Chapter 2
PRESENT STATUS OF THE ELECTRICITY SECTOR AND TRADE

2.1 Electricity Sector Dimensions

The South Asian Region consists of low income developing economies, growing at a rapid rate. The GDP elasticity of electricity demand in such economies tends to be higher than 1 with electricity demand growing at rates faster than the economic growth rate. In addition, unlike in the case of Central Asian States, the extent of electrification, both in terms of geographical coverage and in terms of the population coverage has still a long way to go to reach 100%. Given the constraints relating to financial resource and institutional capacity, supply growth tends to lag behind the demand growth resulting in the operation of supply constrained electricity systems. While the per capita consumption of electricity is very low by world standards, electricity consumption for each dollar of GDP tends to be high.

In 2003, for example, the region had 23% of the world population, but produced only 2.1% of the world GDP. Its per capita Gross National Income at $524 was less than 10% of the world average ($5,552). The region produced only about 4% of the world's electricity, while the average annual electricity consumption per capita at 394 kWh was only one sixth of the world average (2,348 kWh) (see Table 2.1).

Table 2.1: South Asia- Select Economic and Energy Indicators

Country	Population (million)	Land Area ('000 Square km)	GDP ($billion) current	GNI per capita ($) current	Electricity Consumption at the Generation Level TWh (year)	Per capita annual electricity consumption (kWh)	Overall Energy use per capita (kgoe)
Afghanistan	30	652	4.6	n/a	1.59 (2005)	53	n/a
Bangladesh	137	144	51.9	400	21.14 (2004)	128	159
Bhutan	1	47	0.6	720	0.67 (FY04)	665	n/a
India	1064	3,287	600.6	540	540.74 (FY03)	425	520
Nepal	20	147	5.9	230	2.26 (FY03	68	336
Pakistan	148	796	82.4	520	76.66(FY04)	408	467
Sri Lanka	19	66	18.2	930	7.66 (2004)	325	421
Total SAR	1,425	5,139	764.2	524	650.72	457	474
Total World	6,290	133,941	36,835.2	5,552	15,852.41	2348	1734

Notes: (1) All data are from World Development Indicators for 2003 unless otherwise indicated. (2) Electricity consumption data are from country profiles. World consumption is from US DOE/EIA database. (3) Electricity consumption is given at the generation level (4) GNI per capita is on the basis of World Bank Atlas methodology.

The region had a total installed capacity of about 152 GW of which about 27% (or 41.6 GW) was hydroelectric subject to highly fluctuating seasonal and annual water flows. The availability of a substantial portion of the thermal power capacities was somewhat low on account of age of some of the units and problems arising from the use of poor quality coal with high ash and low calorific value. While Pakistan has been having some surplus capacity during the last few years, most other countries (and notably India) suffered from capacity and energy shortages arising from inadequate generation capacity, network problems, fuel related problems or lower than anticipated water flows in

hydropower facilities. The peak demand at 74% of the installed capacity is only partially indicative of the suppressed demand situation (see Table 2.2)

Table 2.2: South Asia- Select Indicators of Electricity Sector Dimensions

Country	Installed Generation Capacity (MW)	Peak Demand (MW)	Electricity Generation (GWh)	Imports and or Exports (GWh)	Past Annual Demand Growth Rate (%)	Forecast Annual Demand Growth Rate (%)	Access to Electricity
Afghanistan	Total 475 MW (of which hydro is 261 MW). Available capacity 270MW	215MW (Suppressed Demand) 363 MW (Unsuppressed demand estimate)	839 GWh	323 GWh import	n/a	6.6% through 2020	26% of the population
Bangladesh	Total 4120 MW (of which hydro 218 MW)	3,592 MW (FY 2005)	21,162 GWh (FY 2005)	None	9% (1996-2003)	About 8,2% per year through 2020	38% by area and 20% by population
Bhutan	Total 481 MW (of which hydro 469 MW)	105 MW (2003)	2,355 GWh (FY2005)	Imports 25GWh Exports 1764 GWh	7.3% (FY 19 98 to FY 2003)	11.5% through 2012	40% of the population
India	Total 124,287 MW (of which hydro 32,300 MW)	93,255MW (FY 2006) Actual Peak demand met: 81,792MW	617,510 GWh (FY 2006)	Imports 1764 GWh (Bhutan) Export 241 GWh (to Nepal)	4.2% during FY 2000 to FY 2004.	6.7% to 7.5% through 2032	55.8% of the households (Census of 2001)
Nepal	Total 684 MW (of which hydro 627 MW)	557 MW (FY 2005)	2,643 GWh (FY 2005)	Import 241 GWh Export 111 GWh	11% FY 1997-FY 2005	7.6% through FY 2020	40% of households (2001 census)
Pakistan	Total 19,505 MW of which hydro 6,500 MW	14,091 MW (FY 2005)	87,114 GWh (FY 2005)	Import 25 MW (from Iran)	About 5% (FY 1994-FY2003)	7.9% through 2025	55% to 60% of the population.
Sri Lanka	Total 2,426 MW of which hydro 1,247 MW	1,516 MW (2003)	7,662 GWh (2003)	None	5.1% 1999 to 2003	7.8% through 2024	73.4% of the population
Region	Total 151,978 MW of which hydro 41,622 MW	113,479 MW	739,285 GWh				

Note: (1) Source mostly country profiles and updated data from utility websites. (2) It is estimated by the CEA that India had a capacity shortage of 12.3% and energy shortage of 8.4% in FY 2006.(3) Since data may relate to different years for the member countries, the regional totals, while not accurate, is taken indicative of the order of magnitude. (4) Regional peak demand is an arithmetical total of the peak demand of the countries and thus may tend to overstate the peak demand.

Under the severely supply constrained situation, demand growth can only follow the growth in supply capacity. Within this limitation, demand for electricity at the generation level had been growing in the range of 5% to 11% during the last several years, but are expected to grow at a faster rate in the range of 6.6% to 11.5% in the next 15 to 20 years, if supply growth could keep pace. In most cases, this is based on GDP growth forecasts and the associated GDP elasticity of electricity demand.

To meet a demand growth of this order, substantial investments need to be made in generation, transmission and distribution facilities. The various options to increase the level of electricity supply include: (a) reduction of the high level of technical and non-technical losses in the power systems; (b) rehabilitation of the existing assets to restore their original capacity and prolong their useful lives; (c) increasing the transfer capacities in the national backbone transmission systems to enable better utilization of the existing generation capacities; and (d) construction of new generation assets. Imports from the countries within the region and from neighboring power and gas systems, had remained on the back burner largely on account of the pursuit of national self-sufficiency objectives till recently, but in the recent years are being discussed in the national and regional policy circles with some enthusiasm.

The energy resource endowments of the countries in the region and those of the region's neighbors in the east and the west would be a major set of determinants in the consideration of policy options based on intra and inter-regional trade and this aspect is addressed in the following section.

2.2 Resource Endowments

The energy resource endowments of the region and its neighbors are substantial, but are unevenly distributed among countries. This makes energy trade among them, prima facie, desirable for deriving optimum benefits from such a resource base. Readily available information on the energy resources of the region is summarized in Table 2.1

India and Pakistan have considerable energy resources by way of hydropower potential, coal, and natural gas, but are considered inadequate to meet the rapidly growing demand for the energy requirements of their large economies. Bhutan and Nepal have hydropower resources far in excess of the possible requirements of their modest power systems and economies and only a very small percentage of these resources have so far been developed. Investments in most of the identified large potential hydropower projects in Nepal (like, Karnauli, Pancheshwar, Sapta Koshi and West Seti) and Bhutan (like Tala and Punatsangchu) would make sense only in the context of export of power to India and possibly to Bangladesh (see Table 2.3).

Bangladesh is widely believed to have very substantial natural gas reserves. Recent studies by US Geological Survey concluded that the country has undiscovered reserves of 935 bcm (32.1 tcf) and that on this basis has a reserves-to-production ratio of over 104 years. The country may thus have a notable potential for export of gas or export of power generated using the gas.

Table 2.3: Energy Resource Endowments of the Region

Country	Oil Reserves (Mt)	Oil Production (Mt/y)	Gas Reserves (bcm)	Gas Production (bcm/y)	Coal Reserves (Gt)	Coal Production Mt/y)	Hydro Power Potential (MW)	Hydro Power Developed (MW)
Afghanistan	10-15/100	0.025	28.3/142	0.114	0.1	0.044	745	262
Bangladesh	7.8	0.340	580/810	13.8	2.2	n/a	755	230
Bhutan	0	0	0	0	0	0	23,760/ 30,000	468
India	786 (2005)	33.000	948	32.680	25/285	409.000	84000/ 150,000	32,300
Nepal	0	0	0	0	modest	0	43,000/ 83,000	600
Pakistan	105	3.100	1300/5700	28.000	185	3.300	54,000	6,500
Sri Lanka	14-18	0	0	0	0	0	9,100	1,250

Note: (1) Under Oil and Gas reserves, proven / probable reserves are shown where available. Under hydro, economically viable potentials / technical potential are shown. (2) Production data relates to the most recent year data available during 2003-2005. (3) With the commissioning of all units of Tala hydropower project, hydro capacity developed in Bhutan will soon be 1,488 MW in 2006. Coal data includes lignite.

The energy resource endowments of the neighbors of the region, Myanmar, in the east and the Central Asian Republics and Iran in the west are summarized in Table 2.4. Myanmar and three Central Asian Republics (Kazakhstan, Turkmenistan, and Uzbekistan) as well as Iran have notable gas or (gas or coal based power) export potential, while two Central Asian Republics (Tajikistan and Kyrgyz Republic) have substantial hydropower export potential.

Kazakhstan, Kyrgyz Republic, Tajikistan and Uzbekistan which constitute the Central Asian Power System have a combined generation capacity of 38,000 MW and annual generation in excess of 135 TWh. Their present surplus generation is of the order of 11 TWh occurring mostly in the spring and summer seasons. This annual exportable surplus could increase to 30 TWh in next five years and to 50 TWh in the next ten years if the envisaged investment program is implemented.[9] About 20% of this would be available in all seasons of the year.

Turkmenistan has an installed generation capacity of 3000 MW and annual generation of 12.3 TWh, of which it exported 10.5% to Iran, Turkey and Afghanistan. Iran's own generating capacity is about 34,000 MW with an annual generation in excess of 149 TWh. Its power system operates in the form of three isolated power systems which are to be interconnected in the near future. In 2005, Myanmar had a total installed generation capacity of 1,667 MW and annual generation of 6,064 GWh. Its main interest is in finding export markets for its abundant natural gas resources as well as for

[9] Central Asian Republics: Regional Exports Potential Study, World Bank, December 2004

hydroelectricity from 10,398 MW of hydropower projects which are either under development or will be developed during the next 15 years.[10]

Table 2.4: Energy Resource Endowment of the Region's Neighboring Countries

Country	Oil	Natural Gas	Coal	Hydro Power
Kazakhstan	Reserves: 29 billion bbl Production:1.3 million bbl/day	Reserves: 65 to 70 Trillion Cubic feet (tcf) Production: 0.570 tcf/yr	Reserves: 37.5 billion tons Production: 95 million tons (2004)	Potential: 20,000 MW Developed: 2000 MW
Turkmenistan	Reserves: 546 million bbl. Production: 260,000 bbl/day	Reserves: 71 tcf Production: 2.1 tcf/year	Modest or negligible	Potential: Modest
Uzbekistan	Reserves: 594 million bbl. [11] Production: 150,000 bbl/day	Reserves: 66.2 tcf Production: 2.07 tcf/year	Reserves: 4 billion tons Production: 2.8 million tons	Potential: Modest Developed: 1700 MW
Tajikistan	Modest or negligible endowment	Modest or negligible Endowment	Reserves: 3.6 billion tons Production: 32,000 tons (2002)	Potential: 40,000 MW Developed 4000 MW
Kyrgyz Republic	Modest or negligible endowment	Modest or negligible Endowment	Reserves: 0.8 billion tons Production: 400,000 tons (2003)	Potential: 26,000 MW Developed: 3000 MW
Iran	Reserves:132.5 billion bbl Production: 4.2million bbl/ Day	Reserves: 971 tcf Production: 3.5 tcf/year	Reserves: 461million tons Production: 1.1 million to tons	Potential: 42,000 MW Developed : 2, 000 MW
Myanmar	Reserves: 3.2 billion bbl Production: 7.3 million bbl (During 11 months of 2005--2006)	Reserves: 18 tcf Probable: 89.7 tcf Production: 362 bcf (10.53 bcm) Exports: 0.28 tcf (8.06 bcm) (During 11 months of 2005--2006)	Reserves: Modest Production: Modest	Potential: 39,720 MW Developed: 747 MW

Source: World Bank documents and US DOE/EIA Country Briefs

The nature of supply-demand situation in the region and the distribution of energy resources in the region and its neighboring countries, prima facie seem to warrant consideration of electricity trade (both intra regional and inter regional) as one of the options to enhance energy security of the countries in the region.

2.3 Existing Interconnections and Electricity Trade

All over the world, interconnection of contiguous electricity grids (with adequate transfer capacity) and electricity trade among them are regarded as enhancing the energy security of the consumers, as they provide for a diversification of energy sources and energy suppliers. Equally, sole or substantial dependence on such imports is regarded as diluting

[10] See presentation made on behalf of Myanmar in the BIMSTEC conference in New Delhi, India during 30-31 October 2006. See also News Item 'Myanmar, Russia, India to explore gas in Myanmar' in People's Daily Online- http://english.people.com.cn/

[11] An Australian company exploring the Fergana valley area in Uzbekistan believes that area itself may have reserves of 1.2 billion barrels of oil and 5.5 tcf of gas.

energy security, because of the possibility of supply disruptions. Such interconnections generally lead to several other substantial benefits (see Box 2.1).

A well known example of this worldwide trend of interconnecting contiguous electricity systems and enabling their integrated operation through suitable agreements is the Union for the Coordination of the Transmission of Electricity (UCTE) in Europe, which covers most of the grids of the countries in West Europe. Many of the East European countries have also recently joined the UCTE and many others are working towards such membership. In 2004 international exchanges in electricity within UCTE were about 300 TWh. Other notable examples include New Jersey-Delaware-Maryland Power Pool, South African Power Pool, West African Power Pool, Nordic Power Pool and the Interconnected Electricity Systems of the Six Central American Countries (SIEPAC). In the South East Asia, electricity interconnections exist and electricity trade takes place among Thailand, Laos, Cambodia, Viet Nam and the southern provinces of China.

Box 2.1: Benefits of Interconnected and Integrated operation of Electricity Grids

Apart from enabling the sale of electricity from the surplus to the deficit grids, interconnections and integrated operations[12] of the grids help to:

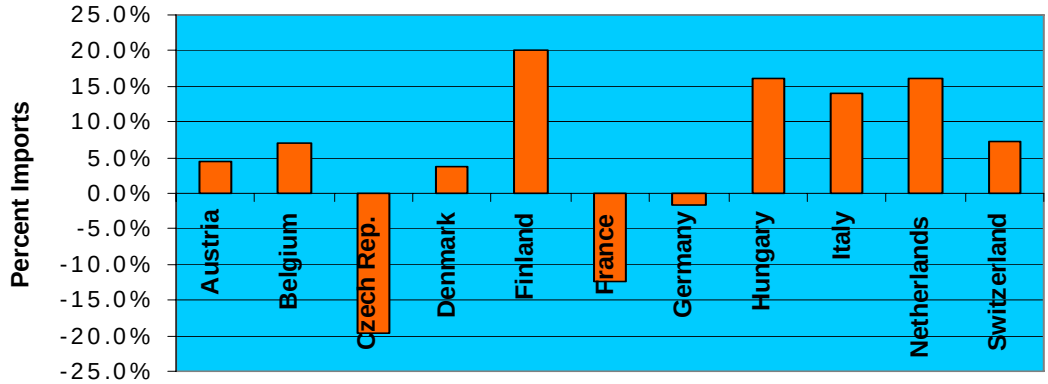
- Exploit differences in resource endowments and their development and operating costs
- Exploit differences in seasonal load and supply patterns
- Pooling of uncertainties: as demand and supply vary stochastically, the larger the system the smaller the fluctuations arising from imbalance (based on the Law of Averages). Thus it helps to improve the reliability of the system (and the load following capability) at a lower cost by ensuring a better balance between hydropower and thermal power units, and among base load, intermediate load and peak load units
- Lower the system capital costs by lowering the reserve margins for the given level of system reliability
- Lower the system operating costs by enabling the substitution of generation from units with high marginal costs of one grid by generation from units in other grids with lower marginal costs
- Lower emission levels by enabling substitution of generation from units with a high level of emissions/kWh of one grid with generation from units in the other grids with a much lower level of emission/kWh
- Enable the construction of large hydropower projects, which would make better economic sense in such interconnected grids and the larger markets they provide, than in the smaller individual grids.
- Enable less expensive peak load management, especially when the interconnected grids are located in different time zones with different peak hours.

In Appendix 1 details of the examples of such interconnections and energy trading projects are given. As an example the level of exports and imports in the European electricity market and in the South African Pool are given below. Figure 2.1 indicates the net annual imports or exports of select European countries as a percentage of their total available power for consumption. It may be seen that several countries have net imports amounting to 10% to 20% of their total consumption. France and Czech Republic export 10 to 20% of their available power. This data represent only the net annual exchange,

[12] Many of these benefits would accrue only in the case of synchronized and integrated operation of the interconnected grids. This involves the use of common grid codes and common rules of use and procedures designed to optimize the system operation and maximize benefits for the system participants.

while the actual exchanges during several parts of the day and the year are substantially higher.

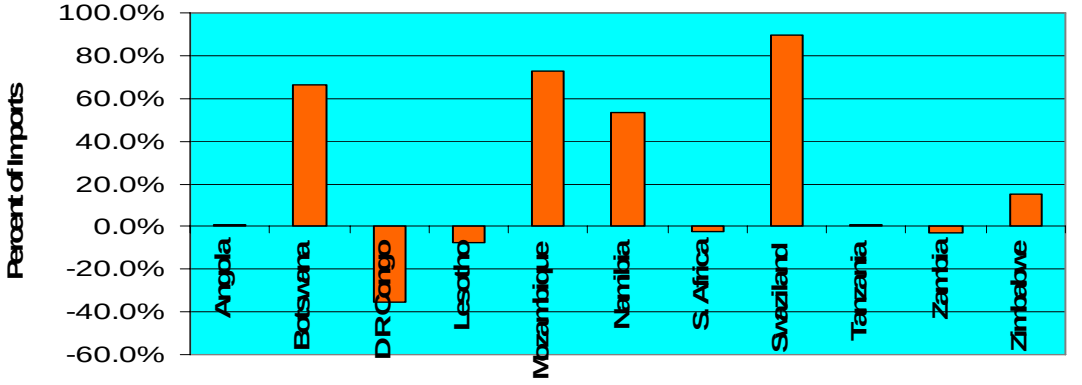
Figure 2.1: Selected European Countries (2005)
Imports (+)/Exports (-) as a Percentage of Available Energy



Source:

Figure 2.2 provides similar data is respect of the South African Power Pool. Even under economic and political circumstances very different from that of Europe, electricity trade is flourishing in this part of the world with some member countries making use of imports to the extent of 50% to 80% of their total annual requirements.

Figure 2.2: South Africa Power Pool (2004)
Imports (+)/Exports (-) as a Percentage of Available Energy



Source:

Compared to such wide reliance on electricity trade in the various parts of the world, such trade in the South Asian region had so far been modest. The details of the existing interconnections and electricity trade are discussed below.

Afghanistan: The war ravaged and fragmented power systems of Afghanistan rely significantly on imports of electricity from Iran, Turkmenistan, Uzbekistan and Tajikistan. In 2005 such imports amounted to about 27.8% of the total supply, and this

share is expected to increase with the rehabilitation of the associated transmission links and the construction of the country's backbone transmission system called North- East Transmission System (NETS). The details of the existing interconnections and the volume of power imports are summarized in Table 2.5.

Table 2.5: Afghanistan: Existing Electricity Interconnections and Imports

Electricity Interconnection Details	Electricity Imports (GWh)		
	FY 2004-05	FY 2005-06	FY 2006-07 (3 months only)
Tajikistan: Geran (Tajikistan) to Kunduz (Afghan) 110 kV single circuit line, operated at 35 kV on the Afghan side	28.99	39.22	23.33
Uzbekistan: Termez (Uzbek) to Khulum (Afghan) and on to Mazar-e-sharif 220 kV line double circuit operated at 110 kV	118.18	149.71	24.18
Turkmenistan: Gushby (Turkmenistan) to Herat (Afghanistan), 120 km, 220 kV single circuit line completed in May 2004, but operated at 110 kV	49.27	95.63	35.39
Turkmenistan: Turkmenistan to Andkhoy-Jawzjan-Sheberghan, 110kV line in poor condition with high voltage drops	48.57	69.72	12.28
Iran: Torbat-e-jam (Iran) to Herat (Afghanistan) 150 km 132 kV double circuit line commissioned in January 2005. Financed by Iran Iran: Tayyebat (Iran) to Herat 2 x 20 kV single circuit lines. Financed by Iran	26.72	57.85	21.48
Iran: Zabol (Iran) to Zaranj (Afghanistan) 20 kV single circuit opened in March 2004	11.55	17.99	9.52
Total Imports	283.28	430.12	126.18

Source: DABM data

Notes: (1) The Fiscal year of Afghanistan ends on March 20. (2) According to the statistics of the Central Dispatch Center of the Central Asian Power System in Tashkent the exports of Uzbekistan to Afghanistan were 33.5 GWh, 129.6 GWh and 148 GWh in the calendar years of 2003, 2004 and 2005. (3) The Tajik power utility reports exports of 10.4 GWh, 27.7 GWh and 39.2 GWh during the calendar years 2003-2005 respectively. In the first 6 months of 2006 the exports amounted to 23.3 GWh.

Bhutan: The eastern part of Bhutan is linked to Bongaigon and Rongia of the State of Assam in India by 66 kV and 33kV lines and the western part of Bhutan is linked to Siliguri in West Bengal State of India by a 220 kV line. Through these lines Bhutan exports a substantial portion of the outputs from the hydropower station at Chuka (336 MW), Kurichu (60 MW) and Basochu (64MW). The export amounted to 1,764 GWh in FY 2006. Through 11 kV and 33 kV interconnections Bhutan imports about 25 GWh a year from India. A large new hydropower project (Tala 1020 MW) has been completed recently and the first unit of 170 MW had become operational.[13] When all the remaining five units are commissioned during FY 2007, the project will generate 4,865 GWh of energy each year of which 3,900 MW is destined for exports to India. Two double circuit 220 kV lines connect the power station to Siliguri in West Bengal State from where the construction of a 400 kV double circuit line (1200 km long, 3000 MW transfer capacity) has been completed in August 2006 by Powerlinks Transmission Limited, a Joint Venture between Tata Power and Power Grid Corporation of India (51:49), inter alia, to

[13] Chuka, Kurichu and Tala hydropower projects were financed by the Government of India with 60% of the cost as grant and 40% as long term debt.

transfer Tala power to the Eastern and Northern regions of the Indian power system. This will result in the annual export of Bhutan to India rising to about 5,664 GWh in FY 2007.[14]

Nepal: Nepal's power system is interconnected with the power systems of the states of Uttar Pradesh and Bihar in India by one 132 kV line, eleven 33 kV lines and one 11 kV line. Most of them have limited transfer capacity and, in FY 2005, Nepal exported to India a total of 110.7 GWh (or about 5.6% of its total sales) and imported from India a total of 241.39 GWh (or about 9% of its total energy supply).

Pakistan: Pakistan's electricity imports from Iran serve demand in the country's border areas of Balochistan, which are isolated from the main integrated national electricity grid. The cross-border interconnections comprise a 132-kV single circuit line and two 20-kV lines. The maximum allowed supply as per contract of 2002 was 39 MW. Maximum actual import recorded was 25 MW in December 2005. In June 2006, Pakistan's main power utility, WAPDA, signed an MOU with Iranian authorities for increasing the supply maximum to 100 MW to meet the forecast increase in demand in the Gwadar area where a deep sea port is being constructed with Chinese assistance. For this purpose a new 170-km long 230-kV line is planned to be built by Iran (70 km) and Pakistan (100 km).[15]

The power systems of Bangladesh and Sri Lanka have no cross border power interconnections. Similarly Pakistan's power system is not interconnected to those of India or Afghanistan. There are also no cross border gas pipelines in the region.

[14] See Pricewaterhouse Coopers of India, *Hydropower Sector Study: Opportunities and Strategic Options*, July 2006 and also the presentation by Powerlinks Transmission Limited in the India Electricity-2006 Conference (Plenary Session III- Transmission), New Delhi on May 12, 2006.

[15] Presentation made by WAPDA in the Central Asia/South Asia Electricity Trade Conference, May 8-9, 2006 in Islamabad. See also www.gulf-times.com, news item dated 15 June 2006 which among other things indicates that the price agreed for new supplies may have gone up to 6.25 cents/kWh. For the existing supply the price is 5 cents/kWh.