic feet per day in meeting a demand of 2 billion standard cubic feet per day, and consequently a power shortage of 1,500 megawatts (MW) in meeting a peak demand of 5,500 MW. The Iran–Pakistan–India (IPI) and Turkmenistan–Afghanistan–Pakistan–India (TAPI) natural gas pipelines have been viewed by India and Pakistan for many years as possible modes of bringing in additional bulk natural gas supplies for their use. However, it is evident from the discussions on these projects in Chapter 4 that a degree of uncertainty exists with respect to the availability of natural gas, as well as the project financing and implementation. Given that India is already an LNG-importing country and that Bangladesh and Pakistan are also considering LNG imports, the region could benefit from embarking on a bulk regional LNG terminal to capture the benefits of economies of scale from terminal size and bulk LNG procurement. This project would provide wider and more flexible opportunities for sourcing natural gas with a high level of certainty through both long-term and spot contracts, and can be pursued in parallel with the IPI and TAPI projects for power generation and other uses of natural gas. Development of the incremental natural gas distribution infrastructure needed would be a parallel requirement.

Setting up an LNG terminal is a capital-intensive exercise. LNG importation and regasification terminals typically become economical when their capacity starts exceeding 2.5 MMTPA. The LNG importation and regasification cost for a 5 MMTPA terminal located in the western or eastern seaboard of

India would be \$0.8 per million British thermal units (MMBTU). The typical LNG shipping cost from Ras Laffan in Qatar to a 5 MMTPA LNG receiving plant on the Indian western seaboard would be \$0.5 per MMBTU, while the regasification cost would be \$0.3 per MMBTU.<sup>25</sup> The regasification cost would rise to \$0.5 per MMBTU for a 2.5 MMTPA LNG receiving terminal and fall to \$0.2 per MMBTU for a 7.5 MMTPA LNG receiving terminal.

Bangladesh and Pakistan could benefit from the economies of scale that India would obtain from a bulk LNG receiving terminal and from bulk LNG procurement if their gas requirements could be sourced through the expanding Indian natural gas system together with the cross-border pipeline infrastructure required. This option would be more economical than having dedicated undersea natural gas pipelines from a bulk LNG receiving terminal on the western seaboard of India to Pakistan, or from the eastern seaboard of India to Bangladesh. However, the cost of natural gas supplied through the Indian natural gas system would still need to be compared with LNG-based natural gas costs that Bangladesh and Pakistan would incur if they were to have their own dedicated, but possibly smaller, LNG receiving terminals and related LNG procurement arrangements. These possibilities reinforce the need to coordinate national energy planning studies within a regional framework.

The LNG spot market now accounts for 15% of LNG supplies worldwide, with the balance being traded through fixed-term contracts. LNG prices ranged from \$6 to \$9 per MMBTU in 2009. The numerical information referred to here can be suitably updated with reference to the regional energy database proposed in Chapter 11.

Critical factors in deciding the LNG terminal location would be the source and availability of LNG, relative transport economics, and the availability of requisite port facilities. The ease of connection to a backbone natural gas distribution pipeline network would also be an important factor to consider. A part of the natural gas output of the LNG terminal can be deployed for electricity generation at the site and the corresponding energy transfer done through electricity transmission. As can be interpolated from Table 13 in Chapter 8, the cost of electricity generated from LNG, priced at \$18 per gigajoule (GJ) works out to \$0.12/kilowatt-hour (kWh), against a diesel-based electricity generation cost of \$0.21/kWh at a diesel price of \$784 per million metric ton (\$18/GJ). Countries that are using diesel to partially meet their electricity demand would benefit immensely by switching fuel to accessible natural gas. Chapter 8 also highlights the economic competitiveness of

<sup>25</sup> Based on Indian LNG terminal costs in the Sri Lanka Natural Gas Options Study. Nexant (2003).

natural gas-based electricity generation compared to that based on coal, when the differential environmental impact is monetized.

## Commercial Arrangements

There are different options that can be considered for deciding on the ownership structure and for the financing options for a regional LNG terminal. The first option for the terminal is to structure it as a joint holding of the participating SMSs through equity participation. Alternatively, the SMSs may consider involving the private sector in building the LNG terminal and using the storage facility on a common carrier principle. The storage facility can be auctioned to interested consumers on a bid basis in order to tie up the supplies. The third option that is available for ownership and financing is to build a merchant LNG terminal for meeting natural gas demand.

The options available for pricing the natural gas to be supplied from the LNG terminal would depend on the expected maturity of the market, price of LNG at delivery, LNG terminal ownership structure, and terms and conditions of the operations of the LNG terminal operator. Under a fixed charge arrangement, the LNG terminal developer charges its customers a fixed charge for the natural gas largely based on the price at which the LNG is procured. In a regulated charge arrangement, the natural gas price is decided based on principles defined by a common regulator using cost plus or performance-benchmarked pricing. Where selling of quantities takes place through a bidding process, the bids invited could be based on price or quantity over a period of time. Under the first case, the bidding process is used to determine the price for delivery and under the latter case the price will be fixed by the terminal operator.

At present, in the region, only India is importing LNG. India set up its first LNG receiving terminal in Dahej, which now has a capacity of 5 MMTPA. LNG receiving terminals have also been set up in Dhabol (5 MMTPA) and Hazira (2.5 MMTPA). The Hazira LNG terminal, located on the west coast of India, is a merchant LNG terminal. It procures LNG on spot contracts and has short- to medium-term contracts on the delivery side. Additional LNG terminals, for completion by 2012, are being set up in Kochi (2.5 MMTPA), Ennore (2.5 MMTPA), and Mangalore (5 MMTPA). Long-term contracts for most of the LNG supply for these terminals have been or are being placed with Qatar and Iran.

## Chapter 8

# Regional Power Plant

### Introduction

With an installed power generating capacity of 141 gigawatts (GW) in 2009, India dominated the total regional installed power generating capacity of 171 GW. However, India itself experienced peak power supply deficits up to 16% in 2009, mainly due to an inability to run facilities at full capacity for various reasons including fuel supply shortages. In this context, India has taken definite steps to rapidly expand its power generating capacity to 300 GW by 2017, by including LNG-based and imported coal-based large power generating plants, in addition to power plants running on domestic natural gas and coal. The emphasis on new liquefied natural gas (LNG)-based, large power plants reflects the need to minimize the adverse environmental impact brought by power generation expansion. This emphasis is clear from the nearly 25 million metric tons per annum (MMTPA) of LNG imports that India is seeking by 2012 to provide an incremental supply of 3,200 million cubic feet per day of natural gas. Nearly 40% of that supply is targeted for bulk power generation in the form of 24 GW of combined cycle power plants. Part of this LNG-based power generation could be in the form of a bulk regional power plant in which interested SAARC member states (SMSs), with adequate power interconnections to it, could invest in and benefit from the economies of scale in power plant operations and in natural gas procurement, preferably through the proposed regional LNG plant.

Imported coal-based large power generating plants of the order of 4,000 megawatts (MW) can also yield similar economies of scale, and one or more could be considered for development as a regional power plant. SMS interest in importing electricity from a regional power plant would,

however, be dictated by the competitiveness of the cost of electricity imported, including electricity transmission costs, when compared with the cost of in-country electricity generation. An LNG-based power plant may not be as competitive as an imported coal-based power plant on financial costs alone. But if the environmental costs, especially those related to emissions of carbon dioxide, are internalized, an LNG-based bulk power generating plant becomes more competitive.<sup>26</sup> The regional power plant may be set up jointly by the countries concerned, by the private sector, or through a public-private partnership. In terms of power plant implementation methodology, the procedure adopted in India for its coal-fired Ultra Mega Power Plants of 4,000 MW capacity can be cited as a best practice example. India's tariff-based bidding for these projects resulted in power tariffs as low as \$0.029 per kilowatt-hour (kWh) at the power plant. A regional power plant with a tariff of this magnitude would be able to capture market share in a regional power market with adequate and cost effective power connectivity.

## Power Plant Economics

The regional power plant economics would depend on the size, location, and technology chosen, including the sourcing of fuel. Size would depend upon the power needs of the participating countries and how much power each country would like to receive from a regional plant, considering its own energy security concerns. Ease of access to location, project construction time, processes for project clearance and approval by concerned authorities, and any country risks would also merit consideration. The environmental and social impacts and power transmission facilities required to transmit bulk electricity to the participating countries could also vary from site to site. A first regional power plant should preferably have minimum complexities in implementation, demonstrable greenhouse gas (GHG) benefits, and indicative tariffs comparable to the marginal cost of generation in the respective countries in economic terms.

Once the concept is accepted and the size, location, and type of the power plant are decided for detailed feasibility study, agreements would be required on the following:

- (i) ownership of the plant, cost/benefit sharing, and royalty issues, if any;
- (ii) selection of the developer;
- (iii) arrangements for project facilitation;

<sup>26</sup> Valued in terms of certified emission reduction price per ton of carbon dioxide, as reported in the study on Relative Economics of Natural Gas and Other Fossil Fuels for Power Generation and Policy Options for India (March 2008).



- (iv) planning and implementation of the associated transmission system; and
- (v) monitoring and control of power transfers and payment settlement mechanisms.

Developing a regional power plant based on the hydropower resources within the region (mainly in Bhutan and Nepal) is technically an option but a difficult proposition to be developed at the pace required to significantly contribute to the incremental electricity requirements of the region in the medium term.

In the interest of expediency, the regional power generating capacity needs to be based on either imported coal or imported LNG—both of which are more attractive than the current dependence on imported diesel-based power generation in the region. Table 13 compares LNG-based and diesel-based power generation costs at various fuel price levels, with these fuels feeding a combined cycle power plant. It can be noted that while a diesel price of \$18/GJ results in an electricity generation cost of \$0.21/kWh, an LNG price of \$18/gigajoule (GJ) would result in an electricity generation cost of only \$0.12/kWh.

The environmental benefit of using LNG rather than coal, as referred to above, has been a driving force in commissioning the new LNG terminals in India. Table 14 shows a comparison of the estimated financial plus environmental cost of electricity generation based on imported coal compared to LNG at different locations in India, and Table 15 shows the main assumptions.

**Table 13 Comparison of Liquefied Natural Gas-Based and Diesel-Based Power Generation Costs**

LNG Price (\$/MMBTU)	LNG Price (\$/GJ)	LNG Electricity (\$/kWh)	Diesel Price (\$/MT)	Diesel Price (\$/GJ)	Diesel Electricity (\$/kWh)
8	7.58	0.060	784	18	0.210
10	9.48	0.072	990	23	0.270
12	11.37	0.083	1,503	35	0.400
15	14.22	0.100	1,605	37	0.430
20	18.96	0.128	1,810	42	0.480
25	23.70	0.157	2,015	46	0.530
30	28.44	0.185	2,527	58	0.660
35	33.18	0.214	3,040	70	0.800

kWh = kilowatt-hour, GJ = gigajoule, LNG = liquefied natural gas, MMBTU = million British thermal units, MT = metric ton.

Source: Authors.

**Table 14 Comparison of Liquefied Natural Gas-Based and Imported Coal-Based Electricity Generation Costs (Rs/kWh)**

Sources	Locations				
	Delhi	Gurgoan	Bilaspur	Vadodara	Kochi
<b>Imported Coal</b>					
Capital cost/kWh of generation	1.64	1.64	1.64	1.64	1.64
Fuel Cost/kWh of generation	2.16	2.15	2.08	1.97	1.91
Annualized O&M expenses/kWh of generation	0.19	0.19	0.19	0.19	0.19
Total financial cost of generation	3.98	3.98	3.91	3.79	3.74
Environmental cost	0.69	0.69	0.69	0.69	0.69
<b>Integrated cost of generation from coal</b>	<b>4.67</b>	<b>4.67</b>	<b>4.60</b>	<b>4.48</b>	<b>4.43</b>
<b>LNG</b>					
Capital cost/kWh of generation	0.98	0.98	0.98	0.98	0.98
Fuel cost/kWh of generation	2.62	2.62	2.62	2.62	2.62
Annualized O&M expenses/kWh of generation	0.04	0.04	0.04	0.04	0.04
Total financial cost of generation	3.64	3.64	3.64	3.64	3.64
Environmental cost	0.34	0.34	0.34	0.34	0.34
<b>Integrated cost of generation from LNG</b>	<b>3.98</b>	<b>3.98</b>	<b>3.98</b>	<b>3.98</b>	<b>3.98</b>

kWh = kilowatt-hour, LNG = liquefied natural gas, O&M = operations and maintenance, Rs = Indian rupees.

Source: Authors.

In current practice, a large-scale imported coal-based power plant would have supercritical steam technology with very high steam pressures and temperatures to capture efficiency gains with reduced environmental impact, and thereby be classed as a clean coal technology power plant. While this will enable the power plant efficiency to be increased to 42%, the superior materials required would raise the capital cost to Rs55 million/MW. A competing large-size LNG-based modern combined cycle power plant would have an efficiency of 50% and have a capital cost of Rs36 million/MW.

Table 15 Basic Power Plant Assumptions

Element	Imported Coal-Based Power Plant	LNG-Based Power Plant
Heat rate (kcal/kWh)	2,048	1,720
Efficiency (%)	42	50
Capital cost (Rs million/MW)	55	36
PLF (%)	80	80
Auxiliary consumption (%)	9	3
Life of plant (years)	30	20
Fixed operating cost as % of capital cost	2.50	1.50

kcal = kilocalorie, kWh = kilowatt-hour, MW = megawatt, LNG = liquefied natural gas, PLF = plant load factor, Rs = Indian rupees.

Source: Authors.

The following are also assumed in deriving the electricity generation cost estimates:

- (i) an LNG free on board price of \$7 per million British thermal units (MMBTU),
- (ii) a natural gas delivered price to all sites of \$9.54 per MMBTU,
- (iii) an imported coal free on board price of \$80 per metric ton,
- (iv) imported coal-based power plant carbon dioxide emission of 970 tons per gigawatt-hour (GWh),
- (v) LNG-based power plant carbon dioxide emissions of 435 tons per GWh,
- (vi) a certified emission reduction price of €15 (Rs850.2) per ton of carbon dioxide, and
- (vii) an exchange rate of \$1 = Rs42.

The environment cost is assessed in terms of the certified emission reduction value of the carbon dioxide emitted per kWh generated. The carbon content in tons per terajoule of heating value of coal and natural gas are taken as 25.8 and 15.3. These figures are multiplied by 44 and then divided by 12 to obtain the quantity (tons) of carbon dioxide emissions per terajoule of heating value. Primary energy consumption in terms of terajoules per kWh works out to 8.58 million joules per kWh for coal, and to 7.20 million joules per kWh for natural gas. The tons of carbon dioxide emission per kWh are then obtained as  $811 \times 10^{-6}$  for coal ( $25.8 \times 44/12 \times 8.58 \times 10^{-6}$ ) and as  $404 \times 10^{-6}$  for natural gas ( $15.3 \times 44/12 \times 7.20 \times 10^{-6}$ ). Finally, the environmental costs are obtained as Rs0.69 per kWh for coal ( $850.2 \times 811 \times 10^{-6}$ ) and as Rs0.34 per kWh for natural gas ( $850.2 \times 404 \times 10^{-6}$ ). Further refinement of these computations can be made using the regional energy database proposed in Chapter 11.

## Implementation Issues

Ownership options for a regional power plant include joint ownership by participating SMSs,<sup>27</sup> full private sector ownership, or a joint venture involving the private sector and the participating SMS. A special-purpose vehicle (SPV) would be useful to facilitate project implementation in the case of the latter two options. The public–private partnership joint venture model is preferable as it could provide some involvement of the SMS governments in the project management. The SPV would provide a single point of contact for the prospective developers. Such an SPV model has been adopted in India under the Ultra Mega Power Plant projects. Under this policy initiative of the Indian Ministry of Power, an SPV has been formed for each of the proposed 4,000 MW Ultra Mega Power Plants. It is entrusted with the responsibility of undertaking all the preparatory work such as site selection, feasibility study, fuel tie-up, and expediting clearances. After completion of the preparatory work, the SPV invites bids from potential developers through a competitive process on a least-cost tariff basis. The SPV is then transferred to the successful bidder along with its assets and liabilities. The process adopted for the selection of the developer needs to be transparent and impartial giving due weight to its qualification, experience, and credibility. The regional power plant developer would enter into long-term power purchase agreements (PPAs) with prospective buyers. The developer may also consider selling power generating capacity in excess of committed long-term sales in the short-term market.

## Power Interconnections

The modality of power interconnections required to transmit the power generated at a regional power plant would depend on the quantity and distance over which the power transmission is required and the need, if any, to transfer the power through intermediate power systems. The extra expenditure involved with a high voltage direct current (HVDC) power interconnection is justified where the transmission distance involved is large or where operational independence of the interconnected systems is desired. The options available for the transmission system arrangements are (i) implementation by an independent power transmission company, either fully privately owned or as a joint venture with a public sector transmission company; or (ii) implementation through the respective national transmission utilities, with a jointly agreed design and construction plan. Both these models are in operation in the region.

<sup>27</sup> This equity holding could be based on the share of electricity for each country from the power plant.

## Chapter 9

# Nonconventional Renewable Energy

## Introduction

Development of nonconventional renewable energy (NCRE) in the form of electricity generation through small-scale hydropower, wind power, biomass power, and solar photovoltaic power has grown steadily in the SAARC member states (SMSs). The SMSs are also in the process of strengthening the necessary institutional arrangements to more vigorously pursue NCRE utilization and also train staff to a higher level of technical competence to address the key barriers to NCRE projects. These barriers are (i) the high front-end capital and project development costs per kilowatt (kW) of installed electricity generating capacity, though operation and maintenance costs are low; (ii) the difficulty of forecasting cash flows of NCRE projects because electricity output from renewable energy projects is linked to availability of natural resources, like water flow, wind speed or solar radiance, which cannot be declared with high accuracy over the life of the project; and (iii) grid intake tariffs for electricity being based on avoided costs of the host grid system, which can also vary. These barriers are exacerbated when other competing energy forms are subsidized, and regional cooperation is most significant in the context of developing collaborative mechanisms to overcome them.

Regional cooperation can be very significant in the context of developing collaborative mechanisms to overcome the barriers to growth of NCRE. In particular in biomass, there is little history of successful commercial development. As noted in the Introduction section, biomass commercialization through the manufacture of biodiesel has the potential for easing energy

security concerns through the use of domestic resources.<sup>28</sup> However, much research and trial-and-error experimentation is needed to set the stage for widespread commercial applications. This work is rightfully a regional public good and joint public sector projects to better understand the commercial promise of biofuels would benefit all.

Outside of biomass, in wind, solar and related subsectors, there is also the need for public sector efforts. In particular, it is crucial to understand the institutions—legal, regulatory, and financial—that would be supportive of private sector operations and to understand how these can be encouraged. Cross-country consultations on the appropriate enabling environment are important to provide confidence to each SMS on how to proceed.

Standardized modular approaches to project preparation, evaluation, due diligence study, and preparation of specific financing packages can lower the up-front costs and the annual electricity generation costs. There is also now increasing emphasis being given to offering stable cost-based tariffs for grid intake electricity to provide more incentives for NCRE development. From a technical perspective, there is increased focus on developing NCRE-fed smart local power grids with information and control technologies, which facilitate the stability of NCRE-based electricity generation, and also on achieving greater economies of scale, particularly with wind- and solar-based electricity generation. In the case of small non-grid options such as micro-hydropower, wind power, solar photovoltaic systems, or their hybrids with battery or diesel back-up for individual consumers, cost control approaches include: (i) leasing the systems to end users rather than selling them, in order to overcome the problem of high front-end cost; (ii) financing vendor credit programs, and providing targeted credits to local development financing institutions to provide consumer credits as a part of an overall renewable energy development program; and (iii) financing renewable energy service companies that install and maintain renewable energy systems, taking a mini-utility approach and collecting a monthly cost per kilowatt charges for use of the facility. For the purpose of lengthening debt maturity, grant or concession funds are accessible from the Global Environment Fund, through the clean development mechanism (CDM), and from bilateral and multilateral donors.

## Key Nonconventional Renewable Energy Issues

India leads the region in terms of NCRE development. At the end of 2006, India had a total of 9,304 megawatts (MW) of NCRE-based electricity generating

<sup>28</sup> See the discussion in ADB (2010). Based on the Final Report of TA 7250 IND: Cross-Sectoral Implications of Biofuel Production and Use. This report specifically focused on biofuel development in India, but the results are likely indicative of the situation throughout SAARC.

capacity coming from wind (6,270 MW), biomass (500 MW), biomass in cogeneration (595 MW), small hydropower (1,895 MW), waste-to-energy (41 MW), and solar photovoltaic (3 MW) sources. It is relevant to note here that the Jawaharlal Nehru National Solar Mission is targeting 20,000 MW of grid interactive solar power in India by 2022. In Pakistan, NCRE-based electricity generating capacity at the end of 2006 was one-tenth of that in India and was dominated by biomass in cogeneration. The key NCRE-related issues faced in India, which are also representative of those faced by the other SMSs, are discussed below. The environmental acceptability of NCRE projects and their ability to address energy security concerns and rural electrification need to be kept in focus. It is also important to note the need for adequate commercial incentives given that NCRE projects are typically driven by private investment.

High capital costs, coupled with low plant load factors, are a common issue with NCRE projects, which makes the electricity generated expensive and noncompetitive with grid-based electricity generation, particularly when grid feed-in tariffs are avoided-cost and fuel subsidies are associated with fossil fuel-fired electricity generation. This issue needs to be addressed through the provision of low-cost capital for NCRE project investment as well as NCRE project cost-based grid feed-in tariffs. While the former has been dealt with through various innovative financing mechanisms, the latter is gaining increasing recognition and cost-based tariffs are already in place in some cases. Another common issue faced is the robustness of the local grid power transmission system, which determines its ability to absorb wind-based electrical power variations due to changes in wind speeds beyond a specific range. Various electromechanical design solutions are being developed to deal with this situation and they are being implemented. Solar photovoltaic technology is proven but still expensive compared to wind-based and mini hydro-based electricity generation. Solar photovoltaic module production costs are declining as the scale of usage increases. The overall costs of solar photovoltaic-based electricity generation would also decline with parallel efforts to gain economies of scale in the production of the balance of plant capacity needed. The main barrier to biomass-based cogeneration is the inability of most sugar mills to raise the financial resources for adding the cogeneration facilities. This needs to be addressed through concessionary financing given the profitability constraints that sugar mills experience.

Some issues in particular are now requiring sharper focus to enhance the penetration of NCRE technologies. These relate to the need for (i) more attractive tariffs for grid-injected NCRE-based electricity that would provide more incentives for NCRE development; (ii) more stable wind-based power generation technology and capturing the benefits of cost-efficiency trade-

offs in photovoltaic technologies; and (iii) developing NCRE-fed smart local power grids with information and control technologies, which facilitate the continued connectivity of NCRE-based electricity generation.

## Tariff Incentive Improvement

Most NCRE tariffs have historically been based on avoided-cost have not provided adequate incentive to developers to expand their NCRE operations. However, there is now a trend to offer cost-based tariffs and increase the NCRE development rate given the emphasis on up-front cost recovery for the developer in such tariffs. This approach is being adopted by some of the SMSs, and a significant increase in the purchase of NCRE-based electricity is being achieved. The methodology adopted can also be used by other SMSs.

Cost-based tariffs are designed to alleviate the problems of negative cash flows experienced by many grid-connected small power producers (SPPs) during the loan repayment period with a technology-neutral tariff, based on avoided costs to the operator of the host power system. Cost-based tariffs track the actual cash requirements of typical SPPs of each technology to meet the debt commitments, operations and maintenance costs, and a reasonable return on equity investment. Unlike tariffs based on avoided costs that fluctuate with international fuel prices, these cost-based tariffs can provide profits to developers from the first year of operation in a predictable manner. Table 16 shows the cost-based electricity purchase tariff offered to SPPs in Haryana (India) and in Sri Lanka for different technologies.

A continuing significant impediment to the penetration of NCRE-based electricity generation is that the pricing of competing electricity generated by conventional thermal power plants does not reflect the economic cost of the input fuel supply. This is particularly true where the fuel involved is a non-tradable domestic resource such as indigenous natural gas or coal.

**Table 16 Purchase Tariff for Nonconventional Renewable Energy-Based Electricity Generation (\$/kWh)**

	Wind	Mini-hydro	Biomass
Haryana, India	0.091	0.082	0.89
(annual escalation, %)	(1.5)	(1.5)	(2.0)
Sri Lanka	0.201	0.127	0.161

kWh = kilowatt-hours.

Sources: Country Report for India (2008); Country Report for Sri Lanka (2008).

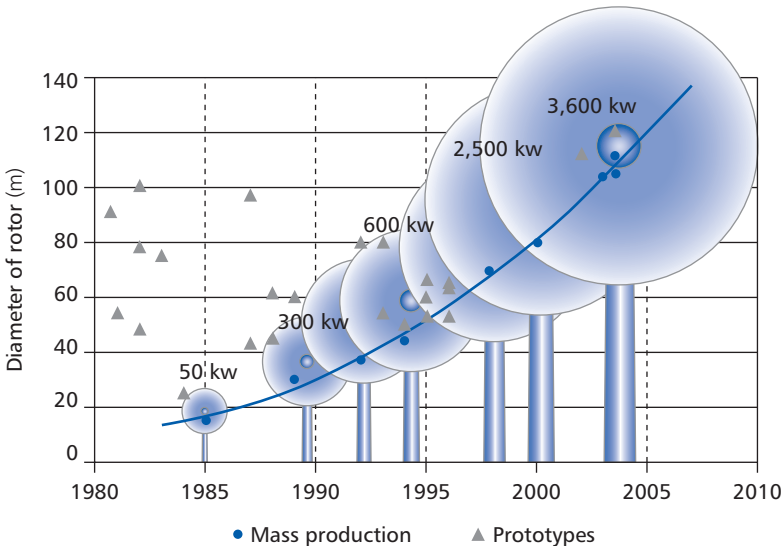


In this context it is important that the SMSs price such resources on the economic cost of production plus a depletion premium that will capture the economic cost of exhausting the particular resource and also ensure that energy subsidies, if any, are targeted with care to the poor.

## Technology Improvement

Significant price and market penetration gains have been achieved in the case of small hydropower-based electricity generation, with increasing standardization of designs and worldwide competition in electro-mechanical equipment. Similar gains have also been achieved for wind-based electricity generation with benefits from widespread wind mapping, manufacturing competition, and increasing grid connectivity through generators of larger capacity capturing economies of scale (Figure 19). However, power system stability issues arising in weak power systems hosting large wind-based electricity generating units need to be further addressed through improved generating unit design and stronger power systems, including smart grid technology. Improved generating unit design would include greater control over the delivery of both active and reactive

**Figure 19 Wind Turbine Capacity Development**



kW = kilowatt, m = meter.

Source: International Energy Agency.

power. In the case of weak host power systems, limits would have to be specified on the wind-based power that can be injected until they are adequately strengthened.

On the other hand, photovoltaic electricity generation is still lagging in similar market penetration due to the high cost per watt of electricity generation, and technical and cost constraints in storing the direct current (DC) power produced and inverting it to alternating current (AC) for wider grid connectivity. However, continuing improvements are being made to reduce the cost per watt of photovoltaic technologies while maintaining an acceptable level of energy conversion efficiency and the cost of power conversion from DC to AC.

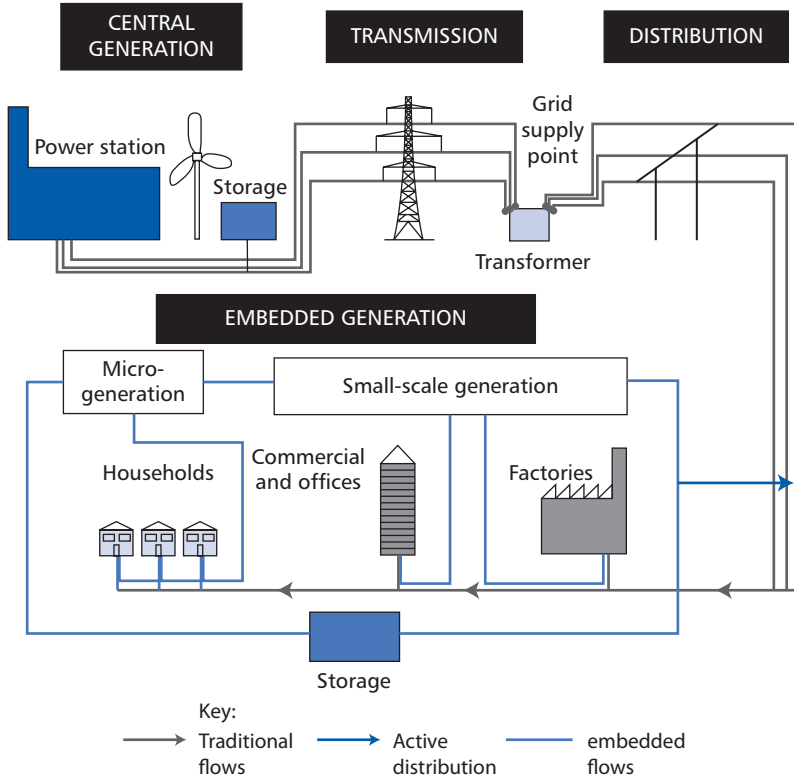
The latest photovoltaic technologies are focusing on thin film manufacturing techniques. Although less efficient than conventional light-absorbing material, thin film photovoltaic cells more than compensate for that by being much cheaper and easier to manufacture. Prototype module efficiency of 12% has been achieved at a cost of \$0.3/watt. These modules, which are expected to be marketed at \$1.0/watt, would become the cheapest solar modules available. The key to achieving greater connectivity to grid systems lies in refining the power inversion process at minimum cost, and the advancements made on improving the power electronics required also enables better integration of photovoltaic-based electricity generation with smart grids.

## Scope for Smart Grids

Developing NCRE-fed smart local power grids is a relatively new area in which much progress is being made. These grids incorporate information and control technologies, which help the NCRE-based electricity generation to stay connected with a hosting power system under electrical disturbance conditions. This increases the productivity and reliability of NCRE-based electricity generation, and thereby the amount of NCRE-based electricity injected and the rate of NCRE penetration in the SMSs.

Smart grids create power network infrastructure that can immediately and favorably respond to an electrical disturbance event, and also coordinate the operation of a generation plant and the connected networks to increase efficiency and reliability. Flexibility can be introduced to a plant by using a power electronic interface that allows fast active and reactive power control. This is possible not only in the case of injecting NCRE-based power into a standard power system but also in the case of typical embedded power generation systems (Figure 20).

Figure 20 **Typical Location of Embedded Power Generation**



Source: Authors.

## Conclusion

The South Asia region has advanced significantly in the deployment of nonconventional renewable energy technologies (NCRE) since mid-1990s. Different countries in the region have different experiences in policies, regulations, and development and deployment of different technologies. In this regard, regional cooperation can assist in the sharing of experiences and lessons learned in the context of developing collaborative mechanisms to overcome the barriers to growth of NCRE. Among the NCRE sources, of biomass, wind, and solar have a great potential due to their high availability in the region. These technologies are particularly useful when providing energy services to the rural populations, which form the majority and have a higher poverty incidence in all South Asian countries. But all of these technologies require effective public sector interventions to address

legal, regulatory, and financial barriers. To overcome financial barriers, a key intervention is the provision of capital and production subsidies. While most of the NCRE technologies tend to be more expensive at present compared to the traditional fossil fuel-based systems, their costs have been fast decreasing with their increased use across the world. Considering that fossil fuels have been continuously provided with indirect subsidies throughout their supply chain and at user level, provision of subsidies to NCRE can always be justified, particularly in those countries where fossil fuels are in heavy supply and use. Such efforts to overcome financial barriers need to be coupled with other policy and regulatory interventions and will have to continue until such time as these NCRE technologies reach grid-parity in terms of their financial costs.

## Chapter 10

# Scope for Private Sector Participation

## Introduction

It emerges from the discussions in the foregoing chapters that clear opportunities exist for specific roles for the private sector in pursuing the intra-regional and interregional energy trade options, including the four options discussed in Chapters 5–8, to bring in additional energy access to the SAARC member states (SMSs). In the case of intra-regional energy trade, scope for the private sector lies in the development of hydropower resources and associated power transmission in Bhutan and in Nepal, initially mainly for sale to India. The proposed expansion of that regional power market would open up opportunities for other regional electricity generators to gain market share by transferring power through cross-border interconnections. In the case of interregional energy trade, private sector activity would be associated with providing the long-distance cross-border bulk natural gas or electric power transmission mainly through participation in joint ventures typically formed for different sections of the transmission. There would also be scope for private sector participation in making available the incremental energy needed at the supply points of these transmission links.

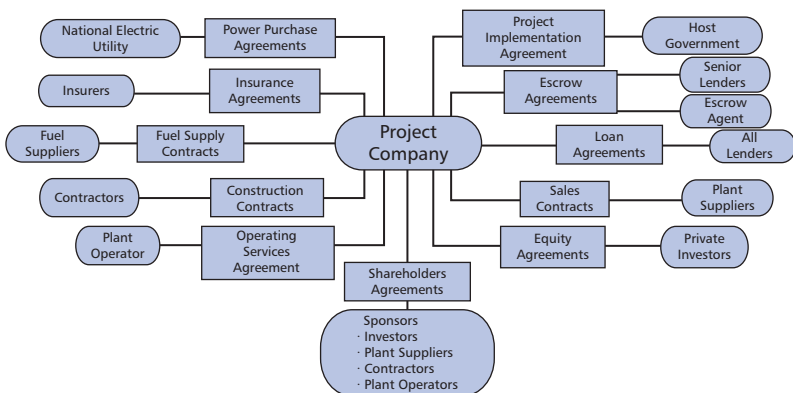
The four additional regional energy trade options proposed for the SMSs offer major opportunities for private sector participation in (i) incremental generation for the regional power market, (ii) provision of incremental oil refinery capacity for regional use, (iii) liquefied natural gas (LNG) terminals for regasification of liquid natural gas for regional distribution, and (iv) bulk thermal- (coal and natural gas) and hydro-based electricity generation for regional consumption. Investing in the associated power and natural gas

transmission would be of interest to the private sector given the success that has been achieved with related private sector initiatives in Bhutan, India, and Nepal. This is, however, an area in which market failure can take place without recourse to public sector funding. It is relevant to recognize here the comfort provided to investors as a result of the participating SMSs being members of the Energy Charter Treaty or a regional energy trade treaty, as discussed in Chapter 11. Such participation ensures the compliance of host governments with respect to investment agreements, trade agreements, and power purchase agreements. Nonconventional renewable energy technologies (NCRE) development and technology innovation is best carried out by the private sector. The focus of a power system operator hosting NCRE-based electricity generation should be on providing the enabling institutional and technical environment, including cost-based power purchase tariffs.

## Private Sector Participation in Electricity Generation

Private sector-funded thermal power projects are typically structured as build–own–transfer (BOT) projects centered on the project company, which is established in and under the laws of the host country by the project sponsors. It is clear from the many relationships shown in Figure 21 that the negotiating process in setting up a BOT project could be extremely complex. BOT project risks are perceived by the sponsor and by the host as shown in Figure 22.

**Figure 21 Typical Thermal Power Plant Build–Own–Transfer Structure**



Source: Authors.

**Figure 22 Build–Own–Transfer Project Risk Perceptions**

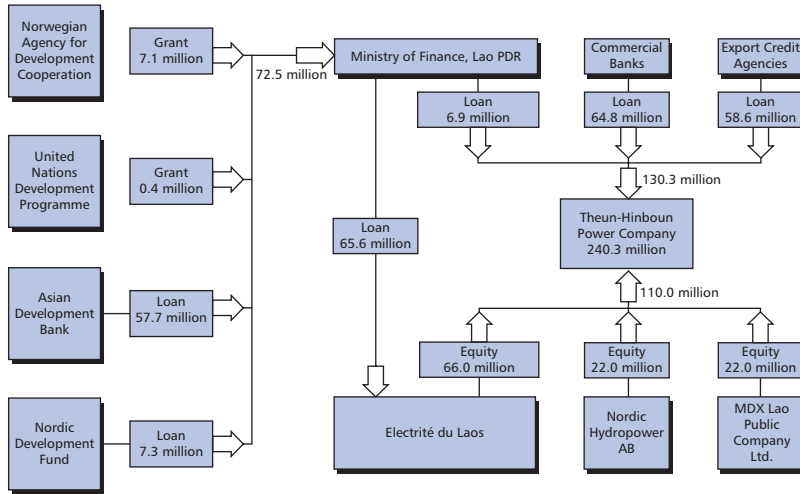
Host Perceptions	Investor Perceptions
Non-competitive bidding	Non-recourse financing
High return on equity	Construction phase risks
Failure to deliver	No-take risk
Failure to maintain plant	Fuel supply and price risks
Dispatch inflexibility	Plant and system reliability
Reserve inflexibility	Remittance and exchange rate
Deviation from least-cost plan	Force majeure and political risks

Source: Authors.

A major concern of the lenders is the limited recourse available in the event of a failure by the project company to service debt. If the project were to collapse, the only recourse available to the lenders would be to acquire the plant (probably nonfunctional) and seize the assets of the project company (probably bankrupt). The assets of the companies holding equity investment in the project company may be large, but the lenders would have no legal recourse to them since the loan agreements are with the project company, which is a separate legal entity. This project risk complicates the project financing and lenders therefore often ask for sovereign guarantees against not only country risks, but also against commercial risks. A common example of the latter is the guarantee of take-or-pay power contracts established between the project company and the host power purchasing utility.

Utilization of the commercial cofinancing and guarantee instruments that are available with multilateral financial institutions will provide comfort to the lenders and help to ease the risk and the debt service burden on the project company through longer maturities and softer interest terms. The invoking of such instruments would, however, require the participation of at least one of those institutions in the project concerned. The risk perceptions can be reduced to some extent by structuring the project on the basis of public–private partnership, with part of the project company equity held by the host government through multilateral or other agency financing. This structure gives some handholding comfort to the private investor, particularly in addressing the environmental and social impacts of the project. This approach has been successfully used in financing hydropower projects, with the Theun-Hinboun Hydropower Project in Lao People’s Democratic Republic (Lao PDR)—an example of good practice.

Figure 23 shows the actual financial structure in the case of the Theun-Hinboun Hydropower Project (210 megawatts [MW], 1,645 gigawatt-hours [gWh]) constructed in Lao PDR in the 1990s as a public–private partnership

**Figure 23 Financial Structure of the Theun-Hinboun Power Company**

Lao PDR = Lao People's Democratic Republic.

Note: Grants, loans, and equities are in US dollars.

Source: Authors.

project with build–operate–transfer (BOT) arrangements mainly to export 95% of the electricity output to Thailand. The total project cost was \$240 million (46% equity and 54% debt), and 60% of the equity in the Thein-Hinboun Power Company was held by the Lao PDR government through Electricite du Laos, the state electricity utility. The remaining 40% was held by Nordic and Thai investors. The Government of the Lao PDR was enabled to invest \$66 million in equity by loans and grants from ADB, the United Nations Development Programme, and Nordic agencies. Debt financing came from several commercial banks and export credit agencies.<sup>29</sup>

## Private Sector Participation in Energy Transmission

A power system interconnection project would typically consider the following:

- (i) the individual power system design specifications, operational procedures, and regulatory mechanisms and their impact on the interconnection design and operation;
- (ii) environmental and social issues;

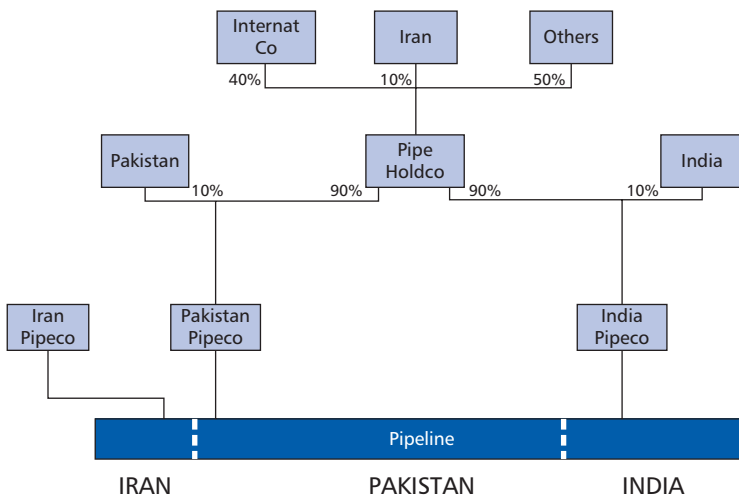
<sup>29</sup> World Bank. (2007a).



- (iii) interconnection capital costs and input electricity supply costs, the basis for calculating transit charges, and benefits due to interconnection;
- (iv) financing structures for interconnection facilities and scope for “project finance” and public–private partnerships;
- (v) legal agreements for electricity purchase and sale; and
- (vi) institutional arrangements to facilitate the interconnection.

In practice, a power transmission interconnection between two countries would involve separate implementation and operation of power transmission facilities in country A and country B through joint venture companies in each country, and with major equity held by the developers of the respective power transmission facilities. Other equity can be held by the power transmission companies of the countries involved, and possibly by multilateral or bilateral financial institutions. The project finance structure would then need access to the best possible sources of debt with leverage applied through participation of multilateral financial institutions in the project, and comfort gained through realistic agreements for project implementation and electricity purchase or sale. A similar approach and project structure can be adopted in the case of private sector participation in interconnections for petroleum products and natural gas transmission. Figure 24 shows a possible equity holding structure for the proposed Iran–Pakistan–India (IPI) natural gas pipeline.

**Figure 24 Possible Financing Structure for the Proposed India–Pakistan–India Natural Gas Pipeline**



Source: Authors.

Annex 2 provides illustrative economic analysis formats for electricity, natural gas, and petroleum products transmission. The risks associated with project finance-based energy transmission projects run parallel to those perceived in the case of a power generation project, and would need similar risk mitigation strategies. The LNG receiving and gasification process and the crude oil refining process are also, in essence, energy transfer projects and their financing for private sector funding can also be structured on the lines of a private sector-funded gas transmission project. The proposed 400,000 barrels (bbl) per day (20 million metric tons per annum [MMTPA]) Jubail Oil Refinery in Saudi Arabia, which is expected to cost \$8 billion, is an example of a recent project finance-based financial structure with Aramco and Total having 75% of the equity, and several commercial banks and export credit agencies targeted for the debt in the envisaged 65/35, debt/equity split.

## Conclusion

There are many opportunities for the private sector to participate in both intra-regional and interregional cooperation activities, particularly when establishing related infrastructure such as cross-border electricity and transmission lines and electricity generation stations. Such participation can already be seen in cross-border power generation and transmission, which can take different forms. In this regard, the relevant governments will play an important role by providing the necessary policy, legal, and regulatory frameworks for such private sector involvement in cross-border projects. It is best that such common frameworks are developed as a part of a regional cooperation exercise.

## Chapter 11

# Conclusions and Recommendations

**T**he South Asian region is one of the fastest-growing regions of the world. This growth increases the demand for energy. At the same time, an adequate supply of energy should be ensured to sustain the momentum of growth. The energy sector's challenges are enormous—ensuring access to energy for all, meeting the increasing demand in a cost-effective manner amidst increasing oil prices, and minimizing pollution of the local and global environment. This report argues that regional cooperation provides better opportunities for addressing these challenges. The report recommends key policy initiatives that would promote energy trade expansion opportunities for the South Asian Association for Regional Cooperation (SAARC) member states (SMSs), and identifies the specific project activities that need to be pursued in the short and medium term.

Regional cooperation in energy has provided significant economic benefits for some regions. This report shows that similar potential exists for the South Asian region. The report recognizes that with greater political will on the part of the SMSs, coupled with improved and harmonized institutional, legal, and regulatory frameworks, and wider opportunities for private sector participation, the pace of intra-regional and interregional trade can be accelerated. The report also highlights the need for pursuing in parallel the development of institutions and infrastructure to enable the region to meet growing energy demands. These options include the development of an expanded regional power market, a regional refinery, a regional liquefied natural gas (LNG) terminal, and a regional power plant. The need to promote greater penetration of nonconventional renewable energy (NCRE) resource utilization through innovative technical and commercial initiatives is also emphasized.

The SMSs need to cooperate more closely to improve the integration of their energy markets through feasible electricity or gas interconnections, provide transparent open access to energy transmission infrastructure, agree on common protocol, and move toward standardization of rules and procedures to simplify transaction mechanisms to reduce energy trade costs. In operationalizing the regional cooperation agenda it is necessary to

- (i) Develop an SAARC Regional Energy Trade and Cooperation Agreement,
- (ii) Harmonize legal and regulatory frameworks,
- (iii) Carry out more detailed studies and develop a comprehensive energy database,
- (iv) Identify the opportunities for private sector participation and financing mechanisms,
- (v) Enhance regional institutional capacity, and
- (vi) Implement the projects identified in this report.

The rest of the chapter briefly summarizes these activities.

## **SAARC Regional Trade and Cooperation Agreement**

As a first step, the SMSs need to commit themselves to a common agreement to promote energy trade in the region. Such an agreement may be called the SAARC Regional Energy Trade and Cooperation Agreement, and would define the policy objectives and the basic framework conditions for developing regional energy trade. In this context, the policy objectives agreed on by the countries of the Greater Mekong Subregion (GMS), which have cooperated in power trade very successfully under an Electric Power Forum, can be adapted for energy trade in the SAARC region and can be summarized as follows:<sup>30</sup>

- (i) Promote efficient development of the SAARC energy sector;
- (ii) Promote opportunities for economic cooperation between SMS in the energy sector;
- (iii) Facilitate the implementation of priority energy sector projects;
- (iv) Address technical, economic, financial, and institutional issues relevant to SAARC energy sector development; and

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<sup>30</sup> ADB (2006a).

- (v) Protect and improve the environment through the adoption of appropriate technologies and plans.

The SAARC Energy Working Group could initially function as an energy forum that would design the SAARC Regional Energy Trade and Cooperation Agreement. To provide greater comfort to those investing in cross-border energy transfer, the SMSs need to either join the Energy Charter Treaty (ECT) or collectively develop a regional energy trade treaty, which may be structured similar to the ECT. The ECT was signed in December 1994 by 51 countries, mostly from Europe and the former Soviet Union, and by the European Community and Euratom (which aims to develop the market for nuclear energy). The objective of the ECT is to strengthen the rule of law on energy issues by creating a level playing field of rules to be observed by all participating governments. An SAARC regional energy trade treaty could be structured on ECT lines to minimize risks associated with energy-related regional investments and trade. Box 2 shows the ECT provisions and benefits.

## Harmonizing Legal and Regulatory Frameworks

Energy markets in individual member states are governed by their individual legal, regulatory, and policy frameworks, as summarized in Chapter 3 and detailed in Annex 1. It is relevant to note that the institutional structure already exists in most SMSs in terms of the relevant energy ministries and energy subsector institutions. This facilitates harmonizing of the relevant energy sector frameworks within the region. Select SMSs such as Bangladesh, India, and Pakistan also have energy sector regulators. While India and Pakistan have separate energy subsector regulators, Bangladesh has one regulator for the whole energy sector. Sri Lanka has a Public Utilities Commission, which is not restricted to the energy sector. Such differences in the mandates of regulators across the region can create coordination issues. The legal, policy, and regulatory risks multiply if cross-border energy transactions, which often have to recover high-cost state-of-the-art technology investments, need to deal with multiple energy sector regulatory frameworks. Therefore, as a first step, regulators in the SMSs need to work together to develop a road map for harmonizing the relevant regulations.

## Developing Energy Database

The establishment of a comprehensive and reliable energy database for the region would facilitate better estimation of intra-regional and interregional energy trade and cooperation benefits. Sharing of information

### Box 2 The Energy Charter Treaty

The provisions of the Energy Charter Treaty (ECT) focus on five broad areas:

- (i) protection and promotion of foreign investments in energy, receiving an extension of national treatment or most favored nation treatment—whichever is more favorable;
- (ii) free trading in energy-related materials and products and energy-related equipment based on World Trade Organization rules,
- (iii) freedom of energy transit through pipelines and grids,
- (iv) reducing negative environmental impact of the energy cycle through improving energy efficiency, and
- (v) mechanisms for the resolution of state-to-state or investor-to-state disputes.

The ECT promotes long-term energy cooperation through stable and predictable “rules of the game.” Developed in line with the rules of the World Trade Organization, specifically for the energy sector, the ECT guarantees security of supply through reliable and well-defined transit rules. Through its various provisions, it creates an investor-friendly environment favorable to the flow of investments and technologies. The treaty acts as a forum for experience-sharing and encourages cooperative efforts aimed at promoting market-oriented reforms in the energy sector.

The ECT has been structured in such a way that it benefits all the concerned parties in a cross-border trade arrangement—the producer or supplier of energy, the transit entity or country, and the consumer as follows:

- (i) The producer member countries benefit from the treaty through increased investor confidence, which results in a constant flow of foreign direct investment into the countries.
- (ii) For the transit country, the treaty creates a secure transit framework, which is an advantage to the purchasers and consumer countries. The treaty also tries to secure a certain income from transit for these countries so that there will be cover for defined risks associated with transit.
- (iii) For the consumer country, the treaty provides a basis for security of supply of energy resources. It can also provide security for the investments made by the consumer country.

Source: Authors.

on energy resources, proposed energy sector development plans, and the respective institutional, legal, and regulatory frameworks would be a strong confidence-building measure among the SMSs. This will also facilitate the evaluation of the potential economic benefits of specific regional energy projects in individual countries and the identification of research needs to strengthen such evaluation. The database could also include information on the various energy planning and control procedures adopted by the SMSs, the methodology adopted, and results achieved in the case of energy resource mapping exercises such as those conducted for the renewable energy resource assessment. The efforts already being made by the SAARC Energy Center to establish a SAARC energy database, as referred to above, need to be fully supported by the SMS. This exercise provides for a true regional public good—the collective capacity to support cooperative, mutually beneficial cross-border projects to improve energy security and enhance sustainable growth prospects.

## Financing Mechanisms

Over the years the SAARC has made a number of efforts to establish a fund for regional trade activities. Earlier there was a South Asian Development Fund (SADF), which came into existence in 1996. SADF was formed with the merger of two earlier funds—the SAARC Fund for Regional Projects and the SAARC Regional Fund. In 2005, SADF was reconstituted to form an umbrella organization—the SAARC Development Fund, with windows for social activity, infrastructure activity, and commercial non-infrastructure activity. The agreement for the SDF, signed during the 15th SAARC Summit held in Colombo in August 2008, lays down the rules for funding according to which funds can be provided only for multilateral regional trade projects (involving more than two member states). A stronger institutional structure to facilitate access to the SDF by prospective cross-border energy transfer project sponsors is a priority need.

At present, most SMS energy sector utilities are publicly owned, and they have not had the financial performance quality to provide substantial levels of self financing for new energy sector projects, due mainly to cost-recovery constraints imposed on them. Increasing emphasis is, therefore, being given to private sector financing of energy sector infrastructure, either individually or jointly with public utilities. Involvement of the private sector in regional energy trade projects would also expedite their implementation. Leverage can also be gained through the participation of bilateral and multilateral financial institutions and the complementary financing and financial guarantee instruments that can be invoked to soften project financing terms. Nevertheless, private sector participation in regional energy trade has been

limited in the SAARC region, mainly due to a lack of policy and regulatory clarity in cross-border dealings. The SMS governments, therefore, need to provide policy, regulatory, and contractual clarity to increase cross-border energy transfer investments in the region.

## Enhancing Institutional Capacity

The SAARC Secretariat has been playing the important and valuable role of providing coordination for the joint activities carried out by the SMSs to promote regional energy trade. It can expand this role by acting as the central agency developing the SAARC Regional Energy Trade and Cooperation Agreement referred to earlier and facilitating any follow-up intergovernmental agreements related to specific energy trade projects. The SAARC Secretariat could also act as the coordinating body for developing an energy trade treaty along the lines of that described in Box 2. To provide this expanded role, the capacity of the secretariat must be enhanced with adequate resources.

## Project Activities

Specific short-term energy trade projects that can be taken up for implementation within a 5-year period include: (i) the India–Nepal oil product pipeline, (ii) the India–Nepal power interconnection from Dhalkebar to Muzaffarpur, and (iii) an India–Pakistan power interconnection from Patti to Dinanath. Improvement of the enabling environment for enhanced NCRE development is also an important short-term activity for the SMSs to encourage more innovative action by NCRE developers.

Specific medium-term energy trade projects that can be taken up after further feasibility studies, for implementation in a 5–15 year period would include:

- (i) an India–Sri Lanka power interconnection from Madurai to Anuradhapura;
- (ii) an India–Nepal power interconnection from Gorakhpur to Butwal;
- (iii) a Central Asia–Afghanistan–Pakistan power transmission interconnection;
- (iv) a reduced capacity Iran–Pakistan–India gas pipeline;
- (v) a Myanmar–Bangladesh–India gas pipeline, given gas availability at source;
- (vi) a reduced capacity Turkmenistan–Afghanistan–Pakistan–India gas pipeline;



- (vii) the expansion of the present regional power market to other SMSs;
- (viii) the establishment of crude oil refining capacity for the region and the creation of an SAARC strategic petroleum reserve;
- (ix) the establishment of an LNG terminal for the region and associated natural gas distribution facilities; and
- (x) the establishment of bulk power generation for regional consumption.

## Annex 1

# SAARC Energy Sector Institutional, Legal, and Regulatory Frameworks

This Annex discusses the energy sector's institutional, legal, and regulatory frameworks currently existing in the South Asian Association for Regional Cooperation (SAARC) member states.

## Afghanistan

### Institutional Framework of the Energy Sector

The Inter-Ministerial Commission for Energy (ICE), established in December 2006, provides overall supervision for energy sector policy and infrastructure investments. The commission includes the Ministry of Energy and Water, Ministry of Finance, and Ministry of Mines as core members and the Ministries of Commerce and Industry, Foreign Affairs, Urban Development, and Rural Rehabilitation and Development as ad-hoc members. The objective of the ICE is to help the government to understand, support, design, and monitor the development of energy resources, based on commercial principles. The commission supervises energy sector policy, infrastructure, and investments and coordinates support and assistance from different development partners. It brings together a wide range of government and donor agencies to assure coordinated actions and practical planning. The commission develops sound policies in line with fiscal and policy priorities and international standards. The energy subsectors are directly supervised by the respective ministries as detailed on the succeeding pages.

## **Power Sector**

The Ministry of Energy and Water provides the regulatory and policy framework for the power sector, with the aim of providing sustainable power supply, at affordable prices, in an environmentally sound manner, for economic growth to improve living standards and to support multipurpose irrigation dams and water resource management. The Department of Power under the ministry is responsible for overall generation, transmission, and distribution of power. The Department of Renewable Energy Development works for the promotion of renewable energy technologies. It promotes programs related to biogas, solar, improved water mills, and micro-hydro, among others. The Department of Policy and Strategy and the Department of Planning deal with policy and strategy formulation for the power sector and energy supply.

## **Hydrocarbon Sector**

The Ministry of Commerce and Industries is responsible for developing the policies and regulatory framework for demand, supply, and purchase of crude oil and petroleum, including technologies; and represents the government when entering into crude oil, petroleum products, gas, and related agreements. It is also responsible for small-scale energy technology imports, fuel and gas supply, and import facilitation and regulations. The ministry aims to integrate Afghanistan markets into the regional and global economies to ensure the competitiveness of domestic industries and to improve the attractiveness of Afghanistan for investors. The ministry is responsible for all international and regional agreements pertaining to petroleum and natural gas at the government level. The Department of Petroleum within the ministry is responsible for supply and quality control, including licensing of national and international fuel companies.

The Ministry of Mines and Industry manages the underground natural resources and mines including exploration of gas, coal, petroleum, and other fossil fuels. It is responsible for the development of policies and regulatory framework for explorations and trade of minerals, chemicals, and petroleum at the national level including technologies, national-level government negotiations, marketing, and related agreements.

All these ministries work in close cooperation with the Ministry of Foreign Affairs, the Ministry of Finance, and the ICE. The Ministry of Finance has jurisdiction over policy formulation in the energy sector and provides appropriate funding to the ministries and institutions in accordance with the developed policy, and the operational and development budget. The Ministry of Foreign Affairs facilitates foreign relations and regional cooperation in all sectors, including energy and power transmission agreements.

In addition to these established institutions, the following advisory positions and national programs are involved in energy sector development in Afghanistan:

- (i) the Advisor on Mines and Energy to the Office of the President,
- (ii) the Afghanistan Investment Support Agency,
- (iii) the Afghanistan National Development Strategy,
- (iv) the Afghan National Standardization Authority,
- (v) the National Solidarity Program of the Ministry of Rural Rehabilitation and Development, and
- (vi) the Priority Reform and Reconstruction Program.

## **Legal and Regulatory Framework of the Energy Sector**

The legal framework for the energy sector in Afghanistan is currently at a nascent stage. The existing energy laws are rudimentary and do not address energy issues in an integrated fashion. There are three key energy laws in the country, as follows:

- (i) the Power Consumption Law, 1982;
- (ii) the Oil and Gas/ Hydrocarbons Law, 2005; and
- (iii) the Coal/ Minerals Law, 2005.

With the aim of alleviating poverty and creating employment opportunities, the Ministry of Mines and Natural Resources makes policies and regulations for the development of the mining sector. These include the Mineral Law, 2005 and the Hydrocarbons (petroleum) Law, 2005. The Hydrocarbons Regulation, Minerals Regulation, and Natural Gas Distribution laws are in the process of being finalized. Specific strategies are being formulated for the identification, exploration, and exploitation of crude oil and natural gas resources.

Along with the aforementioned legal frameworks specific to the energy sector, the government has also developed an interim energy strategy called the Afghanistan National Development Strategy. The strategy aims to promote growth, generate wealth, and reduce poverty and vulnerability. It provides the framework for the development of government policies and acts as a guide for allocating resources and programs toward these goals. The Energy Strategy sets the goal of ensuring that sources of energy reach at least 60% of population. To achieve this, goals are set for the overall energy sector with the aim of

- (i) restructuring energy sector governance and promoting cost-recoverable operations,

- (ii) rehabilitating and expanding the public power grid,
- (iii) providing adequate incentives to attract private investment in the energy sector,
- (iv) improving rural energy access, and
- (v) developing indigenous resources for power and energy use.

To achieve these goals, the following measures have been identified:

- (i) Attract funds from international donors and private players to develop transmission networks.
- (ii) Undertake an intensive capacity building program for the local staff to operate and maintain the system.
- (iii) Increase exploration activities and develop already known reserves.
- (iv) Attract private investment in the operation of gas pump stations and fuel trucks to improve the quality of products and to introduce competitive pricing.
- (v) Develop renewable energy in Afghanistan by promoting usage of solar water heating and lighting, water pumping, and micro-hydro through private sector participation.

The ministries in each energy subsector place special emphasis on the promotion of regional energy trade. The Ministry of Foreign Affairs facilitates regional cooperation in energy. Upgrading electricity transmission ties with the central Asian republics and exploring options for the transport of electricity and natural gas through Afghanistan for regional supply are regarded as important areas for regional cooperation.

Although there is clear distinction in the role of ministries in each of the energy subsectors, these form part of the Interministerial Committee for Energy (ICE). This has been done to integrate individual energy strategies of each energy subsector. A major challenge faced by the Afghanistan energy sector in developing an energy sector policy is the lack of reliable energy sector data and a resource repository.

## Bangladesh

### Institutional Framework of the Energy Sector

The Ministry of Power, Energy and Mineral Resources (MOPEMR) is responsible for the overall planning, development, and management of different types of commercial energy resources and power. The two divisions under the ministry, namely, the Energy and Mineral Resources

Division (EMRD) and the Power Division manage the gas and power sector utilities, respectively. The two main state corporations are the Bangladesh Oil, Gas and Mineral Corporation, commonly referred to as Petrobangla; and the Bangladesh Power Development Board. The institutional framework of each of these energy subsectors is discussed below.

## **Power Sector**

The Power Division of MOPEMR manages the power sector in Bangladesh. There are four generation utilities apart from the small and independent power producers, one transmission utility, and five distribution utilities. Private sector participation is encouraged in the generation of power. Power Cell provides assistance to the Power Division in implementing the reform measures taken by the government, along with the review of tariffs and performance monitoring of the utilities.

## **Hydrocarbon and Coal Sector**

EMRD, within MOPEMR is the administrative authority of all energy and mineral resources (oil, gas, coal, and other minerals) of Bangladesh. Petrobangla, on behalf of EMRD, holds the shares of the companies dealing in oil, gas, and minerals exploration and development. It is at present in the business of hydrocarbon exploration, development, transmission, distribution, compressed natural gas (CNG) conversion, and development and marketing of minerals. It is regarded as an upstream regulator and thus, it administers production-sharing contracts with the international oil companies (IOCs) on behalf of the government. The Hydrocarbon Unit serves as a support wing of the EMRD.

The gas sector of the country is divided into four segments. The utilities involved in various segments of the gas business are as follows:

- (i) **Exploration.** One national company, Bangladesh Petroleum Exploration & Production Company Ltd., and four IOCs are engaged in gas exploration and production activities.
- (ii) **Production.** The national companies, Bangladesh Gas Fields Company Limited and Sylhet Gas Fields Limited, are involved in the gas production business.
- (iii) **Transmission.** A national company, the Gas Transmission Company Limited, is engaged in the gas transmission business
- (iv) **Distribution.** Four gas distribution and marketing companies; Titas Gas Transmission and Distribution Company Limited, Bakhraabad Gas Systems Limited, Jalalabad Gas Transmission and Distribution System Limited, and Paschimanchal Gas Company

Limited; and one compressed natural gas conversion company, Rupantarita Prakritik Gas Company Limited, are engaged in gas distribution activities.

## **Legal and Regulatory Framework of the Energy Sector**

Article 143 of the Constitution of Bangladesh provides that all mineral resources underlying any land of Bangladesh or under land within the territorial waters or continental shelf shall be vested in the Republic.

The Petroleum Act, 1974 defines the basic legal framework in the petroleum sector. It provides that the government may enter into a petroleum agreement with any person for any petroleum operation, and that no person shall undertake any petroleum operation except under a petroleum agreement. Petrobangla, the national holding corporation, is authorized to enter into such agreement(s) on behalf of the government.

The Bangladesh Energy Regulatory Commission (BERC), formed in 2003 and effective since April 2004, is an independent commission with a mandate to regulate the energy sector (gas, electricity, and petroleum products) in Bangladesh.

The major functions of the commission are as follows:

- (i) Determine efficiency and standards for machinery and appliances of the institutions using energy and ensure through energy audits the verification, monitoring, and analysis of economic energy use, and enhancement of energy use efficiency.
- (ii) Ensure efficient use, quality of services, tariff determination and safety enhancement of electricity generation and transmission, marketing, supply, storage, and distribution of energy.
- (iii) Issue, cancel, amend, and determine conditions of licenses and exemption of licenses, and determine the conditions to be followed by such exempted persons.
- (iv) Collect, review, maintain, and publish statistics of energy.
- (v) Frame codes and standards and enforce those that are compulsory to ensure quality of service.
- (vi) Develop uniform methods of accounting for all licensees.
- (vii) Create a congenial atmosphere to promote competition among the licensees.
- (viii) Extend cooperation and advice to the government, if necessary, regarding electricity generation, transmission, marketing, supply, and distribution and storage of energy.

- (ix) Resolve disputes between the licensees, and between licensees and consumers, and refer those to arbitration if considered necessary.
- (x) Ensure control of environmental standards for energy use under existing laws.

The BERC plays a significant role in attracting private investment in electricity generation and transmission, and transport and marketing of gas resources and petroleum products. The commission ensures transparency in management, operation, and tariff determination in the energy sector and promotes creation of a competitive market. It is independent of the government, but is responsive to government policies, which determines the policy and overall planning in the energy sector. The BERC is also regarded as a downstream regulator with responsibility for gas transmission, distribution, and supply. It grants licenses to entities involved in the transmission, distribution, and supply of gas. It is empowered to set tariffs in the future for gas transmission and supply in consultation with the government, based on published policy guidelines and methodology.

## National Energy Policy

The National Energy Policy (NEP) was first issued in 1996 and provides guidelines for the overall energy sector. It is presently under a process of revision. The NEP deals with country specific energy sector issues. The objectives of the revised draft National Energy Policy (NEP 2004) are to:

- (i) provide energy for sustainable economic growth so that the economic development activities of different sectors are not constrained due to a shortage of energy,
- (ii) meet energy needs of different zones of the country and socio-economic groups,
- (iii) ensure optimum development of all indigenous energy sources,
- (iv) ensure sustainable operation of the energy utilities,
- (v) ensure rational use of total energy sources,
- (vi) ensure environmentally sound sustainable energy development programs causing minimum damage to environment,
- (vii) encourage public and private sector participation in the development and management of the energy sector,
- (viii) bring the entire country under electrification by 2020,
- (ix) ensure a reliable supply of energy to the people at reasonable and affordable price,



- (x) develop a regional energy market for the rational exchange of commercial energy to ensure energy security, and
- (xi) provide and secure energy resources for all.

To achieve these strategic objectives, the energy policy focuses on

- (i) providing a sustainable and balanced energy supply,
- (ii) promoting rational use of energy,
- (iii) improving sector management and performance,
- (iv) increasing private sector participation and investment,
- (v) reducing interregional disparity (disparity between the east zone and the west zone), and
- (vi) creating regional energy markets.

The policy framework in Bangladesh indicates the possibility of regional cooperation in energy trade. With regard to electricity trade, the NEP emphasizes the examination of the possibility of cross-border electricity trade among neighboring countries and establishing linkages of local utilities with those in other countries for the provision of a basis for exchange of experience in power development and training of human resources. It also emphasizes the possibility of cooperation and the linking of utilities across the region to promote experience sharing and capacity development.

## Bhutan

### Institutional Framework of the Energy Sector

The energy sector in Bhutan is primarily governed by the Ministry of Economic Affairs (MEA, previously the Ministry of Trade & Industry). It has the following five technical departments:

- (i) Department of Trade,
- (ii) Department of Industry,
- (iii) Department of Geology & Mines,
- (iv) Department of Tourism, and
- (v) Department of Energy

The institutional framework specific to each of the energy subsectors is discussed on next page.

## **Power Sector**

The electricity sector falls under the Department of Energy of the MEA, which looks after all the national planning aspects in the energy sector. Its functions include master plan development; resource mobilization; coordination with donor agencies; monitoring power projects including generation, transmission, and rural electrification; and the implementation of guidelines related to the energy sector.

The Bhutan Electricity Authority (BEA) is the regulatory body for the power sector, as specified in the Electricity Act, 2001. The Bhutan Power Corporation Limited is a publicly owned utility responsible for the transmission, distribution, and supply of electricity in Bhutan. There are three hydro-generating companies, namely Chhukha, Basochhu, and Kurichhu. In January 2008, the corporations holding hydropower generating stations were amalgamated under Druk Holdings and Investments Limited to form the Druk Green Power Corporation Limited, which is responsible for managing all hydropower plants fully owned by the Royal Government of Bhutan. Druk Green Power Corporation Limited has the mandate to develop projects on its own or through joint ventures on behalf of the Royal Government.

## **Hydrocarbon Sector and Coal Sector**

The petroleum sector is controlled by the Department of Trade under the MEA. The department looks after the import of petroleum products and their distribution. The Internal Trade Division of the department deals with the retail and wholesale business within Bhutan (including licensing and regulatory issues) and the Foreign Trade Division of the department deals with bilateral and multilateral trade activities.

The coal and mining sectors are controlled by the Department of Geology and Mines under the MEA. This department functions through two divisions.

## **Legal and Regulatory Framework of the Energy Sector**

As mentioned earlier, the BEA is the electricity regulator in the country responsible for the power sector. Operations such as generation, transmission, and distribution are carried out by the respective licensees within the framework of the Electricity Act, 2001. The following aspects are included under the purview of the BEA: electricity pricing, ensuring that licensees meet their functional obligations and responsibilities to their customers and other stakeholders, ensuring inter-operational discipline and dispute resolution, etc. It also provides various codes and regulations such as grid code, distribution code, grievance mechanisms, and policy preparation.

The government aims to attract private investment for hydropower development in the country through independent power producers. Although the specific regulations in this regard are yet to be finalized (the Hydropower Policy on Foreign Direct Investment and the formulation of independent power producers [IPPs] are in the draft stages), these regulations are expected to provide sufficient incentives for investments in hydropower projects of Bhutan and to ensure sale of electricity outside the country by IPPs, thereby promoting regional trade.

## India

### Institutional Framework of the Energy Sector

The Government of India manages the energy sector through five key ministries for the energy subsectors: power, coal, oil and gas, renewable energy, and atomic energy. A brief description of the institutional framework of each energy subsector is provided below.

#### Power Sector

The Ministry of Power (MOP) is primarily responsible for development of the electricity sector in India. It deals with perspective planning; policy formulation; processing of projects of public sector undertaking for investment decisions; monitoring of the implementation of power projects; training and manpower development; and the administration and enactment of legislation in regard to thermal and hydropower generation, transmission, and distribution.

As specified by the Constitution of India, both central and state governments have concurrent jurisdiction over the electricity sector. The MOP coordinates with the state electricity boards, power departments, and the private sector. It is responsible for the administration of the Electricity Act, 2003; the Energy Conservation Act, 2001; and for suggesting amendments to these acts, as may be necessary from time to time, in conformity with the government's policy objectives. The MOP is also responsible for formulating national electricity policy.

The Central Electricity Regulatory Commission is the regulator at the central government level for interstate power matters. Its responsibilities include licensing, regulating, and promoting power market development; determining generation tariffs of central utilities and projects that supply power to more than one state; regulating interstate transmission, tariffs, and trading of power; and bringing efficiency to the sector and safeguarding

the interest of the consumers. State electricity regulatory commissions have the same responsibilities at the state level. Regulatory issues related to regional energy trade would fall under the purview of the Central Electricity Regulatory Commission.

The Central Electricity Authority assists the MOP in all technical and economic matters. It is responsible for the technical coordination and supervision of programs and is also entrusted with a number of statutory functions. It is also responsible for preparing the National Electricity Plan every 5 years, in accordance with the National Electricity Policy.

The construction and operation of generation and transmission projects in the Central Sector are entrusted to central sector power corporations, such as the National Thermal Power Corporation, the National Hydro Electric Power Corporation, the North Eastern Electric Power Corporation, and the Power Grid Corporation of India Limited. The Power Grid Corporation of India Limited has the mandate to establish and operate regional and national power grids to facilitate the transfer of electricity within and across different regions. The Power Finance Corporation and Rural Electrification Corporation provide support for financing power projects and rural electrification, respectively.

## **Hydrocarbon Sector**

The Ministry of Petroleum and Natural Gas is responsible for the exploration and production of oil and natural gas. The transport, refining, distribution, marketing, import, export, and conservation of petroleum products also falls within its responsibilities. It also deals with the development and implementation of pricing policy and with the supervision, production, and marketing of biofuels.

The Directorate General of Hydrocarbon has been established to look after the interests of the Government of India as it is the owner of all hydrocarbon resources of the country and the operators are only leaseholders. The directorate-general also maintains a repository of data pertaining to oil fields and promotes participation of oil companies in the rounds of bidding and supervises the award of concessions after ensuring proper evaluation of the bids received. It supervises activities of operators and approves the budgets and establishment of reserves of hydrocarbons.

With the enactment of the Petroleum and Natural Gas Regulatory Board Act in 2006, the regulator for the oil and gas downstream sector was established. The objective of the act is to regulate the refining, processing, storage, transport, distribution, marketing, and sale of petroleum, petroleum products, and natural gas to protect the interests of the consumers and

entities engaged in specified activities, to ensure uninterrupted and adequate supply of petroleum products and natural gas in all parts of the country, and to promote competitive markets. It supervises the work of the operator and approves the budgets and the establishment of reserves of hydrocarbons.

## **Coal Sector**

The Ministry of Coal is responsible for the development of the coal industry in the country by formulating plans and policies for exploration and development of coal and lignite reserves and attracting investment in the sector. The ministry works through Coal India Ltd., Neyveli Lignite Corporation Ltd. (a subsidiary of Coal India Ltd.), and Singareni Collieries Company Ltd. (a joint venture between Coal India Ltd. and the Government of Andhra Pradesh).

## **Renewable Energy Sector**

The Ministry of New and Renewable Energy is the nodal agency of the Government of India for all matters relating to new and renewable energy resources. The ministry aims to develop and deploy these energy sources to augment energy supply for the country and for carrying out a national program to increase wind, small hydro, solar, and biomass-based power generation capacity. The Indian Renewable Energy Development Agency is a public sector enterprise under the ministry to promote, develop, and extend financial assistance for renewable energy and energy efficiency and conservation projects.

## **Atomic Energy Sector**

The Department of Atomic Energy, set up in 1954, is directly under the charge of the Prime Minister of India, and administers India's nuclear program. The Nuclear Power Corporation of India Limited, a public enterprise under the department, undertakes the design, construction, operation, and maintenance of atomic power stations for the generation of electricity in the country.

## **Legal and Regulatory Framework of the Energy Sector**

### **Power Sector**

The Electricity Act, 2003 provides the overarching legal framework for India's electricity sector. It consolidates the laws relating to the generation, transmission, distribution, trading, and use of electricity. It aims to promote

competition, protect the interest of the consumers, and rationalize electricity tariffs. The act facilitates the flow of investment into the sector by creating a competitive environment and reforming the distribution segment of the power industry. The act also removed and reduced many barriers to entry by removing the generation licenses for setting up captive generation facilities, recognizing trading of power as an independent activity, allowing multiple licenses in the distribution of electricity, and establishing the regulatory commissions for developing the sector in a transparent and competitive manner by rational tariff management. The National Electricity Policy, 2005 and the National Tariff Policy, 2006 aim to improve access to reliable electricity supply and to make the power sector commercially viable through cost-reflective tariffs.

The Government of India also issued guidelines for tariff-based competitive bidding in 2006 for promoting competitive procurement of electricity by distribution licensees, facilitating transparency and fairness in procurement processes, and protecting consumer interests by facilitating competitive conditions in the procurement of electricity.

Private participation in the transmission segment is encouraged through joint ventures. The development of Ultra Mega Power Projects is another major investment initiative to encourage private participation through international competitive tariff-based bidding. The state electricity regulatory commissions have initiated actions on open access in the distribution segment.

The Foreign Investment Promotion Board grants approval for foreign investment in the coal sector on a case-to-case basis and up to a maximum of 50% of equity. So far, Coal India Ltd. plays a dominant role in the sector, and few private investments have been made in the coal sector.

## **Hydrocarbon Sector**

Reforms in the oil sector began in the early 1990s with private and foreign firms allowed to participate in onshore exploration and production through production-sharing contracts. In 1997, the government announced the New Exploration Licensing Policy to provide a more attractive framework for private domestic and foreign investment in oil and gas exploration.

The government officially abolished the Administered Pricing Mechanism in 2002 for all petroleum products except kerosene and liquefied petroleum gas (LPG). Oil marketing companies were allowed to fix the price of petroleum products for a while, but as international oil prices rose, the government continued its control on diesel and petrol prices. These controls, along with subsidies on kerosene and LPG, have imposed heavy financial burdens on

the downstream oil companies. Private sector participation in building oil-product pipelines through joint ventures has been allowed since 2002. The private sector is also free to invest in gas pipeline infrastructure. Foreign direct investment in the gas sector is allowed in exploration and production and in liquefied natural gas (LNG) terminals.

In 2006, the Petroleum and Natural Gas Regulatory Board was set up. It is an independent regulator for midstream and downstream activities with an aim of promoting competition in the oil and gas sectors and the development of natural gas pipelines and city or local gas distribution networks in the country. The role of the board in the promotion of regional energy trade is primarily related to giving approvals for laying cross-border pipelines within the Indian territory.

## **The Maldives**

### **Institutional Framework of the Energy Sector**

The Ministry of Environment, Energy and Water, established in July 2005, oversees the energy, environment, and water sectors in the Maldives. It replaced the multiple ministries that earlier existed in the energy sector. It aims to encourage energy efficiency and alternative energy use in the country. The following sections discuss the institutional framework of each energy subsector. The ministry is assisted in its efforts by the Energy Advisory Committee.

#### **Power Sector**

The Maldives Energy Authority regulates the energy sector of the country. Although it has a broad mandate to regulate the energy sector, set standards, and conduct awareness programs, its activities are restricted to technical activities in the electricity subsector, such as setting technical standards for improving the quality of electricity supply and resolving conflicts between electricity providers and consumers. The State Electric Company Ltd., affiliated to the Ministry of Finance and Treasury (MOFT), provides electricity. The MOFT raises loans for the company to invest in its business and is expected to generate profit by trading, producing, and distributing electricity.

#### **Hydrocarbon Sector**

The State Trading Organization under the MOFT plays an important role in fossil fuel imports to the country such as for diesel, gasoline, LPG, kerosene, and aviation fuel. It is also licensed to reexport the products.

## Nepal

### Institutional Framework of the Energy Sector

The various institutions involved in the energy sector of Nepal are discussed below.

#### **Power Sector**

The power sector in Nepal is under the jurisdiction of the Ministry of Water and Resources (MOWR). The Department of Electricity Development was formed in 1992 under the MOWR as the electricity development center. It has three working divisions: the Project Study Division (responsible for survey and feasibility study of hydropower projects); the Privatization Division (responsible for proposal evaluation, project licensing, and promotion); and the Inspection Division (responsible for project inspections). The Nepal Electricity Authority is a government institution, responsible for the generation, transmission, and distribution of electricity in Nepal. It undertakes system planning studies including demand forecasts and generation planning. It is in the process of unbundling its vertically integrated structure to improve operational efficiency.

The Water and Energy Commission, established to develop water and energy resources in an integrated and accelerated manner, primarily assists the Government of Nepal, the MOWR, and other related agencies in the formulation of policies and planning of projects in the water resources and energy sectors.

#### **Petroleum Sector**

The Ministry of Industry, Commerce and Supplies is the legislative body for the exploration and development of fossil fuel resources, and for the marketing and distribution of their products. The Petroleum Exploration Promotion Project is an independent unit under the Department of Mines and Geology, to promote petroleum exploration activities. The project acts as the facilitator in negotiations and grants petroleum agreements to private investors in conformity with the procedural arrangement as defined in the Petroleum Act and Regulations. The Nepal Oil Corporation is the public enterprise under the ministry. It primarily arranges for the import of petroleum and oil products and their storage and distribution throughout the country.



## **Coal Sector**

Until 1992, Nepal Coal Limited, a public corporation, had the exclusive right for importing coal from India. However, the corporation was subsequently dissolved to encourage private participation in the sector. Currently, the private sector is engaged in importation and distribution of coal throughout the country.

## **Renewable Energy Sector**

The Ministry of Environment, Science and Technology and the Alternative Energy Promotion Centre under this ministry are the main entities for the promotion and development of renewable energy technologies. The centre provides the financial and technical support to local organizations for promoting and developing decentralized rural energy through technology transfer and research and development activities.

## **Legal and Regulatory Framework of the Energy Sector**

The Government of Nepal is responsible for developing the statutory, legal, and policy framework for the energy sector. Various acts and regulations constitute the statutory framework, under which public and private energy supply activities take place. With regard to energy trade, the government places special emphasis on the development of hydropower projects as export-oriented projects, as reflected in the Hydropower Development Policy of 2001. One of the major objectives of the policy is to develop hydropower as an exportable commodity by pursuing a strategy of bilateral and regional cooperation. To achieve this objective, the government intends to pursue investment-friendly and transparent procedures to promote private sector participation in the development of hydropower, taking into consideration internal consumption needs and export possibilities. It aims to attract investment from both the private and the governmental sectors, as necessary, and through joint ventures.

## **Pakistan**

### **Institutional Framework of the Energy Sector**

Pakistan has a well-defined institutional structure for the energy sector. The country has established regulators for the electricity sector and the oil and gas sector. A brief outline of the institutional structure and the role of each entity involved in the energy sector of Pakistan are discussed on next page.

## **Power Sector**

The Ministry of Water and Power is primarily responsible for the power sector in Pakistan. The National Electric Power Regulating Authority (NEPRA) is the overall regulator of the power sector, and provides regulations for power generation, transmission, and distribution activities in Pakistan.

The Water and Power Development Authority was responsible for supplying electricity across the entire country, except for the greater metropolis of Karachi, which was the responsibility of the Karachi Electric Supply Corporation. In 1992, the unbundling of the authority's power wing began and it was unbundled into four thermal power generation companies, one National Transmission and Dispatch Company, and nine electricity distribution companies. At present, apart from these entities, there are 28 independent power producers (IPPs) in Pakistan. The Pakistan Electric Power Company manages power sector reforms in the country including the restructuring of the power wing of the authority.

The first power sector public entity, the Karachi Electric Supply Corporation, has been handed over to the private sector with licenses for generation, transmission, and distribution to the biggest metropolis of the country, Karachi, involving the private sector to improve the power sector performance within the last 3 years.

The Private Power Infrastructure Board has the mandate to promote private sector investment in Pakistan through a "Single One-Window" facility to investors. The board formulates reviews and updates policies and procedures relating to private sector investments in power generation and associated infrastructure. Provincial private power cells have been formed in each of the four provinces of Pakistan to promote private investment in the power sector, especially hydroelectric plants.

Apart from the above, the power sector also has the Pakistan Atomic Energy Commission, which is currently operating two atomic power stations.

## **Hydrocarbon Sector**

The Ministry of Petroleum and Natural Resources is responsible for the overall activities of the oil and gas sector. The Oil and Gas Regulatory Authority (OGRA), the regulator for the sector, aims to foster competition, increase private investment and ownership in the midstream and downstream petroleum industry, protect the public interest, and provide effective and efficient regulations.

## **Oil and Gas Sector**

The Pakistan State Oil is the market leader for oil in Pakistan, and is engaged in the import, storage, distribution, and marketing of various petroleum products, including gasoline, diesel, fuel oil, jet fuel, kerosene, LPG, CNG, and petrochemicals. Sui Southern Gas Company Limited and Sui Northern Gas Pipe Line Company Limited are the two main companies engaged in gas distribution and transmission.

## **Coal Sector**

The coal sector is a responsibility of the provincial governments. They are responsible for the development of the coal industry in their respective provinces by formulating plans for exploration, development and mining of coal, and attracting investment in the sector. For fast-track exploitation of the very large coal resources in the Thar Coalfield in Sindh, the Government of Sindh has established the Thar Coal and Energy Board. Chaired by the chief minister, the board acts as one-stop organization on behalf of federal and provincial government organizations in matters relating to development, mining, leasing, and attracting investment in the Thar Coalfield.

## **Renewable Energy Sector**

The Alternate Energy Development Board looks after alternate sources of power, especially wind power. Solar, biomass, and other technologies are also promoted through private sector participation.

## **Legal and Regulatory Framework of the Energy Sector**

Pakistan has separate regulatory authorities for power and for the oil and gas sectors.

The NEPRA aims to develop and pursue a regulatory framework, which will ensure the provision of safe, reliable, efficient, and affordable electric power to consumers; facilitate building of competitive markets in the power sector in an efficiency-oriented and market-driven environment; and maintain a balance between the interests of the consumers, service providers, and the economic and social policy objectives of the Government of Pakistan.

For the oil and gas sectors, the OGRA is the regulator. Its functions include regulating refineries, oil storage, oil pipe lines, oil marketing companies, and CNG and LPG supply, transmission, distribution and sale, including determination of gas tariffs. Since its inception, the OGRA has laid down performance and service standards as part of license conditions to improve

the quality of service to the consumers. A number of regulatory measures have been introduced to ensure the provision of safe, efficient, and satisfactory service to CNG and LPG consumers.

A total of 28 private power projects have materialized with a net capacity of 6,707 megawatts (MW), while an additional capacity of 1,800 MW was scheduled in 2008 for connection to the national grid. Apart from this, Karachi Electric Supply Corporation, with a power generation capacity of 1,948 MW, is operated by the private sector. Thus, 40% of the country's total power generation is by the private sector.

Pakistan also has a policy to promote renewable energy-based power generation in the country by providing various types of incentives to developers. It permits investors to generate electricity based on renewable energy resources at one location and receive an equivalent amount of electricity for their own use elsewhere on the grid at the investor's own cost of generation plus transmission charges (wheeling). It facilitates projects to obtain carbon credits for avoided greenhouse gas emission, helping to improve financial returns and reducing unit costs for the purchaser.

## **Sri Lanka**

### **Institutional Framework of the Energy Sector**

The Ministry of Power and Energy (MPE) and the Ministry of Petroleum and Petroleum Resources Development in Sri Lanka are responsible for implementing energy sector policies.

#### **Power Sector**

In the power sector, the Ceylon Electricity Board (CEB), under the MPE, is the owner and operator of the national electricity grid. It owns all large hydropower stations and 50% of the thermal power generation capacity in Sri Lanka. The remainder of the thermal-based power generation is owned by private players. The CEB is the main agency dealing with its counterparts in India in any technical collaboration required for the proposed India–Sri Lanka electricity grid interconnection.

On the distribution side, the CEB caters to 85% of the consumers connected to the national grid and the Lanka Electricity Company, under the MPE, supplies electricity to 15% of all consumers, mainly in urban and suburban areas. Private sector involvement in thermal power generation has been

steadily increasing since the mid-1990s when the first independent power producer entered the supply industry.

## **Hydrocarbon Sector**

The state-owned Ceylon Petroleum Corporation (CPC), under the Ministry of Petroleum and Petroleum Resources Development, is the only player in the petroleum refining business. It handles all crude oil imports in the country. For the import of finished petroleum products, CPC competes with the privately owned Lanka IOC (a subsidiary of Indian Oil Corporation). The import and distribution of LPG is completely owned by the private sector, with CPC contributing 15% of the total LPG supply through its own refinery output.

## **Renewable Energy**

Sri Lanka has recently established the Sustainable Energy Authority to coordinate the development of the renewable energy sector and take forward initiatives on energy efficiency. The government is providing financial incentives to small-scale (less than 10 MW) electricity generation facilities using renewable energy sources such as small hydropower, wind, and biomass. There are many professional nongovernment organizations promoting renewable energy use, such as the Sri Lanka Energy Managers Association, the Energy Forum, and the Bio-energy Association.

## **Regulatory and Policy Framework of the Energy Sector**

The government has developed a 10-year development framework for 2006–2016 for the sector. One of the features of the development framework is the diversification of fuel in such a manner that 90% of electricity generation is from non-oil resources. The overall strategy to address this issue is to build coal-fired power plants, and large or medium hydroelectric power plants, with the involvement of the private sector. Also, a target is being set for 10% of grid energy to be supplied from renewable energy sources by 2015. The development framework also provides for an increase in investment in transmission and distribution network expansion to ensure the stipulated quality and reliability of electricity supply. Other relevant provisions of the Energy Policy include the following:

- (i) Ensuring energy security through diversification of fuel in electricity generation and the transport sector, and the promotion of regional cooperation in the energy sector by establishing cross-border energy transfer links with neighboring countries;
- (ii) Provision of basic electricity requirements for people through grid-extension or off-grid systems at competitive prices;

- (iii) Appropriate pricing policy adoption by the regulatory agency and cost-reflective pricing policy for all commercial energy products including a reasonable rate of return on equity;
- (iv) Provision of necessary incentives for increased usage of nonconventional renewable energy sources;
- (v) Encouraging supply-side and end-use energy efficiency through financial and other incentives or disincentives;
- (vi) Enhancing energy sector management capacity through appropriate training, empowerment, and delegation of authority to develop integrated long-term energy plans and conduct policy analyses in the energy sector; and
- (vii) Reforming and restructuring of the energy industry to accommodate public–private partnership in the development process.

A multi-sector regulatory body, the Public Utilities Commission of Sri Lanka, has been established as an independent regulator for the electricity and downstream petroleum industries. While regulations for the electricity sector have already been issued, petroleum sector legislation is still in the draft stages.

## Annex 2

# Southern African Power Pool

## Structure

The Southern African Power Pool (SAPP) is based on interconnections among the power utilities of 12 countries: Angola, Botswana, Congo, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Tanzania, Zambia, and Zimbabwe. It was set up in 1995, with the objective of providing reliable and economical electricity supply to the consumers of each of the SAPP members, consistent with reasonable utilization of natural resources and effects on the environment. The starting point for the power pool was the preexisting bilateral trade and interconnections among the South African power utilities. The interconnections and bilateral power trading had existed among South African countries since the 1950s. There were interconnections between the Democratic Republic of the Congo and Zambia in the 1950s. In the 1960s, interconnections were developed between Zambia and Zimbabwe with the construction of the Kariba Dam. In 1975, South Africa was connected to Mozambique by a transmission line from Cahora Bassa to Apollo. Consequently, due to the gradual extension of interconnections among the South African countries, two broad networks were developed. These are

- (i) the Southern Network, dominated primarily by thermal-based power generation and including interconnections among Namibia, South Africa, and Mozambique; and
- (ii) the Northern Network, which was primarily hydro-based power generation and included the Congo, Zambia, Mozambique's Cahora Bassa, and Zimbabwe.

The complementing of resource endowments that existed between the two networks was one of the key factors that led to the creation of the SAPP. The

two networks were linked in 1995 with the commissioning of a 400 kilovolt (kV) line. This interconnection between the northern and southern networks laid the foundations for the development of regional trade and cooperation, thereby leading to the creation of the SAPP.

The SAPP is an association of 12 member countries represented by the respective electricity utilities organized through the Southern African Development Community (SADC). The SAPP has a well-defined institutional structure involving all the relevant stakeholders (Figure A2).

**Figure A2 Hierarchical Structure of the Southern African Power Pool**



SADC = Southern African Development Community.  
Source: SAPP.

The Executive Committee, consisting of the heads of the participating utilities, acts as the board of directors of the power pool. The Management Committee, consisting of the senior managers of the transmission utilities and the energy trading departments of each utility, is responsible for collating information from the five subcommittees (planning, operating, markets, and environment, and the Coordination Centre Board),<sup>1</sup> preparing proposals for the Executive Committee, and presenting biannual reports to the Executive Committee. The subcommittees work under the guidance of

<sup>1</sup> The Coordination Centre Board and the Markets Subcommittee was formed in 2007 with the signing of the revised Inter-Utility Memorandum of Understanding.



the Management Committee. The Coordination Centre works under the Operating Subcommittee and is responsible for the working of the pool and monitoring activities. There are a number of guiding documents that have been agreed to by all the participating nations to ensure smooth working of the pool. Broadly, SAPP is guided by the following four agreements:

- (i) **Inter-Governmental Memorandum of Understanding.** Signed among member governments of SADC for the formation of the SAPP, this is the guiding agreement on which the pool was established. The pool was inaugurated by this agreement. It grants permission for the utilities to participate in the SAPP and enter into contracts, and guarantees the financial and technical performance of the power utilities.
- (ii) **Inter-Utility Memorandum of Understanding.** The memorandum of understanding (MOU) among the utilities establishes the basic management and operating principles for the SAPP. The MOU defines ownership of assets and other rights such as provision for a change in status from a participating to an operating member. In 2007, a revised Inter-Utility Memorandum of Understanding was signed, following which a new committee (the Market Subcommittee) was formed. The revised MOU enables other players within the SADC region, such as independent power producers (IPPs) and independent transmission companies, to join the SAPP and to participate in all activities.
- (iii) **Agreement between Operating Members.** The agreement determines the interaction between the utilities with respect to operating responsibilities under normal and emergency conditions.
- (iv) **Operating Guidelines.** The guidelines provide standards and define the sharing of costs and functional responsibilities for plant operation and maintenance.

## Operating Mechanism

There are currently two mechanisms through which the SAPP operates—the bilateral market and the short term energy market (STEM).

### Bilateral Market

Bilateral contracts under the pool are inter-utility long-term power purchase arrangements. “Long term” could be from a 1-year to a 5-year time span. This trade accounts for around 90% of the total trade under the pool. Prices for these transactions are determined on a bilateral basis and are governed by a bilateral contract between the trading parties. The four documents

governing the functioning of the SAPP also lay guidelines for implementing the bilateral trade arrangements.

## Short-Term Energy Market

STEM participants include any party of SAPP or any other participant approved by the SAPP Executive Committee. The STEM operates as follows:

- (i) Each participant of the STEM submits the trading form to the Coordination Centre. The participants may bid for monthly, weekly, and daily contracts. The bid form must provide the details such as participant name, volumes of energy to be traded and peak in MW, type of contract, trading period, prices required, and applicable currency.
- (ii) Each participant network must fall under a larger host control area, which is aware of the network constraints and transfer limits and scheduled bilateral energy trade arrangements.
- (iii) The Coordination Centre matches the bids and offers using an optimization process taking into consideration the bilateral agreements (as they are given the first priority), latest system constraints, and wheeling charges.
- (iv) The Coordination Centre publishes the volume and price results to all successful participants as well as unallocated offers and unmatched bids.
- (v) The Coordination Centre publishes all the offer power and the corresponding offer price without any inclusion of the wheeling charges. The buyers are responsible for payments of all wheeling charges.
- (vi) When a seller advertises an amount of power at a given selling price, for a bidder to qualify for the advertised power it is necessary that the bid price be greater than the selling price including the wheeling charges.
- (vii) All participants notify the Coordination Centre, on the first working day following delivery of the contracted energy, all information pertaining to forced outages or other events that may impact upon final payments.

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## Energy Trade in South Asia

### Opportunities and Challenges

The South Asia Regional Energy Study was completed as an important component of the regional technical assistance project Preparing the Energy Sector Dialogue and South Asian Association for Regional Cooperation Energy Center Capacity Development. It involved examining regional energy trade opportunities among all the member states of the South Asian Association for Regional Cooperation. The study provides interventions to improve regional energy cooperation in different timescales, including specific infrastructure projects which can be implemented during these periods.

### 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 two-thirds of the world's poor: 1.8 billion people who live on less than \$2 a day, with 903 million struggling on less than \$1.25 a day. ADB is committed to reducing poverty through inclusive economic growth, environmentally sustainable growth, and regional integration.

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