Prepared for:
USAID-SARI/Energy Program
www.sari-energy.org

Regional Hydro-power Resources: Summary and Analysis of Selected SARI Data

Nexant

November 2003

Regional Hydro-power Resources: Summary and Analysis of Selected SARI Data

Prepared for

United States Agency for International Development

Under

South Asia Regional Initiative for Energy

Prepared by

Nexant SARI/Energy

List of Abbreviations

CIER	Commission of Regional Power Integration (South America)
GNP	Gross National Product
GDP	Gross Domestic Product
IPP	Independent Power Producers
kV	Kilo Volts
KWh	Kilowatt hour
MOU	Memorandum of Understanding
MW	Megawatt
NEA	Nepal Electricity Authority
SAARC	South Asian Association for Regional Cooperation
SAPP	South African Power Pool
SARI Regions	Bangladesh, Bhutan, India, Maldives, Nepal, Sri Lanka
SARI/Energy	South Asia Initiative on Energy
USAID	United States Agency for International Development

Contents

Section	Page
1. Background	**1-1**
2. Introduction	**2-1**
3. SARI Region Hydro-power Status	**3-1**
3.1 Regional Potential	3-1
3.2 Current Utilization	3-1
3.3 Projects Under Construction	3-2
3.4 Upgrading Existing Projects	3-3
3.5 Future Plans	3-3
4. SARI Regional Hydro-power Policy	**4-1**
4.1 Power Sector Reform	4-1
4.2 Promotion of Private Investment	4-1
4.3 Institutional Restructuring	4-2
5. Issues and Barriers: Summary and Analysis	**5-1**
5.1 Issues	5-1
5.2 Barriers	5-5
6. Resolving Known Issues	**6-1**
6.1 Initiatives	6-1
6.2 Regional Power Market	6-2
6.3 Frameworks of Agreement	6-3
7. Conclusion	**7-1**
8. References	**8-1**

Reports Attached

Regional Hydro-power Resources: Status of Development and Barriers: Bangladesh
Regional Hydro-power Resources: Status of Development and Barriers: Bhutan
Regional Hydro-power Resources: Status of Development and Barriers: India
Regional Hydro-power Resources: Status of Development and Barriers: Nepal
Regional Hydro-power Resources: Status of Development and Barriers: Sri Lanka

Table **Page**

Table 2-1 Economic and Demographic Indicators ……. 2-1
Table 2-2 Poverty Rates ……. 2-1
Table 2-3 Commercial Energy Consumption ……. 2-2
Table 2-4 Electricity Generation by Source, Transmission and Distribution (T&D) Losses, and Electricity Power Consumption Per Capita …… 2-3
Table 3-1 Hydro-power Potential of the Region ……. 3-1
Table 3-2 Current Hydro-power Utilization …… 3-2
Table 3-3 Hydro-power Projects Under Construction …… 3-2
Table 3-4 Hydro-power Development Plans ……. 3-3

Section 1 Background

The advisory meeting on hydro-power development and rehabilitation of hydro-power plants in the SARI/Energy region held in Sri Lanka in 2001 recommended that a number of issues be addressed from a regional perspective. These include:

(i) Evaluation of the economic and other benefits of a hydro-power project and development of a pricing mechanism for hydro-power;
(ii) Development of a master plan for exploitation of hydro-power resources; and
(iii) Development of a least-cost generation plan.

Comprehensive studies, Regional Hydro-power: Status of Development and Barriers of the hydro-power resources of Bangladesh, Bhutan, India, Nepal, and Sri Lanka have already been prepared. These five country-specific, hydro-power resources studies, describing in detail the current status of hydro-power in Bangladesh, Bhutan, India, Nepal and Sri Lanka as well as future development/barriers to development are included as attachments to this report. The purpose of this report is to synthesize these country reports into a summary report that will draw upon the information, analysis, and suggestions contained in the country reports and also make use of other relevant information. This summary report, with the individual country reports, constitutes the regional report that is expected to open the way to achieving the objectives of the Sri Lanka meeting.

With **22.2%** of the world's population and **3.85%** of the global surface area, the SARI/Energy region contributes a mere **1.98%** of global GNP. The average GNP per capita of the region is U.S. $440, which amounts to **9.0%** of the global average of U.S. $4,890 (Table 2.1). The region's export share, as a percentage of world trade, is less than **1% -72%** of the people live in rural areas without adequate access to sanitation, electricity, and other modern amenities. The percentage of people below the national poverty line varies from **34% - 42%** in the countries of the SARI/Energy region (Table 2-2).

Table 2-1: Economic and Demographic Indicators

S. N	Country	Population (1999)	Surface Area (thousands of square kilometers) (1999)	Population Density (people/sq km) (1999)	Gross National Product		GNP per capita	
					Billions of dollars (1999)	Average annual growth rate %) (1998-99)	Dollars (1999)	Average annual growth rate (%) (1998-99)
1	Bangladesh	128	144	981	47	5	370	3.3
2	Bhutan	-	-	-	-	-	-	-
3	India	998	3288	336	442.2	6.9	450	4.9
4	Maldives	-	-	-	-	-	0	-
5	Nepal	23	147	164	5.1	4.6	220	2.2
6	Pakistan	135	796	175	64	3.6	470	1.2
7	Sri Lanka	19	66	294	15.7	3.8	820	2.7
South Asia		1,329	5,140	278	581.1	6.2	440	4.2
World		5,975	13,3572	46	29,232.1	2.7	4,890	1.3
South Asia as % of world		22.2	3.85	-	1.98	-	9.0	-

Source: World Development Report, 2000/2001, Attacking Poverty, World Bank 2000, Page 274, Table 1

Table 2-2: Poverty Rates

S.N	Country	Survey Year	Population below the Poverty Line (%)		
			Rural	Urban	National
1	Bangladesh	1995-96	39.8	14.3	35.6
2	Bhutan	-	-	-	-
3	India	1994	36.7	30.5	35.0
4	Maldives	-	-	-	-
5	Nepal	1995-96	44.0	23.0	42.0
6	Pakistan	1991	36.9	28.0	34.0
7	Sri Lanka	1990-91	38.1	28.4	35.3

Source: World Development Report, 2000/2001, Attacking Poverty, World Bank 2000, Page 280, Table 4

In 1997, the SARI/Energy region accounted for approximately **5.9%** of world commercial energy consumption, up from **2.4%** in 1987. This excludes non-commercial energy sources, such as wood, animal waste, or other biomass, which account for more than half of the region's total energy consumption. Despite rapid growth in energy demand, the region continues to have one of the lowest figures for per capita energy consumption, worldwide, but has one of the highest figures for energy consumption per unit of GDP. The commercial energy mix of the region was **47%** coal, **33%** petroleum, **12%** natural gas, **7%** hydro-power, **1%** nuclear power, and **0.2 %** other sources in 1998. Significant variation in energy mix is observed in the region.

Bangladesh's energy mix is dominated by natural gas (**69%** in 1998), while India is heavily dependent on coal (**55%**). Sri Lanka relies primarily on petroleum (**76%** in 1998), while Maldives is fully dependent on petroleum (**100%**). Pakistan's energy comes mainly from oil (**43%**) and natural gas (**38%**). Nepal and Bhutan have overwhelmingly high shares of petroleum and hydro-power (combined total of about **90%**) in their energy mixes (Table 2-3).

Table 2-3: Commercial Energy Consumption

SN	Country	Commercial Energy Consumption (1998) [1]						
		Total Quadrillion (Btu)	Petroleum (%)	Natural Gas (%)	Coal (%)	Nuclear (%)	Hydro-electric (%)	Other (%)[2]
1	Bangladesh	0.40	29	69	0	0	2	0
2	Bhutan	0.01	30	0	9	0	61	0
3	India	12.51	30	7	55	1	6	0.2
4	Maldives	0.004	100	0	0	0	0	0
5	Nepal	0.04	57	0	8	0	32	4
6	Pakistan	1.74	43	38	5	0.2	13	0
7	Sri Lanka	0.17	76	0	0	0	24	0
South Asia		14.87	33	12	47	1	7	0.2

Source: U.S. Energy Information Administration, International Energy data base, December 1999

These data indicate a trend (Table 2-4). In Bangladesh, the contribution of natural gas has increased from **49%** in 1980 to **85%** in 1997, with a significant decrease in the contribution of hydro-power, from **25% - 6%**, in the same period. In India, the share of coal has increased from **50%** in 1980 to **73%** in 1997, while the share of hydro-power has been reduced drastically, from **39% - 16%**. A significant fall in the share of hydro-power from 1980 to 1997 is also evident in Pakistan and Sri Lanka, as is an increase in those countries' use of petroleum products.

Table 2-4 : Electricity Generation by Source, Transmission and Distribution (T&D) Losses, and Electricity Power Consumption Per Capita

	Bangladesh			India			Nepal			Pakistan			Sri Lanka		
	1980	1990	1997	1980	1990	1997	1980	1990	1997	1980	1990	1997	1980	1990	1997
Source															
Coal	-	-	-	50	65	73	-	-	-	0	0	1	-	-	-
Hydro-	25	11	6	39	25	16	82	100	90	58	45	35	89	100	67
electricity	49	84	85	1	3	6	-	-	-	40	34	25	-	-	-
Natural gas	-	-	-	3	2	2	-	-	-	0	1	1	-	-	-
Nuclear	27	4	9	8	5	3	18	0	10	1	21	39	11	0	33
Oil	35	34	15	18	18	18	29	29	28	29	21	24	15	17	17
T & D losses (%)	16	43	76	130	254	363	13	28	39	125	267	333	96	153	227
Consumption (kWh per capita)															

Source: South Asia Economic Journal 2:2 (2001), "Energy for Economic Development in South Asia: Present status, future requirement and potential for regional cooperation", by Dr. V. Wickramsinghe, Sage Publication, New Delhi

Rapidly growing demand for power, coupled with inadequate supply, presents a challenge throughout the region. Electricity shortages have acted as a constraint on economic growth.

Utilities in the region are mostly operated by the public sector in a commercially unviable manner. Revenues from energy sales do not realize the full costs of supply, and the delivery of service suffers as a result.

Imports of petroleum products to meet the growing demand of energy are expected to increase, which will put additional pressure on these countries' balance of payments. Such over-dependence on imported oil is also likely to affect adversely the energy security of the countries in the region. Providing greater access to modern sources of energy, such as gas and electricity, is a challenge throughout the region. Only a minority of the population has access to these sources, though the numbers are increasing.

Energy-related environmental challenges in the region include deforestation caused by logging and fuel-wood consumption and rapidly growing carbon emissions from the use of carbon-intensive fuel oil. It may be possible to substitute clean fuels for dirty to some extent; the Himalayan countries of the region have enormous hydro-power potential, and only a very small proportion of this potential has been utilized. The possibility of greater use of hydro-power is evident across the entire region as illustrated in the attached individual country reports.

Section 3 SARI Region Hydro-power Status

3.1 Regional Potential

The SARI region is richly endowed with hydro-power potential as pointed in the attached individual country reports, but little of this potential has been realized.

Nepal's hydro-power potential lies in the major river systems of Kosi, Gandaki, Karnali, and Mahakali, all of which flow into the river Ganges in India. The theoretical hydro-power potential is estimated to be around 83,290 MW, with the economically feasible potential assessed at around 42,130 MW.

The Government of India has classified the country into six major river systems. The latest study by the Central Electricity Authority (CEA), conducted from 1978 to 1987, identified 845 possible projects with a total potential of around 84,044 MW at **60%** load factor, representing an installed capacity of 148,701 MW. The Indus, Ganges, and Brahmaputra basins contribute almost **80%** of the total hydro-power potential.

All studies on hydro-power potential in Bangladesh were conducted before 1971. These studies show hydro-power potential, estimated at 1,897 MW, to be confined to the Karnafuli, Sangu, Matamuhari, and Brahmputra river basins. According to the master plan provided by the Ceylon Electricity Board (CEB) for the electricity supply of Sri Lanka, the techno-economically feasible hydro-power potential of Sri Lanka is estimated to be 2,423 MW. The theoretical hydro-power potential of Bhutan has been estimated to be about 30,000 MW, of which 16,280 MW is assessed to be techno-economically feasible.

Overall, the estimated hydro-power potential of the SARI region is as follows (Table 3-1). Some **98%** of the potential lies in Bhutan, Nepal, and India.

Table 3-1: Hydro-power potential of the region

Country	Hydro-power Potential		
	Theoretical Potential (MW)	Techno-Economically Feasible Potential (MW)	%
1. Bangladesh	-	1,897	0.9
2. Bhutan	30,000	16,280	7.7
3. India	-	148,701	70.3
4. Nepal	83,290	42,130	20.0
5. Sri Lanka	-	2,423	1.1
Total		**2,11,431**	100

Source: Country reports of Bangladesh, Bhutan, India, Nepal, and Sri Lanka, 2002.

3.2 Current Utilization

Little of the potential hydro-power in the region is being used (Table 3-2).

Table 3-2: Current Hydro-power Utilization

Country	Techno-economically Feasible Potential (MW)	Installed Capacity (MW)	Utilization (%)
1. Bangladesh	1,897	230	12.1
2. Bhutan	16,280	432	2.6
3. India	1,48,701	25,587	17.2
4. Nepal	42,130	527	1.2
5. Sri Lanka	2,423	1,137	46.9
Total	**2,11,431**	**27,913**	**13.2**

Source: Country reports of Bangladesh, Bhutan, India, Nepal and Sri Lanka, 2002.

Only about **13.2%** of the potential has so far been realized. Shortages of power and limited access to power, long-standing features of power supply in the region, have acted as constraints on economic growth. Rapid development of hydro-power resources, coupled with regional cooperation, could significantly accelerate the pace of economic development.

Several small hydro-power plants have been developed; however, these are mainly intended to serve isolated rural communities, where supply through grid connection is not likely in the next several years. Such developments have not been incorporated in the above table.

3.3 Projects Under Construction

Several hydro-power projects as described in more detail in the attached individual country report are now in various stages of construction in the SARI region. The completion of these projects is expected to relieve power shortages to some extent, but not by enough to meet increasing demand. The likely increase in capacity from the completion of the current projects in the region is given in Table 3-3.

Table 3-3: Hydro-power Projects Under Construction

Country	No. of Projects	Total Capacity (MW)	Likely Year of Commissioning
1. Bangladesh	1	100	Under active consideration
2. Bhutan	2	1,060	2005
3. India	35	13,620	From 2002 to 2012
4. Nepal	3	110	From 2003 to 2004
5. Sri Lanka	1	70	Early 2004
Total	**43**	**14,960**	

Source: Country reports of Bangladesh, Bhutan, India, Nepal and Sri Lanka, 2002.

No hydro-power project is under construction in Bangladesh, although consideration is being given to adding two units of 50 MW to the existing Karnafuli project. Bhutan's new projects are intended to serve mainly the Indian power market. With the completion of these projects of 1,060 MW, the power supply of Bhutan will increase by almost **245%**. Power increases in the countries of India and Nepal are expected to be about **53%** and **20%**, respectively. Only a marginal increase in available power is expected in Sri Lanka. When all 43 current projects in

the region are completed, the utilization of hydro-power, as a percentage of potential hydro-power, will increase from **13.2 % - 20.3%**.

3.4 Upgrading Existing Projects

There does not appear to be much potential for renovating, modifying, upgrading, or extending the useful lives of existing hydro-power projects in the SARI region, except in India. The hydro-power plants in Bhutan are of recent origin. Nepal has recently completed upgrading two hydro-power projects to add some extra capacity during the peak period. One project in Bangladesh has been identified as requiring renovation, but this proposal is still under consideration. Sri Lanka has identified the need to renovate five hydro-power projects, but the proposal is still under study. India has an ambitious plan for renovating, modifying, and upgrading hydro-power projects; eighty projects, with capacity of about 5,430 MW, have been identified as suitable for such work over the next ten 10 years. If completed, this work would increase capacity by **5%**. India's renovation plans concern the power stations' electrical and mechanical equipment—replacing turbine runners and stator windings, reconditioning governors, and so on. This is in sharp contrasts to Nepal's renovation plan, which involves increasing the duration of generating capacity of the existing power station by changing the design of the civil works to increase the amount of water stored for power generation.

3.5 Future Plans

Each country in the SARI region has developed a plan for the future development of hydro-power; some of these plans are elaborate and some are sketchy, for reasons that can be found in the information in the attached individual country reports (Table 3-4).

Table 3-4 : Hydro-power Development Plans

Country	No. of Projects	Capacity (MW)	Likely date of Completion	Remarks
1. Bangladesh	1	100	Not given	Prospects in several river basins held up because of environmental/social activists, high investment required, and lack of needed financing
2. Bhutan	2	1,230	2010-2012	-
3. India	a) 49	19,224	2002-2012	-
	b) 399	1,06,920	Beyond 2012	-
4. Nepal	a) 16	576	2002-2009	As per NEA Generation Expansion Plan
	b) 24	2,238	2005-2012	Candidate projects considered in the Generation Expansion Plan
	c) 16	3,827	-	Project licensed for feasibility study to various IPPs
5. Sri Lanka	1	150	2004	Project faces a strong protest from various parties

Source: Country reports of Bangladesh, Bhutan, India, Nepal and Sri Lanka, 2002

The rationales for the planned development of hydro-power projects in the several countries of the region are not clearly spelled out. This may be because the country reports do not look into the question of power demand and how this demand is likely to increase in the years ahead. Further, increase in power demand can be met by generating power from different sources, and what proportion of this increased supply is to be met by hydro-power is again a policy issue. Mention has been made in some country reports about the share of generation from different sources. Bangladesh appears to have met **5.5%** of maximum demand (3,218 MW in 2002) by hydro-power; this share is unlikely to increase in the years to come because no additional hydro-power developments have been planned, except an addition of 100 MW to the Karnafuli hydro-power plant, which is yet to be implemented. This can change only if power trading takes place in the region and surplus hydro-power from other countries can be exported to Bangladesh. Hydro-power's share of Bhutan's generating capacity is expected to remain about the same for the next ten years, although generation is expected to almost quadruple; most of this will be exported to India.

In India, 49 new projects of 19,224 MW are planned to be completed by 2012, mostly in the public sector; the private sector is expected to build 5 projects of 2,532 MW, about **13%** . Another 399 new projects, with a combined capacity of 106,920 MW, have been identified but it is not clear what point the study of these projects has reached. These projects have been classified into three categories: category A has 98 projects of 15,650 MW, category B has 247 projects of 69,850 MW, and category C has 54 projects of 21,420 MW; however, the basis of these categories is not explained. The country report of India categorically states that India has a target of fully utilizing the country's hydro-power potential by 2026. According to the country report of India, there are existing projects (229) of 25,587 MW; projects under construction (35) of 13,620 MW; and projects planned for the future (448) of 126,144 MW. These add up to 712 projects with a total capacity of 165,351 MW. This differs from the total hydro-power potential, indicated elsewhere in the country report, of 845 projects of capacity 148,701 MW. These figures have not been reconciled.

The share of hydro-power in the Indian power system was **40%** in 1970; this figure had dropped to less than **25%** in 2001. The Government of India has indicated that India's power system should ideally have a hydro/thermal mix of 40:60, given the significant hydro-potential in India, but because of an emphasis on thermal generation in the past three decades, the share of hydro-power has gone down appreciably. It is not clear from the report whether the present undesirable hydro/thermal mix will continue, will improve, or will further deteriorate in the next decade or so.

Nepal's power system will continue to be dominated by hydro-power in the years ahead. It is the declared policy of the government to develop the country's hydro-power resources not only for domestic consumption but also for export to neighboring countries that have power shortages. In addition, Nepal can ill afford thermal generation because of the local unavailability of fossil fuels and the high cost of importing such fuels.

The Nepal country report indicates that 16 projects of capacity 576 MW are planned to be completed by 2009. Of these, 13 projects of 179 MW, amounting to about **31%**, are planned by the private sector. Another 24 projects of 2,238 MW are considered in the generation expansion

plan, which shows expected completion of these projects by 2012. Licenses for feasibility studies of new projects have already been issued to 16 private investors interested in developing projects of 3,827 MW capacity. Thus, plans for hydro-power development in Nepal center on an increasing role for the private sector, which may not be a realistic expectation in the present context. Considerable change in current policies will be needed if the private sector is really to take a greater part than it now has.

Development of Sri Lanka's hydro-power potential appears to be difficult because of opposition from environmental and social activists. This may result in greater reliance on thermal generation, whose share in total power is estimated to increase from **16%** in 2002 to **60%** in 2012.

The variety and imbalances in demand and supply of power in the countries of the region are very evident, but the benefits that can be tapped in such circumstances have hardly been realized. The situation can change for the better if the countries of the region can agree to come together and cooperate in solving energy-related problems. Regional power associations elsewhere have succeeded in integrating the power systems of neighboring countries and then managing the integrated system in a way that benefits the participants. Such an organization would offer the countries of the SARI region a way to derive immense benefits from regional cooperation.

Section 4 SARI Regional Hydro-power Policy

The energy sectors of the countries of the SARI region share a number of characteristics. Common elements include overall power shortage, imbalance between supply and demand, poor quality of supply, low per capita power consumption, high transmission and distribution losses, and low availability of electricity. Utilities are mostly operated by the public sector in a commercially unviable manner. Revenues from energy sales do not realize the full costs of supply, and the delivery of service suffers as a result.

The combination of rapidly growing power demand and inadequate power supply presents a challenge throughout the region. Electricity shortages have acted as a constraint on economic growth. A recent survey funded by the World Bank found that power outages in Bangladesh cost about U.S. $1 billion a year and reduce growth by about half a percentage point. Khatib and Manasinghe (1992) estimated the cost of power shortage to India's and Pakistan's industrial sectors to be **1.5%** and **1.8%** of GDP, respectively.

4.1 Power Sector Reform

There has been a general appreciation of the acute need for power sector reform in the region. Accordingly, the governments of the several countries have approved hydro-power development policies that are intended to make optimal use of hydro-power resources and to produce electricity at low cost, thus ensuring reliable electricity services of good quality and expanding rural electrification to support rural development. The highlights of such policies often include:

(i) Corporatization and/or privatization efficient functioning plus of the public sector agencies,
(ii) Creation of conditions likely to induce private (domestic and foreign) capital flows into the power sector, and
(iii) Institutional restructuring, along with the establishment of a regulatory agency.

Power sector reform is under way in several countries of the region. This can be seen mainly in changes in investment and ownership patterns, and in an increasing role for private investment. Several power projects in the region are being managed by private investors and the number of these investors is likely to increase in the years ahead. State-owned utilities are being unbundled, and regulatory agencies are being established, all with a view to ensuring efficiency gains and more reasonable and competitive tariffs. The central idea behind these reforms is to create competition in the power markets. A more competitive market will bring consumer choice, lower prices, and higher-quality and more reliable service. However, reform is progressing very slowly, although the need to speed it up is widely recognized.

4.2 Promotion of Private Investment

Bangladesh has not formulated any specific policy on hydro-power development but has made provision for private investment in such development. There appears to be plenty of power potential in the Sangu, Matamuhuri, and Brahmaputra river basins, but the environmental and social impacts of these projects are excessively high, and this is apart from problems of

investment and finance. Presumably, the private sector may be called upon to assist in the development of these river basins.

In India, private investors hold a less than **2%** share in existing hydro-power development; under the planned development scenario, this share is likely to go up to around **10%** by year 2012. Because India plans to develop all its hydro-power potential by 2026, the contribution of the private sector is likely to increase further.

Nepal's private sector now owns about **25%** of installed hydro-power capacity. The government's efforts to develop new hydro-power resources and encourage private investment are likely to result in an increase in this share in the years to come.

About **32%** of the hydro-power potential, amounting to 760 MW, is yet to be developed in Sri Lanka. All existing development is state-owned; however, the government has a policy of encouraging private sector participation in hydro-power development.

In fact, most of the governments in the region are now taking steps to encourage private investment. Some, for example, offer various concessions or facilities, such as a "single window" system, all aimed at attracting capital from external markets. However, implementation is still far from satisfactory in most places; delays, disputes, and unnecessarily extensive paperwork are still all too common. These issues must be addressed before the domestic and international markets are likely to start looking seriously at investments in this sector.

4.3 Institutional Restructuring

Most governments of the region have accepted the fact that publicly owned integrated power utilities cannot operate at the levels of performance and efficiency that are expected in the private sector. Reform efforts thus include policies and actions that are meant to restructure various institutions. Common themes are:

(i) Establishment of an independent regulatory authority free from interference from the ministry that is responsible for policy making.
(ii) The setting up of a promotional body responsible for promoting private investment.
(iii) Unbundling integrated public utilities into generation, transmission and distribution companies.

Regulatory commissions with responsibility for different regulatory functions are being established in India, Nepal, and Sri Lanka. There is a need to strengthen these commissions so that they can carry out such functions as setting tariffs and protecting consumers' interests more effectively. There are a number of obstacles to the introduction of competition and transparency in licensing and to the adoption of a single-window system for making concessions and facilities available to private investors.

Several ways to unbundle integrated public utilities have been considered. The plan adopted in the region generally spells out creating separate agencies to oversee generation, transmission,

and distribution. Operation of the national grid system is to be retained by the states. Local bodies, communities, cooperatives, and the private sector should be encouraged to manage the distribution systems. Some nominal steps have been taken in this direction.

Section 5 Issues and Barriers: Summary and Analysis

5.1 Issues

The governments of the countries of the SARI region have made the development of hydro-power potential a key development objective (see the attached individual country report for details). The focus is on producing sufficient hydro-power at a reasonable cost to meet demand at an affordable price. The rural–urban disparity in power supply should be narrowed through comprehensive rural electrification programs linked with other rural economic activities. The environmental and social impacts of hydro-power development must be adequately addressed to minimize adverse effects.

The regional emphasis on hydro-power development follows the adoption of hydro-power development policies that are intended to opens up the sector to private investment and to make institutions operating in the power sector efficient and creditworthy.

Some of the major issues influencing hydro-power development in the region can be summarized as follows:

(i) Optimum utilization of hydro-power resources;
(ii) Creation of a regional power market;
(iii) Expansion of service availability to unserved rural and low-income populations;
(iv) Encouragement of private investment in hydro-power;
(v) Environment-friendly hydro-power development; and
(vi) Riparian rights.

(i) Optimal utilization of hydro-power resources

Only a modest amount of the abundant hydro-power in this region has been developed. Sri Lanka and Bangladesh have developed a substantial portion of their hydro-power potential. Nepal and Bhutan are now developing their abundant hydro-power resources, not only to meet domestic power requirements, but also to cater to the demands of the power markets of the neighboring countries.

The hydro-power-to-thermal generation ratio in the Indian power system has been gradually decreasing over the years, with the hydro-power share falling from about **40%** in 1970 to less than **25%** in 2001. Because of inadequate hydro capacity during the peak demand period, some of the thermal plants are required to operate as peaking plants while some of them are shut down during off-peak hours. This is believed to have the effect of decreasing plant load factor and subsequently raising the per-unit cost of the Indian power system. To overcome this structural shortcoming, the government policy on hydro-power development holds that India's hydro-power-to-thermal mix should be in the ratio of 40:60. The policy also recognizes that hydro-power stations are the best choice for meeting peak demand.

Peaking power shortage is common in the Indian power system, with energy shortages ranging from **1.9% - 9.8%** and peak demand shortages ranging from **8.1% - 19.8%**. A substantial increase of hydro-power capacity will be necessary to overcome this. The Hydro-power potential of the region can be effectively harnessed to meet this requirement of the Indian power market.

Quite a number of major hydro-power projects in the region, planned or otherwise, are multi-purpose in character in the sense that these projects can yield, apart from hydro-power, regulated flows of water that can benefit irrigation, flood control, and navigation. These additional benefits make such projects very much more attractive than they otherwise would be. However, the allocation of common costs to different benefits and the pricing of power and non-power benefits can become important issues. Most of the important rivers in the region are international in character and the presence of a major hydro-power project in the country that lies upstream can result in substantial power and other benefits to the countries that lie downstream. A way to share the costs and benefits of such development should be agreed on among affected countries if optimum development of the resource is to take place.

(ii) Creation of a regional power market

There is a great deal of complementarity in the energy sector in the SARI region, which is endowed with coal, gas, and hydro-power resources. India, Pakistan, Nepal, and Bhutan have high hydro-power potential. Bangladesh is extremely rich in gas resources. India has plenty of coal reserves. If an energy market within the region were to be developed, the countries would be able to reduce their dependency on petroleum imports, which would relieve stress on their foreign currency exchanges and on their balance of payments and ensure greater energy security for the region in general. Complementarities appear not only in diversity of resource endowments but also in the seasonal characteristics of the supply and demand of electric power, the geographical proximity of the demand centers, and the technological base of the electric power industry. All these factors can be usefully integrated.

With power sector reform under way in most of the countries of the region, there is a better opportunity than ever before for developing an integrated power system network and, eventually, a regional power market. This will not only facilitate power trading within the region but also help to improve the overall level of system reliability, efficiency, and security. An integrated system would also be of some benefit to the environment because of reduced consumption of fossil fuels.

A regional perspective on power markets and power sector development suggests that significant advantages can be found. Interconnection of the national power markets will expand overall market size and allow investors to better manage commercial and political risks. Interconnection will also promote the development of large-scale, regional projects, which lower supply costs. Interconnection also opens export opportunities for countries that hold a comparative advantage in hydro-power supply, supporting economic growth.

Over the past five decades, regional power associations that serve to integrate the power systems of neighboring countries have been formed in a number of places. Of particular relevance to the SARI region are the Southern African Power Pool (SAPP), the Nord Pool, and the Commission

of Regional Power Integration (CIER). A World Energy Council study has established that the potential savings from SAPP could be as much as U.S. $785 million (1992), which works out to about **20%** of total costs for the period 1995–2010. The economic benefits of cooperation in energy markets have recently been studied for the greater Mekong subregion (Cambodia, Laos, Myanmar, Thailand, Vietnam, Malaysia, and Singapore). The cumulative savings over the period 1997–2000 from cooperation is estimated to be U.S. $13.7 billion. It is clear that cooperation brings considerable and quantifiable economic benefits to participating countries.

Apart from these factors, energy cooperation can ease political tensions within a region, or at least help to confine disagreements to the negotiating table when they arise. Energy supply is regarded as a strategic matter of great importance. An integrated supply fosters economic cooperation, increasing the cost of conflict to the participants and therefore lessening the likelihood of aggression.

(iii) Expansion of service availability to unserved populations

In the SARI region, the alleviation of poverty is a major economic development priority. It is being increasingly recognized that supplying reliable, sustainable energy, particularly electricity, to poor rural households is critical. Power makes possible such services as steady lighting and motive power, making personal effort more productive and liberating time from subsistence chores. Women, especially, benefit when electricity is supplied. They spend less time in such laborious chores as gathering wood and pumping and carrying water, and have more time to participate in education and health and other social programs. Power supply is also important to the development of local markets. It provides motive power that assists both the rural and the urban poor to engage in more than subsistence activity, to generate some surplus and participate in markets.

Less than **25%** of the population of the SARI region has access to electricity. "The Four Borders Project: Reliability Improvement and power Transfer in South Asia – A Pre-Feasibility Study" conducted by Nexant for USAID-SARI/Energy identified the huge rural population and the economics of the SARI region as two main challenges to supplying rural areas with electricity. Some other challenging aspects include:

(iv) Dispersal of rural population in remote areas, making provision of centralized services difficult and costly;
(v) Relatively higher cost of decentralized technologies, such as solar photo-voltaic systems;
(vi) Higher transaction costs of providing services to rural areas; and
(vii) Inability of many poor rural people to afford electricity.

The study examined various rural energy practices used elsewhere in the region and highlighted some successful models:

(i) Bangladesh's rural electrification model is of a grid-connected rural electricity supply.
(ii) Sri Lanka and Nepal use micro-hydro-power, mini-grid systems to support an off-grid centralized electricity supply.

(iii) Bangladesh and Sri Lanka use a solar photo-voltaic system to support an off-grid decentralized electricity supply.

The study also emphasized the urgent need to expand electricity supplies to poor urban and rural communities in the region.

(iv) Encouraging private investment in hydro-power

Sufficient financial resources to develop the regional hydro-power resources in an environmentally sustainable manner must be found. In the past, substantial investment has come from bilateral and multilateral donor assistance; however, it cannot be assumed that this will continue, and in fact such assistance is on the decline.

Private investment is key to accelerating resource mobilization in the region, especially in the context of increasing Government budgetary burdens on the public sector and the declining availability of resources from bilateral and multilateral donors. The highly capital-intensive power sector, with high need for imported goods and equipment to stay current with advance technology, produces strong demand for foreign exchange. The can negatively affect public investment in human resource development and other infrastructure components that are less easily provided on a commercial basis. Private investment in power infrastructure can help relieve this constraint.

Private investment will also impose some financial discipline on the power sector. Competitive bidding processes and stronger institutional ability to appraise and negotiate proposals, for example, will both become very much more necessary if private investment is to be involved. Direct private investment in power distribution can also help to improve operating efficiencies though new distribution and metering technologies. These changes will lower the cost of power to the consumer as well as making power more reliable and accessible. The hydro-power development policies approved by the governments in the region offer incentives to the private sector and ways to attract private investors. However, market risk, currency depreciation risk, production risk, and foreign exchange risk are all relatively high, and appropriate risk-sharing arrangements, including public-private partnerships, have not been fully worked out.

(v) Environment-friendly power development

In increasing power supply to meet rising demand, from increasing population the countries of the region are experiencing some degradation of the environment. Fossil fuel is, and will continue for some decades to be, the predominant energy source; the main task to use it in an economically and environmentally satisfactory manner.

Excessive dependence on fossil-fuel-based generation, particularly coal-based generation, gives rise to concern in both host and neighboring countries about acid rain from sulphur and nitrous oxide emissions. Measures to mitigate these oxide emission effects can produce significant environmental benefits; however, such measures can increase capital costs by **10% - 20%** and operating costs by **5% - 10%** as experienced in the developed countries. Transferring these added costs to the consumer could lead to increased energy conservation because of increased

cost of electricity. Another concern is carbon dioxide emissions, which contribute considerably to global warming. More efficient use of fossil fuels and a change from coal to fuels lower in carbon can reduce emissions of carbon dioxide per unit of energy output. Another alternative is to use renewable energy sources, including hydro-power. Hydro-power development in Nepal and Bhutan could displace fossil-fuel-based generation in India. A 300 MW hydroproject generating 2,100 GWH in an average year could conceivably supply enough power to reduce carbon dioxide emissions by roughly 2.1 million tons per year. At a carbon offset value of US $20 per ton (or $5.45/ton of CO_2), this amounts to an offset value of roughly US $11.5 million.

However, hydro-power projects can also cause serious environmental and social problems; agricultural and forested land is usually inundated and people are displaced and must be resettled. The magnitude of the difficulties increases with the size of the project.

(vi) River Treaties

The large rivers in the region are international in character; any major development of the water resource in any country is likely to have both beneficial and adverse effects on the country or countries lying downstream. This fact alone should make the need for cooperation evident.

Major treaties for the development and sharing of river water have been signed between countries of the region in the recent past, including the Mahakali Treaty between India and Nepal and the Ganges Treaty between India and Bangladesh. The former has laid down a framework for the sharing of costs and benefits relating to the development of the Mahakali River, a boundary river; the latter offers a framework in which India and Bangladesh can share the water of the Ganges river during the dry season.

Implementation of the Mahakali Treaty has proved to be difficult. However, although more negotiation is needed, the existence of this Treaty and the Ganges Treaty indicate the seriousness of these countries' desire to resolve water-related problems amicably.

5.2 Barriers

Despite the evident benefits of regional hydro-power development, several barriers to full international cooperation exist.

The most important barrier is the lack of a deliberate policy that supports cooperation. Cooperation in hydro-power development is not a high-priority issue for the countries of the region. Insistence on the idea of self-sufficiency, low perceived benefits of cooperation, and absence of any established mechanism for cooperation can be considered the major factors responsible for the absence of a positive policy. Regional cooperation should not be viewed as simple trading in energy; it has the potential to bring about dynamic change in the availability, quality, and efficiency of energy supply and thereby to accelerate economic growth and reduce poverty. The quantifiable economic benefits derived by countries cooperating in regional power associations in various parts of the world amply demonstrate the benefits. Adoption of independent norms and standards in the planning and design of the power systems in the several

countries of the region present technical barriers to system integration. However, technologies are available to overcome these barriers, given the political will to act.

Institutional barriers have impeded the promotion of regional power exchange. Current leaders have failed to push forward the idea of power trading. There is an agreement between Nepal and India that provides for power trading between the two countries, but the agreement is yet to be ratified by the Nepalese Parliament. A similar agreement exists for power trading between India and Bhutan. Such agreements spell out procedural and legal aspects of cooperation and pave the way for joint development and utilization of power.

Commercial barriers (generation and transmission tariffs) limit the ability to identify and evaluate the real delivered cost of power. Power tariffs are most often dealt with on political rather than commercial terms. It would be better to have enabling agreements covering the sector as a whole while leaving individual agreements to commercially valid decision making. Tariffs should be based on a pricing policy that is both sound and sustainable. An unfortunate example of what happens when this is not the case can be seen in the fact that the losses of the state electricity boards of India rose at the rate of **16.7%** annually from 1992/93 to 1998/99 despite an annual increase in tariffs of **11.7%**. The Indian government is now endeavoring to structure tariffs to correspond with the cost of supply and balancing tariff disparities among diverse uses. Harmonization of pricing policy among all cooperating countries is essential to create an atmosphere that is conducive to sustainable energy cooperation.

Lack of finance has always been a constraint to energy development and utilization projects in the region. That lack lies behind the policy of promoting private investment, both domestic and foreign, that is a cardinal element in energy sector reform. Tariff rationalization through harmonization of pricing policies and better management of risk through public-private partnerships can contribute significantly to the mobilization of financial resources for regional projects.

6.1 Initiatives

The governments of the several countries of the region have introduced various domestic policies and regulations for the development of hydro-power resources (see the attached individual country report for details). These include promotion of private investment, establishment of regulatory agencies, and institutional restructuring. The government agencies intended to oversee and enforce these requirements have also been streamlined to some extent. However, there is some distance to go before the energy sector in the SARI region will be truly friendly to investment by the private sector.

(i) Licensing and techno-economic clearance

There should be a clear-cut mechanism for issuing a project license. There are various alternatives to be considered, including the use of a memorandum of understanding (MOU); or competitive bids could be taken. Final authority should be vested in a single agency, which should be well staffed and equipped. Application requirements for licenses and for techno-economic clearances should be clear and not over-elaborate. The application should enable the reviewing authority to judge whether the proposed project is sound, the costs and unit rates are rational, and the construction schedule is realistic.

(ii) Standard implementation agreement and power purchase agreement

To avert protracted negotiations with developers, there should be a standard implementation agreement and a standard power purchase agreement. A further provision of security for payment might be introduced to gain the confidence of private investors.

(iii) Acquisition of land and resettlement of displaced people

Hydro-power development requires acquisition of significant land and forest area and the displacement of those who live there. A major project with storage capacity often results in complex and difficult resettlement needs. Experience suggests that developers should be insulated from the problems arising out of resettlement efforts. Government should form a separate entity to address problems of land acquisition and resettlement. Project cost figures should include these costs.

(vi) Mitigating environmental impacts of hydro-power development

Hydro-power projects have adverse environmental impacts that vary depending on the nature and size of the project. These adverse effects should be carefully assessed and properly addressed in consultation with all stakeholders. Obtaining environmental clearance from the responsible authorities is a time-consuming process; unnecessary delay should be avoided. There should be a single agency that handles only environmental clearances when a hydro-power project is in preparation or under way.

(v) Single-window operation

It can be most useful to enable private developers to fulfill all the formalities--permits, licenses, clearances--connected with a project by working with only one authority or government agency. Such a mechanism exists in most of the countries of the region, but the operation of the mechanism is usually far from satisfactory and is a matter of concern to private developers. This should be corrected.

6.2 Regional Power Market

The region is likely to benefit greatly if a regional power market were created, but the complexity of the task is considerable. A gradual, step-by-step approach is the most pragmatic one, reducing the parties' risks while building mutual trust and confidence.

The sharing of information and technology could be a first step. There is an ample reserve of knowledge and expertise in the region, and this expertise could be made available to those interested through seminars, training programs, and so on.

The second step would be to promote cooperation in power supply, with common or unilateral sharing of spare capacity. National networks would be interconnected and operated in synchrony, but no meaningful power exchange would take place except when system disturbances occur. The networks would share spinning reserves and standby reserves. This will allow participating countries to improve the utilization of existing generation capacity, reducing spare capacity and coordinating maintenance schedules.

Short-term and long-term power exchange may be considered the next step. Power exchange helps to make the best use of the generating capacity in each country, taking into account the different production and demand characteristics of the cooperating networks. Each country would remain economically independent, but cooperation would be closer than before; operations are interdependent and must be coordinated.

The next logical step is power exchange with transfer of power and joint construction and operation of transmission lines. When the amount of power transferred from one network to another exceeds the capacity of existing interconnections, new interconnections become necessary. These new interconnections would be jointly planned, designed, funded, and constructed. Such cooperation should be beneficial to all the participating countries. The Nexant (2001) "Four Borders Project: Reliability Improvement and Power Transfer in South Asia – A Pre-Feasibility Study" under the USAID SARI/Energy initiative proposes such cooperation among Bangladesh, Bhutan, Nepal, and India. Several options have been assessed, with power transfer capability ranging from 50 MW to 500 MW, investment ranging from U.S. $9 million to U.S. $52 million, and operational schedules ranging from 5 to 10 years. It would be useful to supplement this work with some additional studies, such as short-circuit studies, stability studies, and reliability studies.

The final step would be power exchange with joint construction of power stations. It may be appropriate in the early stages to consider development of run-of-river projects, which are

relatively uncontroversial because the associated social and environmental problems are less than those of major hydro-power developments. Three run-of-river projects in the Arun river of Kosi Basin, with a total generation capacity of about 1,000 MW, may be worth considering in this connection. A recent meeting in New Delhi among officials of the governments of Nepal, Bhutan, India, and Bangladesh ended in an agreement to examine this option. The study, to be funded by the Asian Development Bank, is expected to be completed in one year.

6.3 Frameworks of Agreement

The Mahakali Treaty between Nepal and India and the Ganges Treaty between India and Bangladesh are significant landmarks in the history of bilateral cooperation between countries in the region. These treaties have resolved long-standing issues. Implementation of the Mahakali treaty is proving to be difficult because of several emerging issues, including some related to internalizing the externalities of development. Major hydro-power developments in Nepal, such as Karnali (Chisapani) (10,800 MW), Pancheswor under the Mahakali Treaty (6,480 MW), and West Seti (750 MW), are multi-purpose in character; they also involve significant submergence of land and forest, and considerable displacement and resettlement of people. These large projects, apart from generating substantial power and other benefits in Nepal, may also benefit countries that lie downstream by improving irrigation, flood control, and navigation and transport.

If major hydro-power projects with regional implications are to succeed, participating countries must take into consideration all these factors and arrive at an acceptable, sustainable arrangement for sharing water and power, evaluating benefits and difficulties, sharing benefits and costs, resolving pricing questions, and so on. Formulation of a general framework of agreement that addresses these issues can pave the way for cooperation among the participating countries in a manner satisfactory to all. Such a general framework will have to provide for the establishment of an appropriate regional institution. The existing SAARC Technical Committee on Energy could initiate the process.

Section 7 Conclusion

The region that includes Bangladesh, Bhutan, India, Nepal, and Sri Lanka has a very substantial hydro-power potential, but the degree of realization of that potential now is extremely low. When current projects are completed, hydro-power utilization is expected to increase from the present level of **13.2% - 20.3%** of the assessed potential. Some **98%** of regional hydro-power potential in the region lies in Bhutan, India, and Nepal; these countries have extensive plans for future development of hydro-power.

Power shortages, poor and inefficient power supply, low per capita power consumption, and inadequate access to electricity are some of the region's common features. Electricity shortages have constrained economic growth. There is now a general recognition of the need for power sector reform, and reform is under way, but at a very slow pace. Long-standing issues include how best to determine the optimal use of hydro-power resources, how to make power available to now-unserved communities, and how to ensure that questions of social and environmental effects inevitably raised by hydro-power projects will be resolved.

Although the countries of the region actively wish to promote private investment in hydro-power development, progress has not been encouraging. Improvements are needed in the processes of licensing and techno-economic clearance, and standard implementation and power purchase agreements have yet to be formulated. A regional power market offers immense benefits, but these can be realized only through sustained cooperation among the countries of the region; and much of this cooperation has yet to be built.

References

- Country reports of Bangladesh, Bhutan, India, Nepal and Sri Lanka
  - Regional Hydro-power Resource: Status of Development and Barriers, Bangladesh, Sept. 2002
  - Regional Hydro-power Resource: Status of Development and Barriers, Bhutan, Sept. 2002
  - Regional Hydro-power Resource: Status of Development and Barriers, Sept. 2002
  - Regional Hydro-power Resource: Status of Development and Barriers, Nepal, Sept. 2002
  - Regional Hydro-power Resource: Status of Development and Barriers, Sri Lanka, Sept. 2002

- Khatib H. and M. Munasinghe, "Electricity, The Environment and Sustainable World Development", World Energy Council, 15th Congress, Madrid, Sept. 1992.

- World Bank, "Nepal – Proposed Power Sector Development Strategy", Report No. 21912 – NEP, March 19, 2001.

- Nexant, "The Four Borders Project: Reliability Improvement and Power Transfer in South Asia – A Pre Feasibility Study ", prepared for USAID SARI/Energy, programme, Nov. 2001.

- World Bank 2000, " Energy and Development Report, 2000; Energy Services for the World's poor; Washington DC.

- Ahluwalia, Sanjeev S., " Power Tariff Reform in India ", Economic and Political Weekly, Sept. 16, 2000.

- Shah, Pranesh, "Sub-Regional Cooperation Potential for Power Exchange/ Trade in South Asia ", paper presented in the regional workshop on "Improving the Availability of Power in South Asia – Search for Optimal Technological Options", Dhaka, Bangladesh, 7-8 August, 1998.

- USA Energy Information Administration 2000, "Energy South Asia" Conference Kathmandu, March 6-8, 2000.

- Malla, S. K., "Energy Cooperation in South Asia " prepared for South Asia Centre for Policy Studies (SACEPS), IIDS, Kathmandu, Nepal, July 2003.

- Malla, S. K., "Regional Cooperation in the Energy Sector in South Asia – Nepal Perspective ", prepared for Centre for Policy Dialogue under CPD – CASAC Research Program, July 2003.