Private Sector Hydropower Development Project – 2

Nepal-India Transmission Line Link to Facilitate Power Trade

December 2006

Submitted by

International Resources Group Ltd.
1211 Connecticut Avenue, NW, Suite 700
Washington, DC 20036 USA

IRG/Nepal
DOED Building, Anam Nagar
Kathmandu, Nepal

under

USAID/GON – SO6 Increased Private Sector Participation in
Environmentally and Socially Sustainable Hydropower Development
Contract No. 367-C-00-02-00011-00

Table of Contents

List of Tables

List of Figures

ACRONYMS AND ABBREVIATIONS

ABT	Availability Based Tariff
ADB	Asian Development Bank
BOOT	Build, Own, Operate, Transfer
BPC	Butwal Power Company
CERC	Central Electricity Regulatory Commission
DOED	Department of Electricity Development
ED	Electricity Department
ETFC	Electricity Tariff Fixation Commission
FBR	Four Border Interconnection Report
GDA	Global Development Assistance
GOI	Government of India
GON	Government of Nepal
GWh	Gigawatthour
HVDC	High Voltage Direct Current
INPS	Integrated Nepali Power System
IRG	International Resources Group
IPP	Independent Power Producer
IPPAN	Independent Power Producer's Association of Nepal
kV	kilovolt
kWh	kilowatthour
MOP	Ministry of Power
MOWR	Ministry of Water Resources
MW	Megawatt
NERC	Nepal Electricity Regulatory Commission
NEA	Nepal Electricity Authority
PDR	People's Democratic Republic
PSHDP-2	Private Sector Hydropower Development Project
PowerGrid	Power Grid Corporation of India
PPA	Power Purchase Agreement
PROR	Peaking Run-of-River
PTC	PTC India Ltd
REB	Regional Electricity Board
RLDC	Regional Load Dispatch Center
ROR	Run-of-River
SCADA	Supervisory Control and Data Acquisition
SEB	State Electricity Board
SERC	State Electricity Regulatory Commissions
SLDC	State Load Dispatch Center
SARI/E	South Asia Regional Initiative/Energy
USAID/N	United States Agency for International Development /Nepal
WB	World Bank

EXECUTIVE SUMMARY

Nepal's Hydro Power

Of the immense hydropower potential in Nepal, projects totaling approximately 23,000 MW have been studied by domestic and international agencies over the last three decades. Only 551 MW of hydro has been developed to date with 403 MW and 148 MW respectively owned and operated by the Nepal Electricity Authority (NEA) and by independent power producers (IPPs). For the last 20 years every Nepalese government, political party, bureaucrat, and multilateral and bilateral donor agencies have touted the benefits of hydropower and committed to its development as the major under-developed resource which could transform Nepal's socio-economic landscape. Based on the significant and meteoric growth of the gross national product (GNP) of Bhutan and Lao People's Democratic Republic (PDR) solely by means of hydropower export to neighboring countries, it is clear that the potential for Nepal's transformation to a viable and vibrant economy by exporting some of its hydropower resources can become a reality in a short time.

The NEA, a government-owned utility, is the dominant player in Nepal's power sector serving approximately 1.2 million customers. The NEA's power generation comprises primarily run-of-river (ROR) hydropower projects whose generation is dependent on available river flows and hence, not well suited to meet system peak demands. Only the 60 MW Kulekhani I project has seasonal storage capacity. With the 32 MW Kulekhani II operating in tandem, these two projects provide the only significant peaking hydro capability to meet the system's peak demand of 558 MW (Dec 2005). The NEA sold approximately 2,060 million kilowatt hours or 2,060 gigawatt hours (GWh) of energy in 2005-06. In the absence of storage projects, it is estimated that approximately 500 GWh of energy (approximately 25 percent of NEA's sales) could not be generated by NEA and IPP plants during high river flows because of a lack domestic demand, and a lack of transmission line interconnection for export of this energy to India.

During its dry season (Oct-May) evening peaks, Nepal experiences significant (greater than 100 MW) power deficit because of low water flow in the rivers and the inability to import energy from India because of a lack of transmission interconnections.

Nepal - India Transmission System

The backbone of NEA's transmission system is a 132 kV overhead line running east to west through the Terai and connecting 15 major substations throughout the country. The NEA's transmission system has developed over the years to meet the need to evacuate power from individual power projects. There has been a lack of investment for long-term grid strengthening and planned expansion.

The power system in India is the fourth largest in the world having an installed capacity of about 127,000 MW and 280,000 circuit kilometers of high voltage (132 kV and higher) transmission network. India is in the process of interconnecting its five regional transmission systems to form a national transmission grid with a power transfer capacity of 37,000 MW by 2012 from one region to the other and to facilitate imports from neighboring countries.

There are three existing 132 kV radial (intermittent) interconnections between Nepal and India and 21 other interconnections at lower voltage levels. However, there is no continuous (permanent) interconnection between the two systems.

Nepal's Power Trade with India

India experienced a significant energy deficit of approximately 52,000 GWh and a peaking power deficit of 12,000 MW in 2006. The deficit will continue to grow even with the 70,000 MW generating capacity planned to be added by 2012. If the deficit situation continues, power shortages, poor quality power supply (voltage fluctuations), and frequent load shedding threaten to undermine India's industrial competitiveness posing severe constraints on its social and economic development.

The PTC India Ltd (PTC) is the nodal Indian agency for cross border power trade with Bhutan and Nepal. The PTC has initialed a contract with the Snowy Mountain Engineering Corporation, an IPP, to purchase power from the proposed 750 MW West Seti project located in the north west of Nepal. The PTC has consistently stated that it will also purchase surplus energy available during the wet season (April-October) from Nepal. In fact, the PTC and the NEA are in advanced discussions for such trade. Given the shortages of power in India, hydro power exports from Nepal will have a long-term market in India.

The Independent Power Producer's Association of Nepal (IPPAN) believes that power trade options with India are increasingly attractive providing an impetus for further IPP investment Nepal. The Power Summit 2006 (www.ippan.org.np) jointly organized by the PTC and IPPAN in September 2006 underscored the enormous interest of entrepreneurs, industrialists, and industry organizations in India to develop Nepal's hydropower for domestic and export markets.

Currently, there are a few privately-owned transmission lines connecting IPP plants to the Indian grid. The Indian Electricity Act of 2003 assures open access on the transmission system for other market players – power traders and bulk consumers. The Nepalese Electricity Act of 1992 in Nepal and related NEA Act allow NEA to wheel power from the IPPs for delivery to third parties. No significant legal or regulatory obstacles hinder the development of a privately financed and operated transmission link between Nepal and India.

Need for a transmission line study

In 2001, US Agency for International Development (USAID), through its South Asia Regional Initiative for Energy Cooperation and Development (SARI/E) prepared a report, titled Four Borders Interconnection Report (FBR), to identify an optimum location for an interconnection of the grids of Bangladesh, Bhutan, India, and Nepal to facilitate regional energy linkages. The report identified a location at the "chicken neck" to the south east of Nepal where the four countries are the closest.

India will be the biggest and probably the only importer of large quantity of energy from its neighbors for some time to come. The Government of India (GOI) has stated publicly that its energy policy with its neighbors will be conducted on a bi-lateral basis and that it does not support the FBR as a model for electricity trade and hence, a major regional interconnection is not likely to be implemented in the near-future.

The chicken-neck location does not offer any advantage for Nepal's power export. In fact, Nepal's eastern region has a power deficit which is met partly from imports from India's eastern region which has an energy surplus. Major deficit areas in India lie to the south and west of Nepal. Available surplus energy from Nepal can be transferred more effectively to India from the southern part of NEA's system. To address this specific issue, USAID authorized International Resources Group (IRG), its implementing partner fro the Nepal's Private Sector Hydropower Development Project 2 (PSHDP-2), to carry out a study to identify the best location for a transmission link between India and Nepal, the capacity of such a link, and to make to recommendation on how to proceed with the implementation of such a project thorough a Build, Own Operate, Transfer (BOOT), Global Development Alliance (GDA), or other feasible mechanisms.

Transmission Line Study Objective

The purpose of the study is to identify transmission line link(s) that may be feasible now or in the immediate future to initiate a sustainable commercial power trade between Nepal and India by maximizing benefits from existing and planned small and large projects with installed capacities less than 500 MW. The study would provide a model for increased, long-term private sector involvement in generation, transmission, and cross-border power trade to match energy surpluses and deficits in Nepal and India. The study specifically would exclude consideration of large export projects such as the West Seti with dedicated transmission lines to India.

Study Approach

Nepal must break its traditional approach of project-specific transmission line development for domestic needs through visionary emphasis of large scale development of its vast hydropower resources for export. It needs to strengthen and expand its existing transmission grid on the basis of a “build and it will get used” philosophy and the oft-proven self-generated traffic because of the availability of a transmission link. It is timely for Nepal to embark on an interconnection with India to take advantage of the opportunity presented by Indian market development for power export as well as to address Nepal’s short-term import needs.

The enactment of an availability-based-tariff (ABT) and the use of system frequency support in power trading in India provide a significant opportunity for Nepal to sell to the Indian market at attractive price. An established trading mechanism and an opportunity to trade will provide private sector developers with incentives to optimize their plant development to better harness the rivers’ potential instead of the current practice of sub-optimal water basin development based solely on NEA’s power needs and transmission system constraints.

Generation Expansion and Quantum of Export Energy

The NEA’s current (2006) generation expansion calls for an installed capacity of over 1,600 MW by 2014 with all additions coming as new run-of-river hydro projects to meet domestic power needs. During the wet season (April-October), when NEA’s system demand is low, significant surplus energy in excess of 3,600 GWh with an annual value of $140 million in current dollars is expected to be available.

The planned generation expansion will require an investment commitment of over $2 billion in the next 6-7 years through major international assistance and private investment. The NEA is rightly concerned that such investment may be difficult to come by, resulting in significant reduction in export potential as well as major shortages to meet domestic demand. IRG believes investment for major projects will most likely come from the private sector, public-private partnerships, bilateral agreements with India, and the international community but will depend on Nepal’s commitment and ability to export power successfully over the next several years. In our opinion, Nepal must demonstrate to the private sector, international donors, and other investors its commitment to provide an environment conducive for such investment through implementation of the needed regulatory reform and initiate construction of a first commercial export project in the next 1-2 years.

System interconnection capacity and system stability

In accordance with the terms of reference, IRG analyzed a number of scenarios to provide for a capacity to commercially export approximately 100 MW in 2010 and 500 MW in 2016. Exporting power in excess of 500 MW after 2016 would require substantial increase in Nepal's generation capacity and grid expansion, well above the level planned by the NEA.

A key technical decision that needs to be resolved early on in the design process relates to whether to connect the Nepali and Indian systems synchronously or asynchronously. The two national systems operate at a nominal frequency of 50 Hz and hence, a synchronous connection would be the simplest and the least cost method, if feasible. Unfortunately, there is a considerable difference in the frequency at which the two systems are currently operated. This difference in operational frequency would likely lead to major issues of system instability, power flows, and fault transfers if the two systems are connected synchronously. Asynchronous connection would involve connecting the two systems through back-to-back high voltage direct current (HVDC) stations, which would facilitate operating the two systems independently without regard to the difference in operational frequencies. In either case, the candidate voltages for transmission links between the two countries would be at 220 kV and 400 kV because these voltage levels are used extensively in India.

Interconnection links between Nepal and India

The existing Mahendranagar - Tanakpur transmission link in the extreme west and the Duhabi - Kataiya transmission link in the east of the country are both used primarily for importing power from India. No significant potential to export through these connections exist. The existing Bardghat - Gandak - Ramnagar link in the central area is attractive for only up to 100 MW power transfer and hence, not considered further in our study. This interconnection may be considered as an alternative for potential supplemental interconnection needs.

The Power Grid Corporation of India (PowerGrid) and the NEA had studied a 132 kV transmission link in the east from Anarmani in Nepal to Siliguri in India, following from the FBR report. The connection would serve the purpose of import from India to supply Nepal's deficit east but would not be of immediate value as export line. IRG studied four interconnection options - Butwal/Gorakhpur, Dhalkebar/Muzaffarpur, Parwanipur/Muzaffarpur, and Duhabi/Purnea with several sub-options to assess phased development of an interconnection, primarily from power export point of view. The Butwal - Gorakhpur and Dhalkebar - Muzaffarpur options were found to be the most suitable at this time. Both the transmission links were found to be technically feasible. Both the options will have no significant adverse impact on the environment and are estimated to have comparable development costs.

Price of Energy Sales to India

The price offered for Nepal's surplus energy will be based on the alternative energy cost to the Indian system which varies during the day from $0.022 (Indian rupee INR1) to $0.11 (INR5) per kWh for stabilizing system frequency. IRG estimates, conservatively, that

Nepal's surplus energy would command an average price of about $0.04 (INR1.8) per kWh, provided a workable trading norm is established in Nepal to increase the confidence of the Indian buyer on the quality, quantity, and availability of energy exports.

Cost of Surplus Energy Purchase in Nepal and Wheeling Charges

IRG's discussions with Nepali IPPs indicate that they would be willing to sell the excess energy, which has currently no market in Nepal and unlikely to have any for a long time, for a nominal $0.015 (Nepali rupee NR1 or INR0.7) per kWh. This price is about 33 percent of the off-peak price currently paid by the NEA. The NEA will be willing to sell its surplus energy at a nominal price of $0.005/kWh. In addition, based on NEA's reported transmission costs, IRG has assumed that the NEA would levy a wheeling charge of $0.005/kWh for all exported energy.

Preferred Option

Connecting the two countries synchronously through the Dhalkebar - Muzaffarpur link, in two phases, would be the preferred option. This interconnection link would dove-tail with NEA's proposed Khimti - Dhalkebar 220 kV line which fits well with the proposed development of the 309 MW Upper Tamakoshi project. The Dhalkebar - Muzaffarpur option is close to a number of proposed/planned IPP projects and also has the advantage of consolidated development of Nepal's grid (Map ES-1). The 138 km Dhalkebar - Muzaffarpur option would allow future exports up to 800 MW with no significant additional investment. The Butwal - Gorakhpur link would have a restricted capacity of 420 MW for export without significant grid strengthening.

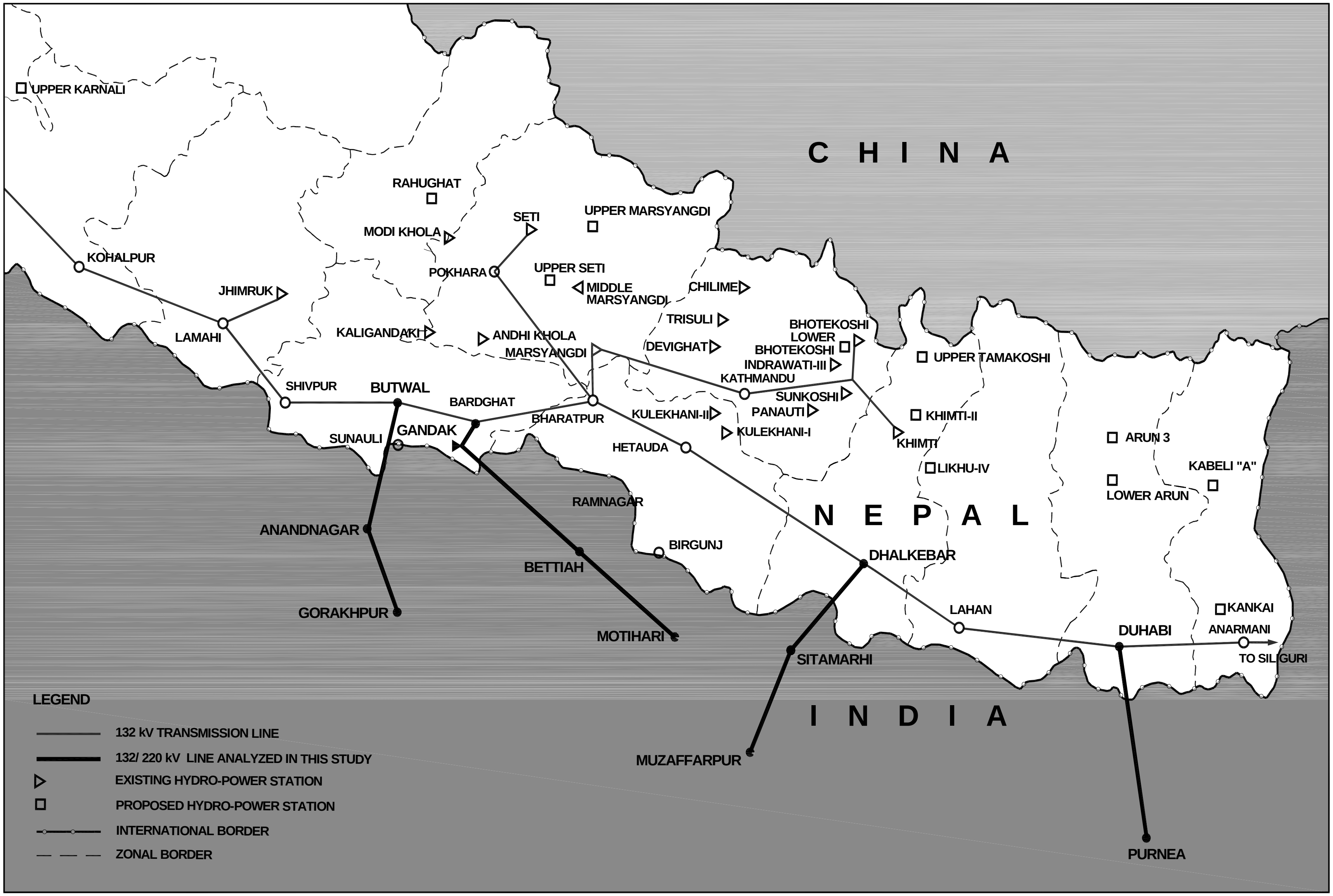
A two-phase development of the synchronous Dhalkebar - Muzaffarpur transmission link is estimated to cost approximately $52.4 million. This estimate does not include the cost for possible remedial actions to be taken to make the synchronous connection feasible. Detailed system studies will be needed to determine these costs which are likely to be lower than the cost of asynchronous connection. Such system studies are outside the scope of IRG's current study. Using a set of typical financial parameters, IRG found this option to have a benefit cost ratio (B/C) of 2.2. The Butwal - Gorakhpur link is also considered viable with a B/C ratio of 2.0.

Results of Financial Analysis

Table below shows the results of the financial analysis for the two final options considered:

Description	**Dhalkebar-Muzaffarpur 220 kV link**	**Butwal-Gorakhpur 132/220 kV link**
Synchronous connection (base case)		
Total cost	$52.4 million	$55.6 million
B/C ratio	2.2	2.0
IRR (NPV)	26.1%	25.4%

B/C – Benefit/cost; IRR – Internal rate of return; NPV- net present value



Map ES-1: Major Transmission Lines & Generating Plants (Existing & Proposed by 2016)

Budgetary prices received from leading manufacturers of HVDC equipment were used to estimate cost of asynchronous connections. These equipment costs average approximately $200,000 per MW of capacity. It is expected that unit prices will likely reduce in the future. An asynchronous interconnection is estimated to cost $152.4 million and the Dhalkebar – Muzaffarpur link would be marginally attractive with a B/C ratio of 1. 5. In our opinion, the cost for an asynchronous interconnection may deter private and public-private partnership investments for a maiden venture at this time, without some donor grants or low interest debt from multi-lateral funding agencies.

Table below shows the results of the financial analysis for an asynchronous connection with and without either donor grants or low cost debts.

Description	**Dhalkebar - Muzaffarpur 220 kV link**	**Butwal - Gorakhpur line 132/220 kV link**
Base case		
Total cost	$152.4 million	$139.6 million
B/C ratio	1.4	1.3
IRR (NPV)	9.2%	7.7%
With donor grant of $20 million for project development		
Total cost	$132.4 million	$119.6 million
B/C ratio	1.5	1.4
IRR (NPV)	13.3%	11.9%
With discounted debt interest at 6%		
Total cost	$152.4 million	$139.6 million
B/C ratio	1.4	1.3
IRR (NPV)	10.2%	8.8%

B/C – Benefit/cost; IRR – Internal rate of return; NPV- net present value

Both the above interconnection links may be used to import power to Nepal, as needed on a short-term basis. Such increased use of the link will further improve the attractiveness of the project. Approximately 100 MW of imports for 1,000 hours in a year (4 hours per day for 8 months) for the first five years of the project, would marginally improve the B/C ratio of each of the alternative.

Conclusions and Project Implementation

The study indicates that the transmission line link may be feasible even with only available spill energy assuming that NEA will be able to commission all its proposed generation plants in a timely manner as planned.

A transmission interconnection now with India to facilitate commercial, bilateral power trade would be a small but emphatic first step to demonstrate Nepal's commitment to energy export as an engine to develop its economic base.

The most critical first step in the implementation of the project should be an unequivocal commitment from the GON for accelerated, large scale power export to India by legislation of the proposed new Electricity Act and the Nepal Regulatory Commission (NERC) Act that will enshrine the national Hydropower Development Policy 2001. The government ministers and officials have expressed such commitment in numerous forums, as recent as POWERing

Nepal – Connecting Markets seminar sponsored by the US Embassy in Kathmandu and USAID Nepal and implemented by IRG in November 2006 (www.doed.gov.np). Without such commitment, no significant actions to move forward would be realistic.

Any transmission link between Nepal and India should be developed and operated by the private sector or through a public-private partnership mechanism since the government entities such as the NEA have the primary mandate of supplying domestic demand. Also, it is unlikely that the GON or the NEA will be able to mobilize funds to construct a transmission line link for the long-term future instead of other immediate system needs. The power trading market in India is mushrooming with over 200 entities including 16 power trading companies. Such ventures would become common place in Nepal as well and the GON should facilitate establishing such trading entities.

The private sector would likely come up with the needed investment but given the rapid changes in Nepal's political horizon, private investors may take a "wait and see" approach for the next 6-12 months. Because bilateral commercial power transactions between Nepal and India are still perceived to have significant political/commercial risks, IRG concludes that donor and multilateral funding agencies must devise a package of incentives to the private sector to accelerate the investment process. These incentives may be in the form of outright GDA/other donor grant to the project, lower than-market debt interest rates etc under a BOOT type arrangement. Such international support, even if small, would lead to positive perception and commitment to consolidate political and economic stability in Nepal.

Successful implementation of the proposed project would set the stage for significant private sector participation in generation and transmission projects. Availability of a transmission line link will also promote more efficient use of existing generating capabilities and planned future development on both sides of the border through power trade in both directions, leading to increased energy security of the region.

Recommendations

Based on our study and discussions at the POWERing Nepal – Connecting Markets Seminar, IRG recommends the following time-bound actions:

1. As soon as possible,

    - Champion teams comprising industry associations and interested organization in Nepal and India be formed to facilitate legislation of the new Electricity Act and the NERC Act in Nepal; amend the Indian Electricity Act 2003 for cross-border wheeling for short-term contracts; assist potential developers on both sides to meet regulatory, legal, and administrative requirements; and develop public-private partnerships, match making among developers, investment communities, financial institutions, consultants, equipment manufacturers, software/hardware developers, and contractors. The POWERing Nepal – Connecting Markets seminar has initiated the process for forming Champions teams.

    - USAID consider funding system stability studies in India and Nepal to confirm if synchronous or asynchronous transmission link should be made and to develop model third party energy sales contracts in India and Nepal to facilitate cross-border power trade and obtain approval from the relevant GON and GOI agencies and institutions for such contracts

2. In the next 5-6 months,

- Champions teams facilitate obtaining regulatory approvals in place in Nepal for power trading; wheeling through NEA TL system and third party power sales contracts and regulatory approval in India for wheeling Nepal's power through Indian grid (for short term) for third party power sales

- The NEA should establish a mechanism and procedures to ensure appropriate connection and system controls, the ability to monitor power flows, and to enact billing systems for power wheeling.

- The GON/GOI entities with possible assistance from USAID, solicit and obtain donor grant for implementation of the project and secure such grant. IRG recommends that $20 million to be provided as donor grant to implement the project if asynchronous interconnection link is required. If synchronous interconnection becomes the choice, we recommend donor-funding of the entire cost of system remedial measures (subject to a maximum of $20 million) to be undertaken in Nepal and India to facilitate synchronous interconnection. Alternatively, GON/GOI may solicit and obtain low-cost debt for project implementation from multi-lateral financial institutions such as World Bank and the ADB. IRG recommends a debt-interest of no more than 6%.

3. In the next 12 months,

- NEA, DOED, and the GON prepare/confirm plans for generation and TL strengthening of Nepal's integrated power system.

- NEA, DOED, and GON conduct focused discussions with donor community, multi-lateral financing institutions, and IPPs for timely development to fund generation and other proposed TL projects with NEA, private or public-private partnership ownership arrangement.

- USAID consider funding detailed design of the selected alternative and preparation of contract documents for implementation of the project under a BOOT mechanism by private sector or public-private partnership; establishing grid code conformity for transactions in both countries; and supporting the NEA, DOED, and the GON in their endeavor in planning generation and TL expansions and in negotiation of financing and contracts arrangements for such development.

1. INTRODUCTION

1.1 Nepal's Hydro Power

Blessed with over 6,000 rivers and streams, and high mountains, Nepal is reported to have a hydropower potential of 83,000 megawatt (MW), of which about 42,000 MW is considered economically feasible to develop. Projects totaling approximately 23,000 MW have been studied in varying details by domestic and international agencies. Less than one percent of the potential is currently developed. The Government of Nepal (GON) sees hydropower as critical to the nation's sustainable economic and social growth and is committed to its development for domestic use and to generate valuable foreign exchange through exports.

The Nepal Electricity Authority (NEA) is the government-owned utility serving approximately 1.2 million grid-connected customers. Currently, the NEA's installed generation capacity is approximately 607 MW of which 551 MW is hydro. The Butwal Power Company (BPC), a private company, was spun off from the NEA in 2004 and owns and operates two power generation facilities that in 2004-2005 generated 97.8 gigawatthour (GWh), most of which was sold to NEA with the rest sold directly to its 23,000 customers. Its distribution area includes 55 Village Development Committees and one municipality. In the countryside, there are numerous but scattered off- grid small hydro facilities with installed capacities under 1,000 kW, windmills, and bio-fuel facilities supplying local populations and usually locally owned.

Despite its huge hydroelectric potential, fuel wood, agricultural wastes, animal wastes, and imported fossil fuel account respectively for 68%, 15%, 8% and 8% of the nation's energy needs with hydropower accounting for only 1% (Table 1.1). In its 2004-2005 annual report, the BPC attempted to convert Nepal's current energy demand into an electricity equivalent to demonstrate how the development and use of electricity from hydro can replace other fuels, many of which are devastating to the environment.

Table 1.1: Electricity equivalent of Nepal's fuel usage

Fuel	Electricity Equivalent in MW
Fuel wood (at morning and evening peak)	17,813.8
Agriculture wastes (at morning and evening peak)	1,729.4
Animal wastes (at morning and evening peak)	1,973.5
LPG (morning, evening, and midday)	300.7
Kerosene (at morning and evening peak)	1,060.7
High Speed diesel	524.9
Others	21.0
Coal	556.9
Electricity	417.2
Total electricity equivalent	24,398.1

Less than half of Nepal's 25 million people have access to electricity and many of these households, according to the World Bank (WB), have only one or two light bulbs suggesting that electricity may only reach 30-35% or less of the population in any meaningful quantity. Current per capita electricity consumption of 55 kilowatthour (kWh) is among the lowest in the world.

Currently, NEA estimates annual electricity demand growth at nearly 10%. While other commentators argue that growth is closer to 8-8.5 % per annum, even at 10%, domestic demand will reach only 3,500 MW by 2025. Thus, the tremendous undeveloped hydro potential presents Nepal with a major commercial opportunity to develop its capacity for export to India which experiences severe power shortages that are expected to continue for the indefinite future. The experience of Bhutan and Lao PDR provide a clear indication that the benefits accruing to Nepal from hydro power exports can be substantial. The revenues earned by exports from the 300 MW Chuka project since early 1990s has almost doubled the Gross National Product (GNP) of Bhutan. When the 1,080 MW Tala project commences export sales shortly in 2006, Bhutan's GDP will double again. Revenues earned from hydro exports are allowing Bhutan to invest in vitally needed economic and social infrastructure. As in the case of the Lao People's Democratic republic (PDR) which has generated huge revenue by exporting power to Thailand, Nepal could use hydropower revenue to finance its economic and social transformation.

In order to minimize and mitigate adverse localized environmental effects, Nepal has developed, with USAID assistance, clear and enforceable environmental laws and regulations that allow for development through balanced economic, environmental, and engineering trade-offs. There is empirical evidence that access to electricity has a positive impact on literacy by allowing children and adults to read or have access to the outside world (radio, television, internet) after dark; electricity allows enhanced access to markets through better information, better health care facilities, year-round cultivation, reduced workloads for women and other minorities through tube well development and irrigation, and enhanced governance through better radio, television and internet communications facilitating effective participation of the people in the country's governance. The availability of electrical energy in adequate and affordable quantities can replace fuel wood and fossil fuel consumption improving the environment and reducing deforestation, in addition to saving foreign exchange, and contributing to reduce the threat of global warming in the region.

1.2 NEA's Electric System

NEA's power generation is dominated by run-of-river (ROR) hydropower projects. Only the 60 MW Kulekhani I project has significant storage. Kulekhani II, with a 32 MW capacity, operates in tandem with the Kulekhani I project providing the only significant peaking hydro capability to meet the system's peak demand of 558 MW (Dec 2005). There are four types of generating plants in the NEA system: (1) private ROR plants with (or without) take or pay contracts, (2) NEA- owned and operated ROR and limited peaking plants with daily storage; (3) NEA- owned hydro storage plants and (4) NEA-owned thermal plants. In FY 2005-2006, the total energy available in the NEA system was approximately 2,800 GWh which represented an increase of 5 % over the previous year; this includes about 930 million GWh purchased by NEA from domestic IPPs while 266 GWh was imported from India. In FY 2005-2006, NEA increased its customer base by 10% to 1.28 million grid connected customers. The company experienced a record peak demand of 603 MW, an increase of 8.2% over the precious year. In FY 2005-2006 (NEA, 2006a), electricity sold totaled 2,066 GWh, an amount 8% higher than the previous year.

NEA's system peak load occurs in the evenings for about two hours during the dry season (November- March). Average daily demand is approximately 54 percent of peak demand. The peak demand during the wet season (April-October) is marginally lower than during the dry season but the daily load distribution is similar (see Section 3 for typical load-duration curves). River flows are the lowest in the dry season and increase after April from snow-melt. Peak flows occur during the monsoon (July-September) exhibiting a mismatch between hydropower supply and electricity demand. The estimated hydro energy "spilled" by the NEA and IPP hydro plants in 2004-2005, because of a lack of domestic demand, was in excess of 650 GWh. This amount of spill energy will reduce with increased demand but the NEA estimates that in 2010, there will be spill energy of 500 GWh in its hydro plants (valued at $3 million). The existing IPP plants have spill energy of approximately 70 GWh annually.

There are 19 interconnections (mostly 33kv or 11kV) between India and Nepal but the two systems are essentially operated independently. Energy swaps occurs in several border areas on what may be termed a "drop off and pick up" basis. Certain areas in Nepal are disconnected from the Nepal system and connected to the Indian system when supply is not available from Nepal. Similarly areas in the Indian system are connected to the Nepal system during certain times. However, there is no continuous interconnection between the two systems. According to NEA's 2004-2005 Annual Report Nepal was a net importer of electricity from India every year during the last decade. Net imports from India in 2004-05 were 130.7 GWh.

1.3 NEA's Transmission System

The backbone of NEA's transmission system is a 132 kilovolt (kV) overhead line running east to west through the Terai. This line combines single circuits, double circuits and double circuit towers, with one circuit strung. In addition, there are 132 kV loops supplying Pokhara (with significant generation) and Kathmandu which also has an extensive 66 kV distribution network. The 66 kV network is connected to Birgunj on the Indian border where there is significant industrial demand.

The electricity system usually operates on an "n-0" basis, i.e. there is no spare transmission capacity. Consequently, in many locations the system is heavily loaded with poor voltages as low as 0.7 p.u. In fact, a major technical problem on the NEA system is the poor voltage level in the Kathmandu- Hetauda - Birgunj corridor. NEA's transmission system has developed over the years based on the need to evacuate power from individual projects. Because of a lack of funding, the planned expansion of NEA's transmission system has not been possible. Currently, the NEA is unable to sign power purchase agreements (PPAs) for projects located in certain parts of the country because of a lack of transmission capacity to evacuate the power from these facilities even after they are built. There are cases of IPP projects developed at less-than optimal installed capacity resulting from transmission line constraints.

1.4 The Indian Electricity Sector

The power system in India is the fourth largest in Asia with an installed capacity of about 127,000 MW and an extra high voltage transmission network comprising 280,000 circuit-kilometers (cct-km). The power network is organized into five regions: (northern, northeastern, eastern, western and southern). Currently, India has connected four of its five regions through a national transmission grid. The last region will be interconnected shortly providing a power transfer capacity of 37,000 MW by 2012 from one region to the other and facilitating imports from neighboring countries. Although total electricity production in 2005-06 was 617 billion kWh, the peak deficit was 9% while energy shortages were 8.3%. These are expected to increase to 10.5% and 8.4% respectively by 2012. If world economic growth slows over the next few years, the actual capacity additions in India will be much less than planned, suggesting that shortages will be higher than estimated. Though 85% of villages are electrified, only one-third of rural households have access to good quality electricity. Consequently per capita power consumption of 567 kWh in India is one of the lowest in the developing world. If not corrected, power shortages, poor quality power supply (voltage fluctuations), and frequent load shedding threaten to undermine India's industrial competitiveness posing severe constraints on social and economic development.

Since the early 1990s, India has imported about 300 MW from Bhutan's Chuka hydroelectric facility. With the 1,080 MW Tala hydroelectric plant completed recently, imports from Bhutan will exceed 6,400 GWh per year. There are 220 kV transmission interconnections between Bhutan and India; 400 kV double circuit lines from Tala to New Delhi are under construction.

The PTC is the nodal agency for cross border power trade with Bhutan and Nepal. PTC has initialed a PPA with an Australian Independent Power Producer, Snowy Mountain Engineering Corporation, for the purchase of power from the proposed 750 MW West Seti project in the northwest of Nepal. The PTC has also stated that it will purchase any available energy from Nepal with guarantee of at least some supply. The PTC is in talks with the NEA in this regard. The price of power will be based on the alternative energy cost to the Indian system which varies between $0.022 (NR1.6) and $0.11 (NR8) per kWh. Clearly, such rates are attractive to Nepal and given the shortages of power in India, hydro power exports from Nepal, if only during the wet season, are likely to have a long-term market in India.

The NEA and the PowerGrid have studied several interconnections for the two systems, primarily to supply pockets of customers in each country with power depending on availability. It is understood that while attractive, technically viable options exist for continuous interconnection, NEA and the PowerGrid could not justify the cost of such connections based on limited export volumes.

2.0 STUDY NEED AND PURPOSE

2.1 Need for a Transmission Line Study

As a result of the large number of run-of-river plants in NEA's system, significant excess energy (estimated in excess of 550 GWh annually to 2010) is available during the monsoon season, when NEA's system demand is low. NEA's middle Marsyangdi (70 MW) project is a run-of-river project nearing completion. NEA's guarantee that it will purchase energy from all IPP generating plants under 5 MW combined with the imminent availability of partial low-interest funding for IPP plants from the WB's Power Development Fund (PDF) make it likely that several new ROR plants will be developed providing additional excess energy during the monsoon season. With the development of medium sized ROR and limited peaking plants, surplus energy available during the wet season will increase. Even with large storage hydro projects, there will be excess energy available during high flow periods since these plants will likely be designed for seasonal storages with plant factors in the range of 25-35 percent.

While NEA has proposed introducing a seasonal tariff that may result in some of the surplus wet season energy being utilized within Nepal, an availability-based tariff and the need for system frequency support for the weak Indian transmission system near Nepal's border provides an opportunity to export all available excess energy if the price is competitive with those in India. Both the NEA and the IPPs will have excess energy that can be sold to India where a demand exists.

The USAID's SARI/E project conducted a pre-feasibility study for a transmission link connecting the four countries - India, Bangladesh, Bhutan, and Nepal. The key question the report attempted to address was to identify a feasible link to connect the four countries for possible power export. In the five years since the study was completed, much has changed in the power sector in India including institutional and market changes brought about by the passage of the Indian Electricity Act 2003, implementation of large-scale hydro power imports from Bhutan, proposed natural gas imports from Bangladesh, Myanmar, Middle-East and Central Asian countries, major liquefied natural gas and coal imports for power generation, and an acceleration of India's nuclear energy program. Also, India has consistently maintained that while it appreciates regional initiatives, it prefers bilateral trade agreements,

All these developments affect how India views the role of Nepali hydropower in its energy mix and the longer Nepal waits to market its hydro power potential as a vital component of India's energy future, the more likely it is that Nepal may miss a major commercial and potentially highly beneficial opportunity.

2.2 Purpose of Study

The above factors indicate the need for a transformation in Nepal's energy policy. Rather than build transmission lines only for specific projects, Nepal needs to embark upon an over-all strengthening of its national grid involving interconnection(s) between Nepal and India. Such a policy shift will serve as a roadmap providing opportunities for power trading that will generate its own sustainable traffic leading to the economic development of both nations. Based on these factors and discussions with the Ministry of Water Resources (MOWR), the NEA, the Department of Electricity Development (DOED), other stakeholders, and the PTC, USAID/N and International Resources Group (IRG) included a transmission line study to be initiated in 2005 under the Private Sector Hydropower Development Project (PSHDP-2).

In September 2005, USAID/N requested IRG to conduct a study to assess the feasibility of a privately or independently run transmission line linking a major substation in Nepal to a point on the Indian Grid aimed at facilitating private sector power trade with an emphasis on exports. USAID/N requested a comprehensive analysis and recommendations for the best location and capacity of the line. USAID/N requested that the study recommend how to proceed with the implementation of such a project including its estimated costs and to assess whether a Build, Own, Operate, Transfer (BOOT) scheme, the provision of Global Development Alliance (GDA), or other appropriate mechanisms should be pursued to facilitate the project. Complete terms of reference for the study are included in Appendix A. The study was initiated in October 2005 with meetings with the NEA and the DOED followed by a visit to government agencies, private developers, industrialists, and industry organizations in India (See Appendix B). A stakeholder meeting was conducted in Kathmandu in November 25, 2005 to discuss the scope of work and obtain key inputs for conducting the study as well as to discuss observations from IRG Team from the India visits (Appendix C). IRG team held extensive meetings with the NEA, Independent Power Producer's Association of Nepal (IPPAN) members, and others. IRG team visited the NEA’s Load Dispatch Center in Siuchatar on November 27, 2005 to familiarize with actual operations. A report on IRG Team’s observations is presented in Appendix D.

2.3 Report Layout

An executive summary of the transmission line study is presented in Section 1. Following the Background provided in this Section, the existing Nepali and Indian systems are described in Section 3. A short review of the Four Borders Report is presented in Section 4. An analysis of the Nepali and Indian power markets is presented in Section 5. Section 6 details system modeling, technical, cost, and financial analyses conducted to assess the options for meeting short-term and long-term export scenarios. Section 6 also provides analysis of selection of a preferred alternative and a likely schedule and steps for its implementation. Appendices are included at the end of the report.

3.0 REVIEW OF POWER SYSTEMS OF NEPAL AND INDIA

3.1 Power system of Nepal

3.1.1 Structure of electricity sector in Nepal

The electricity sector in Nepal is under the MOWR. The vertically integrated NEA with over 458 MW installed capacity dominates the industry in generation, transmission and distribution and serves over 1.2 million customers. The BPC owns and operates 2 hydroelectric plants with a total capacity of 17.4 MW and distributes power to 23,000 consumers in 5 districts. There are 11 IPP hydro power plants, totaling over 148 MW selling power to the NEA under long-term PPAs.

The DOED is the hydropower promotional and regulatory department of the MOWR and issues licenses to study, build, and operate hydropower projects greater than 1 MW. The Electricity Tariff Fixation Commission (ETFC), functioning under MOWR currently serves as the tariff regulator for electric consumers. The ETFC is expected to be replaced in the near future by a new, independent Nepal Electricity Regulatory Commission (NERC) with greater autonomy and a mandate to regulate the sector. The MOWR has prepared a draft Act to establish the NERC which is under consideration by the GON. The DOED has the responsibility to monitor operation of all hydropower projects with an installed capacity of more than 1 MW.

Currently, every project developer (NEA, IPPs, and others), must obtain a survey license from DOED allowing the developer up to five years term to study the feasibility of the project, conduct requisite environmental studies, obtain approval from the Ministry of Environment, Science, and Technology for the project's environmental documentation (e.g. Environmental Impact Assessment), negotiate a PPA with the NEA, and arrange for project financing. The survey licensee has the right-of-first-refusal to develop the project at the specific site. The developer then obtains a generation license from the MOWR for the construction and operation of the project and associated transmission facilities. A similar licensing process is followed for the development of electrical distribution facilities. Once the NERC is created, it will grant licenses for transmission and distribution projects and monitor operation of all generation projects.

3.1.2 Overview of the Nepali power system

Nepal is rectangular in shape with its long 900 km axis running approximately east-west and its short axis, about 180 km long running north-south. Nepal is bordered on the west, south, and east by India and on the north by China (Tibet).

A majority of Nepal's generation is from ROR hydroelectric power plants[1]. The total installed capacity as of June 2006 is 607 MW including approximately 57 MW of diesel plants (Table 3.1).

Most of the generating plants are located in the central part of the country stretching 450 km between the Lamahi substation in the west and the Lahan substation in the east (Fig. 3.1).

[1] Generation: Third Edition. Published by NEA, August 2005 (NEA, 2005a)

Table 3.1: Installed capacity in Nepal (December 2005)

Plant and year of commissioning	Installed Capacity (MW)	Annual Energy available GWh/yr)	Project Type
Trishuli (1967)	24.00	277.00*	ROR
Sunkoshi (1972)	10.05	62.73	ROR
Gandak (1979)	15.00	106.38	ROR
Kulekhani-1 (1982)	60.00	146.00	ST
Devighat (1984)	14.10	Incl. in Trishuli	ROR
Kulekhani-2 (1986)	32.00	73.00	Storage type
Marsyangdi (1989)	69.00	462.30	Peaking ROR
Puwa Khola (1999)	6.20	48.00	ROR
Modi Khola (2000)	14.80	91.50	ROR
Kali Gandaki – A (2002)	144.00	842.00	ROR
Small Hydro Plants	12.82	63.38	ROR
Total (NEA Hydro)	**401.97 (Peaking: 371.85 MW**)	**2,171.79**	
Andhi Khola	5.10	32.00	ROR
Jhimruk	12.00	54.00	ROR
Khimti Khola	60.00	350.00	ROR
Bhotekoshi	36.00	246.00	ROR
Indrawati-III	7.50	49.70	ROR
Chilime	20.00	133.00	ROR
Piluwa Khola	3.00	19.55	ROR
Syange Khola	0.18	1.19	ROR
Chaku Khola	1.50	6.30	ROR
Sunkoshi Small	2.50	14.38	ROR
Rairang Khola	0.50	3.09	ROR
Total (IPP Hydro)	**148.58 (Peaking: 89.51MW**)	**909.21**	
Total (All Hydro)	**550.55 (Peaking: 461.36)**	**3,081.00**	
Hetauda Diesel (new+old)	14.41		-
Duhabi Multifuel -1	26.00		-
Duhabi Multifuel -2	13.00		-
Rani	1.03		-
Marsyangdi	2.25		
Total (NEA Thermal)	**56.69**		
Total (Installed Capacity)	**607.24**		

Source: Long term Generation Planning Study, 2004/05 - 2019/20, NEA, June 2005 (NEA, 2005b); and Near-term Generation Planning Study, 2006/07 – 2010/2011, NEA, Feb 2006 (unpublished – NEA, 2006b)

The Nepali power system operates at a nominal 50Hz frequency. Peak demand for electricity recorded on November 27, 2005 was 558 MW. Peak demand in 2006 is estimated to reach 642 MW (NEA, 2006).

The NEA operates the Integrated Nepali Power System (INPS). The INPS comprises a 132 kV longitudinal spine running from the Anarmani substation in the east to the Mahendranagar substation in the west, a distance of about 850 km (Fig. 3.1). This spine connects 15 substations and is of single circuit construction at its eastern (Anarmani to Duhabi) and western (Mahendranagar to Kohalpur) extremities. In the central region, the spine is partially single circuit (Hetauda to Bharatpur), partially double circuit (Butwal – Bharatpur and Hetauda – Duhabi) and partially one circuit strung on double circuit towers (Kohalpur – Butwal). Transmission connections from the spine to generation and demand centers are at 132 kV and 66kV. The distribution system uses 33kV, 11 kV, and low voltage lines.

3.1.3 Existing generation

As noted, power output from Nepal's ROR plants is governed by the river flows which are the highest in the rainy season (June – October), and the lowest in the winter (December – February). The Kulekhani-1 (60 MW) power station is the only project with a reservoir that can store water from the wet season to provide peaking power in winter. Kulekhani–2 (32 MW) operates in tandem with Kulekhani-1 and consequently serves as a seasonal peaking plant. The Marsyangdi (69 MW) plant has a small pondage and is used to provide limited daily peaking in an operation termed peaking run-of-river (PROR) plant by the NEA. The NEA operates several diesel and heavy fuel-oil units in different parts of the system to meet peak demand. Details of Nepal's generation plants are provided in Table 3.1.

Nepal's peak demand occurs during winter evenings, when the ROR plants are at their lowest output as the rivers are at their lowest flows. This results in available peaking capacity being restricted to 518 MW (Table 3.1). Consequently, although current installed capacity (607 MW) exceeded the peak demand (558 MW in 2005), the peak demand could not be met without load shedding and imports from India.

Average daily demand is about 54% of peak demand, which lasts for only a few hours in the evening. For the remainder of the day, NEA has to reduce power plant output and spill significant quantities of water owing to the lack of internal demand for power. Figures 3.2 to 3.5 show the load-duration curves for peak and average days in the dry and wet seasons. NEA has calculated the monthly surplus energy that is available in the system. The IPP projects also have surplus energy that NEA does not purchase during the wet season. Table 3.2 shows an estimate of monthly surplus energy available in the system in 2005.

3.1.4 Generation expansion plans

Norconsult[2] International A.S. prepared a Power System Master Plan (1997-2017) for the NEA in 1998 (Norconsult, 1998). This Master Plan comprised four reports:

1. Load forecast for period 1998 – 2020
2. Generation expansion plan 2003 - 2017
3. Long run marginal cost of generation
4. Transmission expansion plan 2003 – 2017

[2] Power System Master Plan for Nepal. Financed by ADB under TA 2614-NEP. Norconsult International A.S, 1998 (Norconsult, 1998)

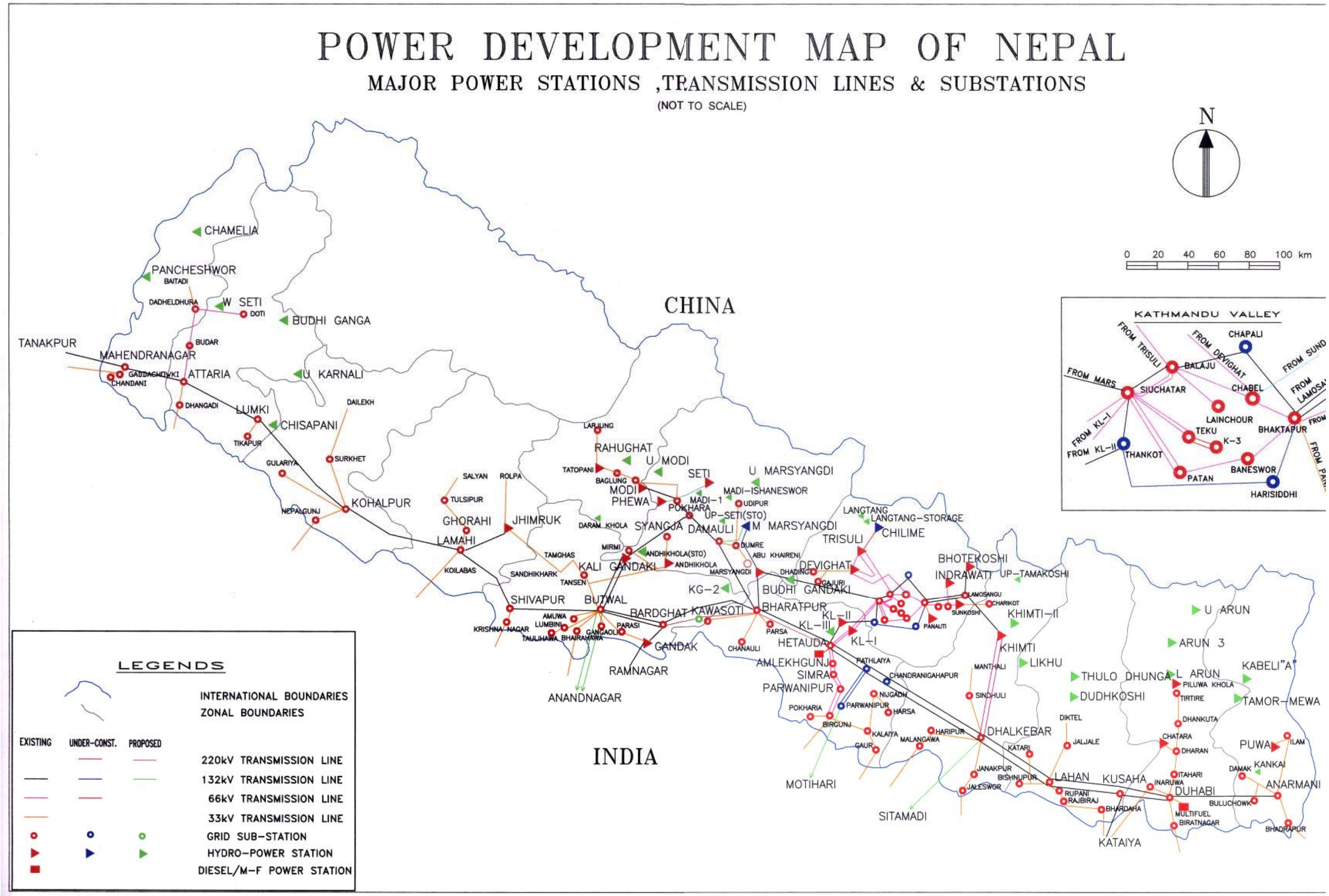


Figure 3.1: Power Map of Nepal

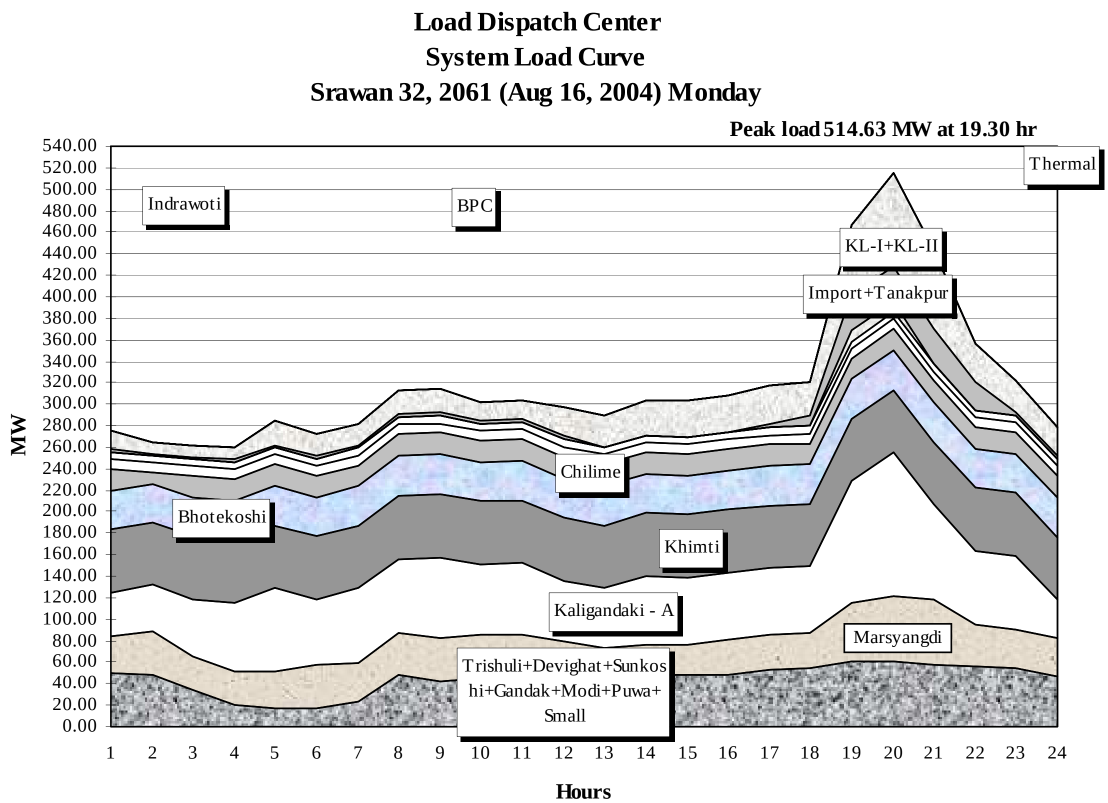


Figure: 3.2: NEA's System Peak Day Load Curve – August 2004

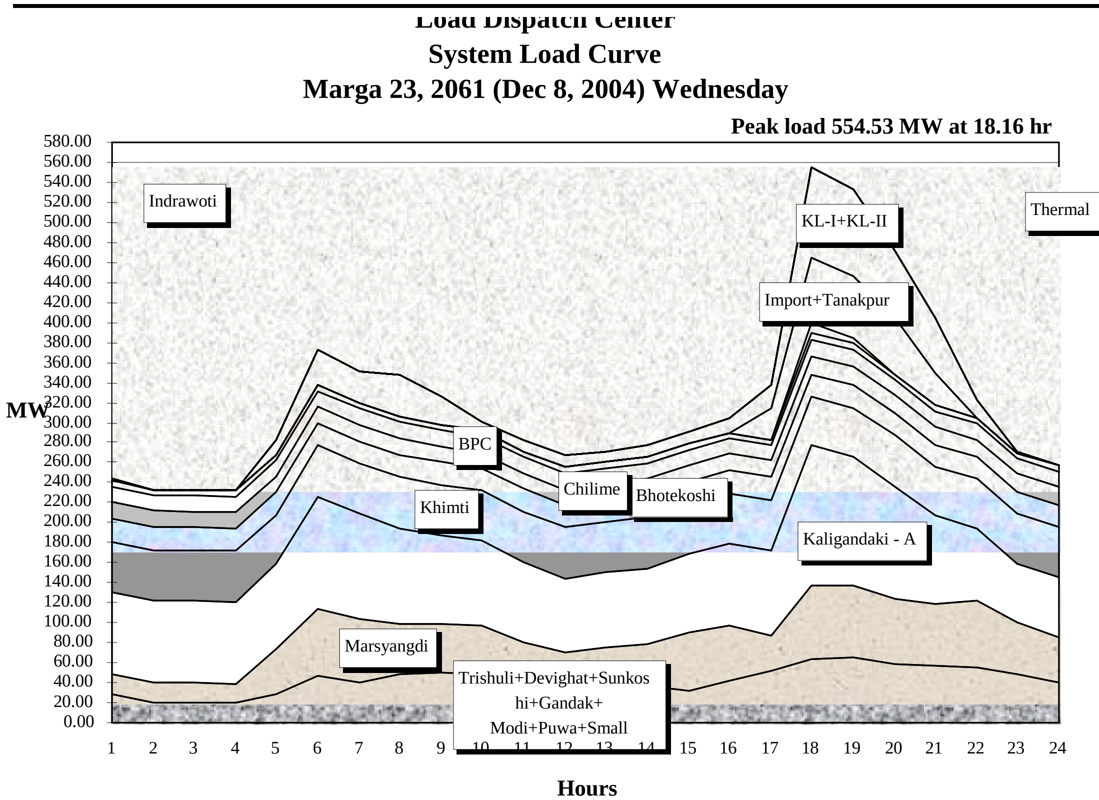


Figure: 3.3: NEA's System Peak Day Load Curve – December 2004

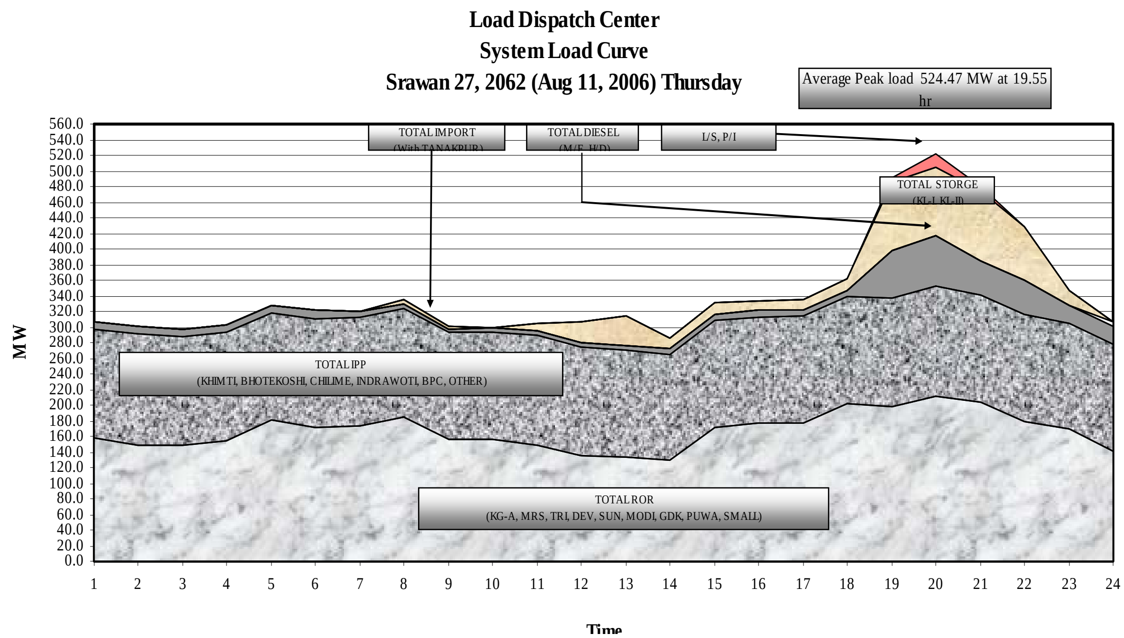


Figure: 3.4: NEA's System Average Day Load Curve – August 2006

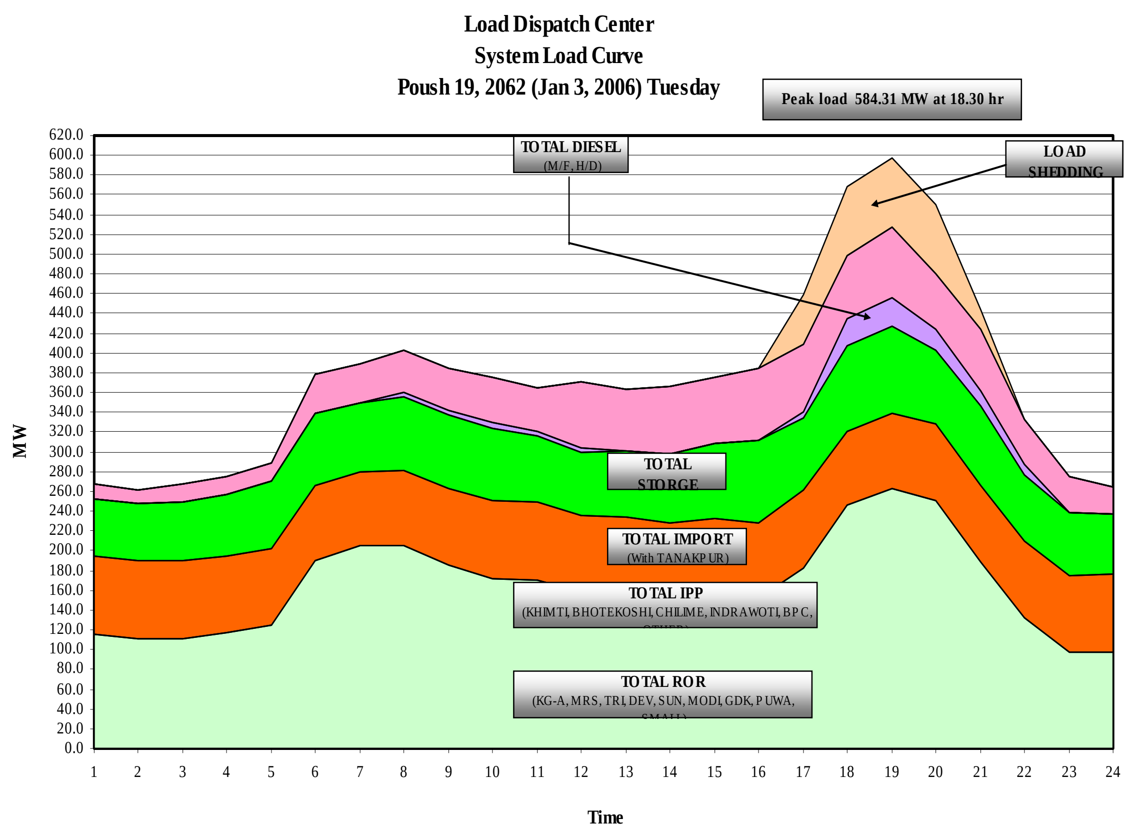


Figure: 3.5: NEA's System Average Load Curve – January 2006

Table 3.2 – Surplus energy in 2005/06

Month	Surplus energy GWh
July	107.0
August	105.3
September	142.7
October	136.3
November	42.1
December	1.4
January	0.4
February	0.5
March	1.0
April	3.8
May	64.2
June	80.4
Total	**685.2**

As part of its power system planning studies, NEA prepared a load forecast for major consumer groups (residential, industrial, commercial, irrigation, and others) using several economic parameters including gross national domestic product, population statistics, income and price elasticity (NEA, 2005a). Load forecasts were made in 1997 by Norconsult and in 2002[3] and 2005[4] by NEA's System Planning Department. Forecasts for selected years are given in Table 3.1 below. The load forecasts represent the total demand in Nepal, even though some demand is often supplied from the Indian system. These forecasts indicate that average demand for electricity is growing by 7% to 8% annually (Table 3.3).

Table 3.3 Load forecast for Nepal

Year	Load forecast NEA/Norconsult 1997-8		Load forecast NEA, 2002		Load Forecast NEA, 2004-05	
	MW	GWh	MW	GWh	MW	GWh
2004	518	n.a	510	2,321	515*	2,381*
2005	561	n.a	570	2,596	558*	2,458
2010	805	n.a	864	3,936	822	3,599
2015	1,140	n.a	1,236	5,629	1,220	5,450
2017	1,304	n.a	1,419	6,466	1,398	6,367
2020	n.a.	n.a	1,742	7,933	1,733	7,894
Average Growth rate (% per year)	7.4	n.a.	8.0	8.0	7.9	7.8

*Actual recorded for the year 2004-05; n.a. not available

[3] North-South 132 kV Transmission Line feasibility study. Report by System Planning Department, NEA (NEA, 2003)
[4] Report on Transmission Planning Study 2005; System Planning Department, NEA (NEA, 2005c)

The Generation Expansion Plan considered alternative scenarios and recommended a "Hydro Only Scenario", in line with the GON's commitment to develop its under-developed hydro potential. NEA's Transmission Plan was based on this assumption. The Generation Expansion Plan considered expansion through large scale PROR-type hydroelectric plants and recommended seven generation projects totaling 878 MW for development by 2016 as shown in Table 3.4.

Table 3.4: List of generation projects considered in Power System Master Plan

Project	Installed Capacity (MW)	Planned Completion Year	Present Status (Dec 2005)
Middle Marsyangdi	61	2003	Under construction; expected to be completed by 2008.
Khimti Khola-2	27	2004	No firm program
Kulekhani-3	14	2005	Committed project on NEA list; no procurement action commenced.
Likhu-4	44	2006	No firm program
Upper Karnali	300	2007	No firm program
Arun-3	402	2011	No firm program
Chameliya	30	2016	No firm program
Total	878		

Source: Norconsult, 1998

Power system planning is dynamic and Norconsult acknowledged that the generation plan could be modified over the planning horizon owing to changing environmental, economic, technical, financial opportunities and constraints. Norconsult noted that actual load growth might not be in line with predictions and that the pace of implementation of rural electrification programs could affect generation and transmission plans. NEA has developed a power system analytical capability and regularly reviews the demand estimates and generation and transmission plans.

In 1996, the WB decided to abandon the 402 MW Arun-3 project. Since then, both the WB and the Asian Development Bank (ADB) have drastically reduced funding for large hydropower projects throughout the world. Nepal is acutely dependent on bilateral and multi-lateral donor agencies for significant investment in the power sector. The NEA is not able to raise adequate capital through its tariff structure. Hence, no new large plant has come on line and generation plans have been modified dramatically. The most recent generation expansion plan (NEA, 2005b), on which NEA's current transmission expansion plan is based, shows that of the generation plants envisaged in 1998, only the Middle Marsyangdi project is currently under construction. Of the remainder, five plants remain in the 2005 plan with significantly later projected commissioning dates while the Arun-3 project has been eliminated.

Political insurgency and uncertainties of the past decade have reduced to a trickle all large private and public-private investment except for two IPP projects. Hence, both the NEA and local entrepreneurs have been forced to focus on development of smaller projects. With the revived WB investment in hydro projects in the Lao PDR and ADB interest in the West Seti project in Nepal, NEA has added four large projects - the 122 MW Upper Seti plant, the 309 MW generation station at Upper Tamakoshi, the 300 MW facility at Dudh Koshi, and the 180 MW station at Andhi Khola to its 2005-2020 generation expansion plan (NEA, 2005b). The most recent generation expansion plan is shown in Table 3.5 below:

Table 3.5: Generation expansion plan – 2005

Project	Installed Capacity (MW)	Expected Completion Year	Likely ownership and Present Status (Dec 2005)
Baramchi	0.98	2007	IPP; Under construction; completion by 2007.
Khudi Khola	3.50	2007	IPP; Under construction; completion by late 2006
Sisne Khola	0.75	2007	IPP; Under construction; completion by 2007
Pheme Khola	0.95	2007	IPP: Financial closure (May 2006)
Sali nadi	0.23	2007	IPP; Under construction
Lower Indravati	4.50	2008	IPP; Under construction; completion by 2009.
Tadi Khola	0.97	2008	IPP; PPA concluded
Mardi Khola	3.10	2008	IPP; Land acquisition completed.
Thoppal Khola	1.40	2008	IPP; Under construction; completion by 2008.
Middle Marsyangdi	70.00	2008	NEA; Under construction – commissioning by 2008.
Mailung	5.00	2009	IPP; Under construction; completion by 2009.
Lower Nyadi	4.50	2009	IPP; Construction started
Daram Khola	5.00	2009	IPP; Financial closure 2006; completion by 2009.
Upper Modi	14.00	2010	IPP; Construction started; completion by 2009.
Kulekhani-3	**14.00**	**2009**	**NEA; Committed project; Anticipated by 2010.**
Upper Mai Khola	3.00	2010	IPP; PPA concluded
Madi-1	10.00	2010	IPP; PPA concluded
Hewa	**10.00**	**2011**	**NEA: committed project**
Mewa	**10.00**	**2011**	**NEA; committed project**
Lower Modi Khola	19.00	2010	IPP; No progress
Kabeli-A	30.00	2011	IPP; competitive bid; RFP due out July 2006
Upper Marsyangdi-A	50.00	2011	IPP; No progress
Rahughat	27.00	2011	IPP: No progress
Upper Trishuli	**61**	**2012**	**NEA; committed project**
Tamor	**83.00**	**2012**	**NEA; committed project**
Likhu-4	51.00	2012	IPP; No progress
Upper Modi A	42.00	2012	NEA-private sector joint venture; no firm plan
Chameliya	30.00	2011	NEA-private sector joint venture; no firm plan
Upper Karnali	300/75	2013	NEA-private sector joint venture; no firm plan
Upper Seti	122.00	2013	NEA; planned storage project
Upper Tamakoshi	309.00	2013	NEA-private sector joint venture; no firm plan
Kankai storage	90.00	2013	NEA; No progress
West Seti	750/75	2014	750 MW dedicated for export to India; Financial closure pending.
Dudh Koshi-1	300.00	2018	No progress
Budhi Ganga	20.00	2019	No progress
Andhi Khola	180.00	2020	No progress
Total	**2,625.88**		

Source: (NEA, 2005b); Projects in italics and bold are considered committed projects

NEA's most recent load forecast (August 2005) for peak demand in 2010 is 822 MW (Table 3.3) with an annual energy demand of 3,599 GWh. However, the total installed capacity of the Nepali power system by 2010 (existing + under construction, including thermal units) may only amount to 772 MW including committed and candidate projects. If only projects under construction are commissioned, the installed capacity will be around 680 MW. The Government of Nepal (GON) is developing a competitive procurement process for medium and small scale hydro projects. A request for proposal for development of the 30 MW, IPP Kabeli-A project is expected to be released shortly. Major GON initiatives are underway to obtain bilateral and multi-lateral assistance to initiate construction of at least one large (300+MW) project. Nepal's IPPs, in association with overseas developers, are contemplating development of several projects in the Eastern region. Among them, the lower Bhotekoshi projects (120 MW), other Khimti developments (80 MW), Budhi Gandaki (500+MW), and the Arun river (up to 1,000 MW) are noteworthy.

However, with project construction typically taking 4-5 years, forecasting the number of plants that actually may be commissioned by 2010 is difficult. A significant peaking deficit (150-200 MW), by 2010 in the dry season is likely. In spite of this deficit, however, there will be surplus energy available during the wet season that can be exported. Table 3.6 shows estimated monthly excess energy available from NEA's proposed generation plan and the currently operating IPP plants.

Table 3.6: Table of available surplus energy: 2009/10 and 2015/16

Month	Surplus Energy GWh	
	2009/10	2015/16
July	89.2	534.8
August	117.5	543.1
September	118.3	580.4
October	97.5	562.9
November	22.5	391.5
December	0.8	106.6
January	0.4	30.8
February	0.5	7.4
March	1.0	40.6
April	2.6	111.5
May	48.6	254.4
June	84.0	446.5
Total	583.0	3610.6

3.1.5 Transmission system of Nepal

The Nepali transmission system uses voltages of 132 kV, 66kV, 33kV and 11kV. The Nepali 132 kV transmission system is comparatively simple (Fig 3.1). The longitudinal spine runs east – west, with 15 substations (NEA, 2005c). There are three single circuit 132 kV lines that branch off this spine to the south, crossing the border to India, at:

- Mahendranagar to Tanakpur, in the extreme west of the country
- Bardghat via Gandak (on the border) to Ramnagar in India
- Kusaha via Bhantabari (on the border) to Kataiya

One loop to the north of the spine goes to the hill country around Pokhara. This loop leaves the spine at Butwal, returning at Bharatpur and connects the important load centre of Pokhara, as well as a significant amount of generation facilities (Fig 3.1).

A second loop goes from Bharatpur to Hetauda, connecting generation stations and the significant load centre of Kathmandu. A subsidiary loop supplies Kathmandu ; this line passes to the north of Kathmandu, with 4 substations supplying the city and its environs, before going to Bhaktapur about 10 km to the east of Kathmandu. NEA intends to complete this loop by constructing a circuit from Bhaktapur to Thankot via Chapagaon[5]. From Bhaktapur, a 132 kV line extends east with two branches to connect the Khimti (60 MW) and Bhotekoshi (32 MW) hydro stations.

In addition to completing the Kathmandu loop, a second significant extension to the 132 kV system is under construction comprising a double circuit spur to the south of the spine into the Terai (from Kataiya to Parwanipur) to relieve the load on the 66 kV system.

An extensive 66 kV system acts as a high power distribution system in the Kathmandu valley. The 66kV system extends south to Hetauda (a substation on the 132 kV "spine") and then continues into the Terai to the Indian border at Birgunj. The area between Hetauda and Birgunj contains a large proportion of Nepal's industrial demand (cement plants, steel fabrication plants, spinning mills, etc.).

The 33 kV and 11 kV lines act as distribution systems supplied from the 132 kV or 66 kV network, although in Nepal 33kV is classified as a "transmission" voltage. All load demand is connected at 11 kV.

<u>Interconnections with India</u>
There are currently 21 electricity circuits crossing the border between Nepal and India, at voltages of 132 kV, 33 kV and 11 kV, but the main Nepali and Indian grids are not permanently interconnected.

<u>Security standards</u>
Owing to resource constraints, the INPS is built on an "n-0" basis, i.e. there is no redundancy in the network allowing single fault to result in the loss of generation, loss of load or, even a full system collapse. Although system collapses are frequent, its impact is diminished by the ability to restart hydro generation quickly. NEA indicated that the system can be restored usually within 20 minutes after a total collapse

<u>Voltage performance</u>
Transmission of electrical energy inevitably leads to losses of power resulting in reduced voltage levels along the length of a transmission line. Often the voltage at the receiving substation falls below reasonable operational limits so that connected customers have an unacceptable quality of electrical supply. Table 3.7 illustrates the issue using a snapshot of

[5] NEA: Fiscal Year 2004/5: A Year in Review (NEA, 2005d).

the system taken at 18:00 on Sunday 27 November 2005 close to the system's peak load. At the time, the total system load was 558 MW, and the system frequency was 50.4 Hz. One means of supporting the voltage so that it does not fall below acceptable limits is to install capacitor compensation on the system, normally at the receiving transmission substation as the compensation should be near to the demand to be most effective. NEA plans their system to include necessary capacitor compensation to support the voltage on the system. NEA has installed (or is planning to install) capacitors at a number of locations, as depicted in Table 3.8 below.

Table 3.7: Voltages on the Nepali system at 18:07 on Sunday, 27 November 2005

Substation	Area	Voltage	
		kV	p.u.
Hetauda 132 kV	Kathmandu	126	.95
Siuchatar 132 kV	Kathmandu	128	.97
Lamasangu 132 kV	Between Khimti and Kathmandu	137	1.04
Lahan 132 kV	Eastern Nepal	126	.95
Duhabi[6] 132 kV (Nepali)	Eastern Nepal	128	.97
Duhabi 132 kV (Indian)	Eastern Nepal	120	.91
Birgunj 66 kV	Birgunj Corridor	52	.78

Table 3.8: Capacitive Compensation on the Nepal Transmission System

Location	Area	Voltage kV	Capacitor installed (MVAr)	Status
Siuchatar	Kathmandu	11	10.2	Existing
New Patan	Kathmandu	11	10.2	Existing
Lahan	Eastern Region	132	2x10	Existing
Duhabi	Eastern Region	33	32 (42?)	Existing
Birgunj	Birgunj corridor	33	5	Existing
		11	5	Existing
Anarmani	Eastern Region		15	To be installed
Simra	Birgunj corridor		9.5	To be installed
Baneswor	Kathmandu		15	To be installed
Chabel	Kathmandu		15	To be installed

<u>System losses</u>

Losses on the 66 kV and 132 kV systems were quoted by NEA as “between 6 and 7%” (i.e. around 35 MW) and are relatively high. One reason for the high losses is poor voltage performance.

[6] At the time Duhabi substation was being run in two sections, one part of the Nepali system, one connected to the Indian system.

3.1.6 Transmission expansion plans

The NEA initiated power system planning utilizing simulation models five years ago. Prior to that time, the practice was to connect the power stations to the nearest points on the INPS leading to a weak grid with no redundancy. The Transmission Expansion Plan (Norconsult 1998) recommended the transmission line be strengthened as shown in Table 3.9:

Table 3.9: List of transmission projects recommended in the Power System Master Plan

S. N	Recommended Transmission Scheme in the Master Plan	Present Status (Dec 2005)
1	132 kV d/c line from Middle Marsyangdi – Dumre (30 km); 132 kV s/c line from Dumre – Damauli (14 km); 132 kV s/c line from Dumre – Marsyangdi (14 km); and associated substation bays by 2003 for power evacuation from Middle Marsyangdi	Contract for construction of 132 kV Middle Marsyangdi – Marsyangdi is being awarded; the project is expected to be commissioned in 2008
2	132 kV s/c line from Khimti Khola 2 – Tama Koshi (25 km); 132 kV s/c Khimti Khola 1 – Dhalkebar (72 km); and associated substation bays by 2004.	No progress with Khimti Khola 2 generation plant; hence no progress for the line from Khimti Khola 2. However the 132 kV s/c Khimti Khola 1 – Dhalkebar line was upgraded as 220 kV line and included as priority item in 2003. NEA has a firm proposal to install a 220 kV line (initially charged at 132 kV) which will be available by December 2007
3	66kV s/c line from Kulekhani 3 – Hetauda (3 km) and associated substation bays by 2005	Yet to start as construction of Kulekhani 3 generation project has not commenced.
4	132 kV d/c line from Likhu 4 – Dhalkebar (149 km) and associated substation bays by 2006.	No progress as no firm program for Likhu 4 plant.
5	220 kV d/c Upper Karnali – Kohalpur (94 km); 220 kV d/c Kohalpur – Butwal (208 km); 220 kV d/c Butwal – Hetauda (183 km); 220 kV d/c Hetauda – Thankot (40 km); and associated substation bays by 2007.	Not in the latest plans of NEA as no progress with Upper Karnali generation project.
6	220 kV Arun 3 – Duhabi (123 km); 220 kV d/c Duhabi – Hetauda (283 km); and associated substation bays by 2012.	Not in the latest plans of NEA as no progress with Arun 3 generation project.
7	132 kV s/c Chameliya – Ataria (97 km) and associated substation bays by 2016.	Not in the latest plans of NEA as no progress with Chameliya generation project.
8	Western 132 kV System Improvement: Stringing of second circuit from Butwal – Kohalpur by 2000; stringing second circuit from Kohalpur – Ataria from 2003; 132 kV s/c line from Hetauda to Bardhgat by 2002.	Butwal – Kohalpur second circuiting now planned to complete by 2008. No plan for second circuiting of Kohalpur – Ataria. 132 kV s/c Hetauda – Bardghat line is completed (via Bharatpur).
9	Strengthening of Birgunj Corridor: 50% of all load at Hetauda 66kV shifted to 132 kV substation; All load around Hetauda Cement to be connected to Hetauda 132 kV substation; 50% load at Parwanipur to be shifted to the planned 132 kV substation etc.	132 kV d/c Pathalaya – Parwanipur line and Parwanipur 132 kV substations are now under construction. Expected completion by 2008.

The Master Plan (Norconsult, 1998) recommended nine transmission expansion projects, seven of which were required to connect proposed new generation projects to the grid and to transfer the power to the load centers. Two of the recommended projects were based on the development of major hydroelectric plants – Upper Karnali (300 MW) in the west and Arun 3 (402 MW) in the east - and connecting them with major load centers through 220 kV d/c lines. These projects would have built an effective east-west 220 kV back- bone transmission system representing a major investment in the INPS. The other four related generation projects were for new 132 kV or 66 kV lines.

Norconsult noted that since the generation scenario might change over time, the transmission master plan should not be used to make firm decisions beyond 10-15 years. Indeed, the generation scenario has changed and instead of being based on a small number of large plants is now predicted on a large number of smaller plants. This inevitably has affected the transmission expansion plan significantly. The transmission plan recommended in the 2005 study (NEA, 2005b) is shown in Table 3.10.

Table 3.10: Transmission projects recommended in Transmission Planning Study 2005

S. N.	Major Transmission schemes proposed	Remarks
Transmission schemes planned for system reinforcement		
1	132 kV Butwal – Sunauli by 2007	
2	132 kV Birgunj Corridor by 2007	
3	132 kV Thankot – Bhaktapur by 2007	
4	220 kV Khimti – Dhalkebar by 2007	220/132 kV substations are planned at Khimti and Dhalkebar only by 2015.
5	220 kV Hetauda – Bardhgat (charge at 132 kV) by 2009	
6	132 kV Butwal-Kohalpur second circuiting by 2008	
7	220 kV Bharatpur – Hetauda second circuiting by 2010	
8	132 kV Tamor-Mewa-Kabeli-Hewa-Duhabi by 2010	
9	132 kV Kulekhani 3 – Thankot second circuiting by 2011	
10	220 kV d/c New Bharatpur – Hetauda by 2013	
11	132 kV Thankot – Siuchatar second circuiting by 2013	
12	220/132 kV substations at Kohalpur, New Bharatpur and Hetauda by 2013	
13	220/132 kV substation at Dhalkebar and Khimti by 2015	
14	220 kV Thankot – Hetauda by 2016	
15	220 kV Thankot – Hetauda second circuiting by 2019	
16	220 kV Dhalkebar – Duhabi by 2019	
17	220 kV Dhalkebar – Duhabi second circuiting by 2020	

Transmission lines planned for evacuation from generation projects		
1	132 kV Rahughat – Pokhara by 2011	
2	132 kV Upper Marsyangdi – Middle Marsyangdi by 2011	
3	132 kV Chameliya – Ataria by 2012	
4	132 kV d/c Likhu 4 – Khimti Khola 1 by 2012	
5	132 kV Budhiganga – Ataria by 2012	Budhi Ganga plant is planned for completion by only 2019.
6	220 kV d/c Upper Seti – New Bharatpur by 2013	
7	220 kV d/c Upper Tamakoshi – Khimti Khola 1 by 2015	
8	220 kV d/c Dudhkoshi 1 – Dhalkebar by 2018	
9	132 kV d/c Andhi Khola – Butwal by 2020	

Source: NEA, 2005b; several 33kV, 66kV and 132 kV lines planned for evacuation from small hydro projects are not included in the above list

3.1.7 System operation

NEA has a state-of-the art control center at Siuchatar in Kathmandu equipped with supervisory control and data acquisition systems (SCADA) and energy management systems (EMS) technology allowing it to reduce system collapses drastically while providing improved scheduling and dispatching activities with the help of efficient communication facilities. The total number of system outages during 2004-05 was reduced to 23 from 28 in the previous year. The system restoration time has also been reduced. The cumulative system outage during 2004-05 was 409 minutes against 569 minutes the previous year. The average system restoration time during 2004-05 was 18 minutes (Source: NEA, Fiscal Year 2004/05-A Year in Review, NEA, 2005d)

IRG visited the Siuchatar control center on 27 November 2005 to observe real-time operations. As noted earlier, there are no significant generation facilities in the eastern region (east of Lahan) and the western region (west of Lamahi) in Nepal. To meet the daytime load in these regions, hydro power from the central region is moved over long transmission links resulting in heavy losses. The peak-load in these regions is met by imports from India (from Tanakpur to Mahendranagar in the west and from Kataiya to Duhabi in the east) and by running the high cost Duhabi multi-fuel thermal units (up to 25 MW). To facilitate imports from India, every day eastern and western sections of the INPS are disconnected at about 5 PM to connect with the Indian grid; they are reconnected to the INPS at 10 PM.

3.1.8 Review of existing interconnections with India and NEA Transmission System Modeling

An analysis of the three, existing 132 kV interconnections between India and Nepal shows the following:

Mahendranagar to Tanakpur

This interconnection is in the extreme west of the country and is used primarily to import power to Nepal during peak conditions from the Tanakpur hydro plant in India. Although this interconnection is geographically connected to the deficit Northern region of India, it is not well suited for exports from Nepal for two reasons:

- There is little generation in western Nepal; generation form the 750 MW West Seti project located here will be evacuated to India via a dedicated transmission line
- Exporting significant amounts of power past India's Tanakpur plant may require a significant reinforcement on the Indian system.

Bardghat via Gandak to Ramnagar and Muzaffarpur

This interconnection is in the centre of the country, relatively close to the load centre at Kathmandu and most of Nepal's generation facilities. A 132 kV line runs from the Bardghat substation to the Indian substation at Muzaffarpur via Gandak where there is 15 MW of generation, Ramnagar, Bettiah and Motihari. The Indian part of this line lies in the state of Bihar. This circuit can be used both to import and export power and is analyzed in Section 6.0.

Duhabi via Kusaha to Kataiya

The Kusaha substation is located close to Duhabi in eastern Nepal. The 132 kV transmission circuit extends beyond Kataiya in India to Purnea, where it interconnects to a 220 kV system in India. This interconnection is used under peak conditions to import power to Nepal from India. It does not appear suitable for export from Nepal for the following reasons:

- The eastern region of Nepal is a deficit area requiring imports from India; no generation plants are proposed in NEA's recent generation expansion plan
- The market for Nepali power in India is located in the western, northern or southern regional grids; the eastern region of India has a surplus. The power exported from Nepal to India's eastern region will have to be wheeled back to other regions resulting in significant transmission losses and wheeling charges.

NEA Transmission System Modeling

Because of the comparative simplicity of the Nepali 132 kV transmission system, it is possible to produce a simplified model of the system. NEA has developed such a model using the internationally recognized PSS/E software that maps the demand and generators onto a substation on the 132 kV spine. In most cases, the mapping is unambiguous; in other cases approximations has been made as shown below:

- Kali Gandaki is mapped onto Butwal
- Damauli, Pokhara and its associated substations are mapped onto Bharatpur
- Marsyangdi is mapped onto Bharatpur
- Siuchatar and the Kathmandu demand are mapped onto Hetauda.

Demand and generation are taken from NEA sources (NEA, 2005c). The generation follows the hydro- only scenario with medium load growth and limited export capacity of NEA. To model the fact that some plants only operate at peak demand, the following assumptions have been made:

- Hetauda diesel only operates at demand levels above 95%
- Multifuel plant at Duhabi only operates at demand levels above 90%
- Hydro storage plant at Kulekani-2 only operates at demand levels above 85%
- Hydro storage plant at Kulekani-1 only operates at demand levels above 82.5%: between 80% and 82.5% demand, half of Kulekani-1 operates[7].

3.2 Power system of India

The power system in India is the fourth largest in the world, with an installed capacity of nearly 127,000 MW. In FY 2005 (April 2005 to March 2006), utilities generated 617 TWh of energy while captive generators produced another 68 TWh. The transmission system comprises over 280,000 cct-km of high and extra-high voltage transmission network (132 kV, 220 kV, 400 kV, 500 kV high voltage direct current (HVDC) connections, and a few 765 kV lines operated at 400 kV) and is organized into northern, northeastern, eastern, western and southern electrical regions. Each region has interconnected power systems with neighboring states within the region and limited inter-regional connections mainly through HVDC back to back stations. Constitutionally electricity is the dual responsibility of both central and state governments. The major players in the power sector are the 21 State Electricity Boards (SEBs), 8 state electricity departments (EDs), the 6 EDs of the Union Territories; and key central sector organizations such as the National Thermal Power Corporation Ltd. (NTPC), National Hydroelectric Power Corporation Ltd. (NHPC), Nuclear Power Corporation Ltd. (NPC), Neyveli Lignite Corporation Ltd. (NLC), North Eastern Electric Power Company Ltd. (NEEPCO), Bhakra Beas Management Board (BBMB), Damodar Valley Corporation Ltd. (DVC), Power Grid Corporation of India Ltd (POWERGRID), Power Finance Corporation Ltd. (PFC), and the Power Trading Corporation Ltd (PTC). Approximately 62% of the generating capacity is owned by the states, 26% by central government organizations, and 12% by private sector companies. The Central Electricity Authority (CEA) is responsible for overall system planning and the Central Electricity Regulatory Commission (CERC) and the State Electricity Regulatory Commissions (SERCs) are responsible for regulatory functions.

3.2.1 Generation and demand

Table 3.12 presents installed capacity in India by type of fuel used and Table 3.13 presents this information by fuel-type and ownership.

[7] These assumptions on Kulekhani are modeling approximations, made for simplicity. In reality, the output of both Kulekhani plants will be increased together (as they use the same water) from about 80% load up to 85% load.

Table 3.11: Region-wise installed capacity in India Year (March 2006)

Region	Installed Capacity (MW)				
	Hydro	Thermal	Renewable	Nuclear	Total
Northern	11,071	20,611	920	1,180	33,782
Western	6,476	25,882	1,085	1,300	34,743
Southern	11,027	20,053	3,829	830	35,819
Eastern	2,467	14,021	193	0	16,681
Northeastern	1,095	1,223	125	0	2,443
Islands	0	70	5	0	75
Total	**32,135**	**81,859**	**6,158**	**3,310**	**123,543**

Source: Annual Report 2004-2005, Ministry of Power, GOI (MOP, 2005)

Table 3.12: Installed capacity in India, by Sector

Type	Installed Capacity			
	Central Sector	State Sector	Private Sector	Total
Hydro	6,172	25,053	910	32,135
Thermal	30,426	41,898	9,535	81,859
Renewable	0	3,496	2,662	6,158
Nuclear	3,310	0	0	33,110
Total	**39,908**	**70,447**	**13,187**	**123,543**

Source: Annual Report 2004-2005, Ministry of Power, GOI (MOP, 2005)

In 2004-05 the peak load deficit was estimated at 11.7% while the energy shortage was 7.4 percent. The Central Electricity Authority (CEA) of India conducts extensive demand forecasts every five years. The forecast method is a combination of *end use method* and a *time series analysis that*, involves a micro level forecast of electricity end use in various sectors where sufficient historic data is available and projected future electricity use is well defined. The estimated demand for peak power and energy as per the 16th electric power survey (EPS) is given in Table 3.14

Table 3.13: Load forecast for India

Year	Energy demand (TWh)	Peak demand (MW)
2006-07	719	115,705
2011-12	975	157,107
2016-17	1,319	212,725

Source: 16-th Electric Power Survey of CEA, 2001 (CEA, 2001).

During the 10th five year plan (2002-2007) nearly 41,100 MW of new capacity is planned with an additional 61,000 MW projected during the 11th Five Year Plan (2007-2012). The estimated peak deficit and energy shortages at the end of the 11th plan in 2012 are anticipated to be 10.5% and 8.4% respectively. Anticipated capacity additions during the 10th Plan are likely to be about 70% of the planned capacity and hence shortages will likely be higher.

3.2.2 Transmission system

The Indian grid is operated at a nominal 50 Hz, although the frequency often falls well below 49 Hz. The main transmission system voltages are 400 kV and 220 kV in most parts of the country. Salient system details are given in Table 3.15.

Table 3.14: Details of the transmission system in India

Details	Central Sector	State Sector	Total
Transmission Lines (cct-km)			
765 kV*	937	409	1,346
400 kV	42,057	23,026	65,083
220 kV	9,232	98,946	108,178
HVDC lines (500 kV)	4,368	1,504	5,872

(* presently operated at 400 kV)

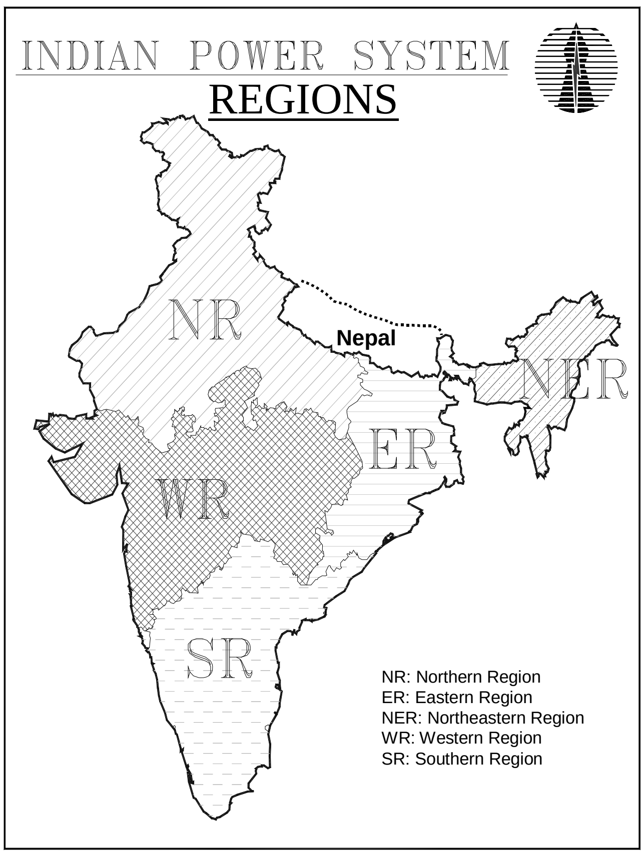


Figure 3.6: Electricity regions in India

As shown in Figure 3.6, the power system in India is operated as five regional grids. The northern region is short of both energy and power throughout the year while the western and southern regions experience a severe shortage of peak power although they have an energy surplus during the rainy season (June-Sept). The eastern and northeastern regions have surpluses at all times. The total inter regional power transfer capacity is 9,300 MW and is expected to increase to 37,000 MW by 2012. Since 2003, the western, eastern and northeastern regions are connected synchronously and are operated as a single grid at one frequency. The northern grid is scheduled to be connected synchronously to the eastern region in 2006, when the Tala transmission system is commissioned. Only the southern region will operate as a separate grid.

3.2.3 Industry structure

The Electricity Act 2003 (passed by the parliament in 2004) and the National Electricity Policy issued in February 2005 have given a fresh impetus to the ongoing reforms and restructuring of the power sector in India that were initiated in 1991. The Electricity Act made it mandatory for all the SEBs to un-bundle into separate generation, transmission and distribution entities. The important objective of the National Electricity Policy is to provide electricity access to all households by 2012. The Electricity Act guarantees open access to transmission and distribution facilities for consumers with a minimum load of 1 MW. Realization of these goals demands massive investment in generation, transmission, distribution and strengthening of legal and regulatory institutions. In order to achieve these goals the policy envisages:-

- addition of 100,000 MW of new generation capacity by 2012;
- construction of 60,000 cct-km of new extra high voltage transmission lines;
- increasing inter-regional power transfer capacity from 9,500 MW to 37,000 MW by 2012.

Currently, there are some privately-owned transmission lines connecting IPP plants to the grid. The present law permits private investment in the transmission sector and the CERC has framed norms for competitive bidding for private transmission projects. The Electricity Act also ensures open access on the transmission system for other market players – power traders and bulk consumers.

The SEBs account for nearly 80% of commercial electricity sales. The fiscal deficits of the SEBs, however, continue to increase owing to their inability to recover the cost of service in their tariffs owing to political and regulatory malaise. This situation affects all the SEBs and makes private investment in their unbundled G, T and D sectors extremely problematic. Furthermore, transmission and distribution losses in the country still average above 30% with many states reporting losses above 40%.

The Electricity Regulatory Commission Act, 1998 was enacted and the CERC was established on 2 July 1998. However as of March 2006, SERCs were constituted in only 22 states. Out of 21 SEBs, 13 have unbundled, and 8 are in various stages of reform. Two (2) states have privatized distribution.

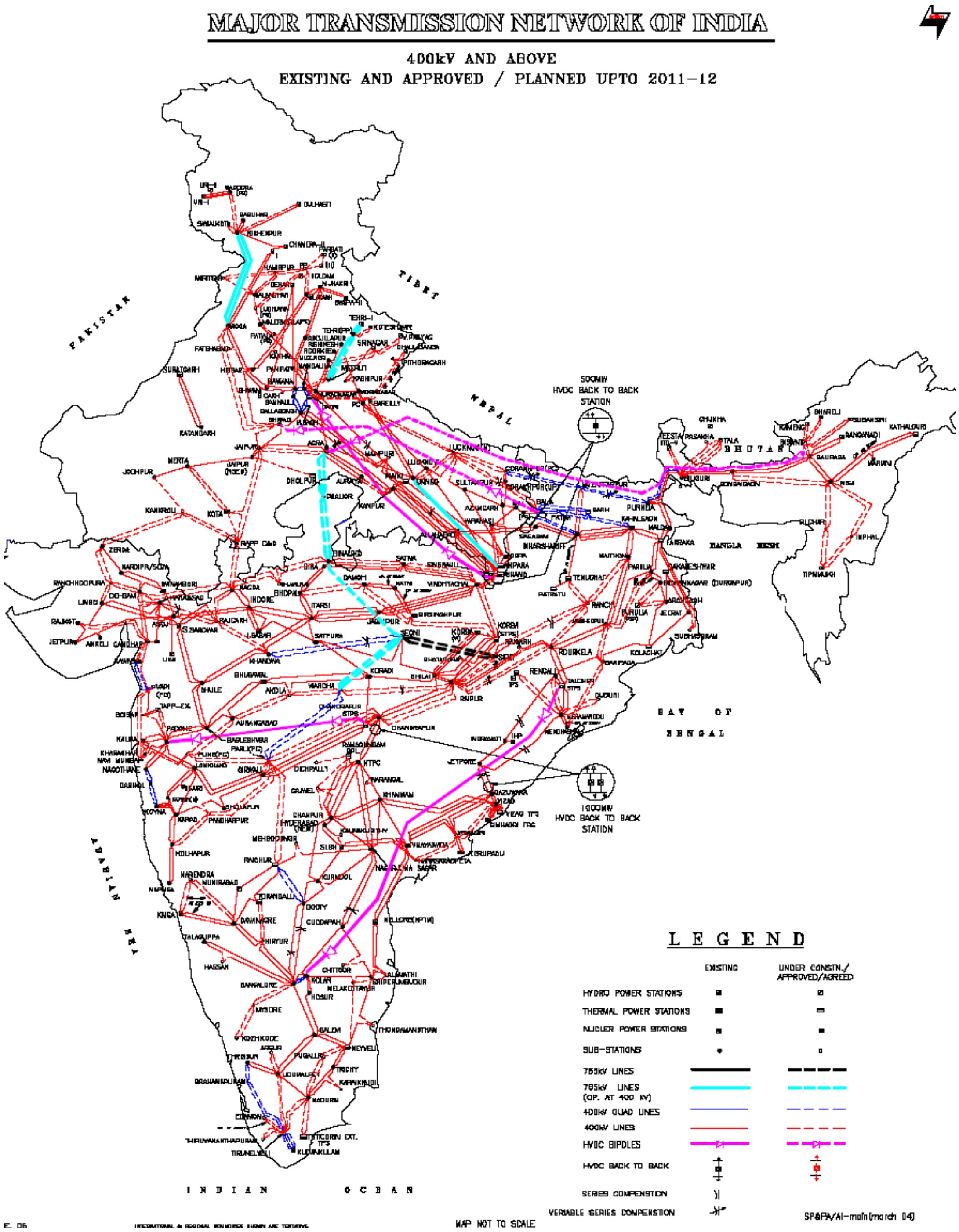


Figure 3.7: Power system map of India

The power trading market in India is mushrooming with over 200 entities including 16 power trading companies. Trading is carried out through both long and short term contracts. An Availability Based Tariff (ABT) system introduced in 2003 has been a vital force in achieving grid discipline. As a result, grid disturbances have been reduced drastically. Under the ABT system, any unscheduled draw of power from the grid by any member is assessed a penalty varying according to the grid frequency.

3.2.4 National transmission grid and National load dispatch centers

The five Regional Electricity Boards (REBs) were constituted to coordinate power trade between the SEBs and the central sector generating plants in each electricity region in 1964. These REBs which were given statutory authority in 1991 functioned under the CEA. Under each REB, regional load dispatch centers (RLDCs) were established during the early 1970s; however, these RLDCs were first transferred to POWERGRID and subsequently modernized with SCADA systems and EMS. As part of the modernization of the RLDCs, all the state load dispatch centers (SLDCs) in the country (32 SLDCs) were upgraded and modernized. Presently a national load dispatch center (NLDC) is being set-up in New Delhi. This NLDC combined with the other RLDCs is expected to become an independent body in control of the functioning of the national grid by 2007.

3.2.5 Role of Private Sector

The major objective of the 1991 power sector reforms was to make the sector attractive for private sector investment. This has not yet occurred despite nearly 15 years of reform policies. Against a target of 2810 MW of private sector plants in the eighth five year plan (1992-97), only 1430 MW was built. In the ninth five year plan (1997-2002), against a target of 17588 MW of capacity additions through private sector projects, only 5061 MW of capacity was built. The major impediment to development of private sector projects are:-

- delay in financial closure of the projects;
- frequent changes in policies;
- absence of adequate arrangements for ensuring payment security owing to the poor financial health of most SEBs; and
- governance issues.

However, the passage of the Electricity Act 2003 revived the interest of Independent Power Producers (IPPs) and 11 IPPs, totaling over 4000 MW achieved financial closure during 2004-05, though most of these were by Indian investors.

3.2.6 Role of Power Trading Corporation in Nepal-India Power Trade

The PTC is the nodal agency for power imports from Bhutan and Nepal to India. The NEA, the IPPAN, and IRG have had a number of discussions with the PTC regarding purchase of small and large power purchases from Nepal. The PTC has consistently stated that it will purchase surplus energy that is available. The PTC maintains that it needs some guarantee of the quantum and timing of such energy before it can provide a purchase price for the same since pricing is controlled by the regulatory regime in India. Discussions in this regard between the NEA and the PTC are in an advanced stage. NEA is reported to be considering providing guaranteed exports, albeit representing a small quantum of energy because of the overall attractiveness of such export. The IPPAN has had similar discussions with the PTC and has identified the opportunities for power trade with India to take advantage of the following:

- Sale of surplus power from the IPPs on an ABT to take advantage of the daily time lag between the Nepali and Indian system peaks
- Purchase of low cost power from India to meet potential deficits now and in the coming years

3.2.7 India's cooperation in electricity sector with neighbors

India has cooperated in electricity sector development with Nepal and Bhutan for several decades. There are 21 connection points across the Indo-Nepal boarder including three 132 kV lines (the rest are 33kV and 11kV lines). India imported 110.7 GWh from Nepal and exported 241.4 GWh to Nepal in 2004-05. Trishuli (21 MW), Devighat (14 MW), Gandak (15 MW) and Pokhara (1 MW) plants in Nepal were constructed with financial and technical cooperation from India. Indian agencies (both governmental and the private sector) have expressed interest in development of large hydroelectric plants in Nepal but to date progress has been slow.

India started exchanging power with Bhutan in 1989. More than 75% of Bhutan's 444 MW capacity is exported to India. The Chukka (336 MW) and Kurichu (60 MW) plants in Bhutan have been built with Indian financial and technical assistance. These plants are connected to the Indian grid and are operated as part of it. The 1,080 MW Tala project started exporting power to India earlier in 2006.

3.3 Important Observations

Following are IRG's observations on the Nepali and Indian power systems:

- The demand for electricity in Nepal is growing at a rate above 8% per annum both for peak capacity as well as for energy. However, the pace with which new generation capacity is being added is much slower than that required to meet the demand growth. Among the major reasons for the slow growth are political uncertainties of the past decade, a lack of NEA's internal resources for major project development and the need for Nepal to obtain donor/private sector funding for its power sector investment, withdrawal of WB, ADB, and other international agencies from significant hydropower investment, and a slow-down in international private investment in power sector following the Enron debacle. However, with the recent reassessment by the WB and ADB to hydro project developments in South Asia, and a burgeoning Indian economy, there is, now, a window of opportunity for Nepal to initiate commercial power trade with India.
- The Indian utility industry and the government are under enormous pressure to improve power supply because the consumers do not see low quality power supply with frequent brown-outs and black-outs as options for the future.
- By 2010, demand for electricity in Nepal will be about 822 MW during winter months; but the maximum peaking capacity will be 772 MW or less if no significant additions are made. While the NEA and the IPPs are working towards additional generation, Nepal will have an estimated 550 GWh of surplus energy that has no

domestic market energy available for export in 2010. This surplus will increase over time.

- The eastern and western sections of the INPS may be connected permanently to the Indian system under normal conditions while the surplus energy available during the day time in the central region can be exported to India through a continuous transmission link. Imports from India are likely to be cheaper than running multi-fuel plants. Synchronous operation of the western and eastern segments of the INPS with the Indian grid may be feasible and may facilitate a totally integrated power system between Nepal and India that will in turn accelerate the efficient cross border trade in electricity.
- If a continuous/permanent transmission link between Nepal and India is established, Nepal will be able to sell at least some of its surplus energy, effect more efficient operation of its system, and import less expensive energy to meet some of its demands.
- The shortage of power in India's northern, western and southern regions is likely to increase in the foreseeable future. There are transmission constraints within the Indian system restricting power evacuation from the eastern to the northern region. However, such constraints are being addressed in an accelerated manner by Indian agencies.
- The PTC has stated consistently that it is interested in importing available energy from Nepal even in small quantities
- It is a prudent and timely opportunity to explore establishing a continuous transmission link between Nepal and India to foster commercial power trading on the transmission link for both export (and import) of energy

4. FOUR BORDERS INTERCONNECTION REPORT RECOMMENDATIONS

In 2000, USAID launched the South Asia Regional Initiative for Energy Cooperation and Development (SARI/E) program to build energy linkages among the countries of South Asia – initially Bangladesh, Bhutan, Nepal, India, Sri Lanka and the Maldives; later Pakistan and Afghanistan were added to the program. SARI/E's goal is to promote energy sharing and cooperation to improve the regional energy supply-demand balance thereby enhancing the energy security of the individual states and the region. The SARI/E program organized activities promoting regional power exchanges and development of a regional power transmission network to provide access to untapped energy resources and to enhance regional energy security. Under SARI/E, USAID prepared a pre-feasibility study in 2001 for establishing an electricity transmission interconnection across the four-border region of Bangladesh, Bhutan, Nepal and India (Figure 4.1). The major findings and recommendations of this study were published as "Four Border Interconnection Report" (FBR). A summary of the report's recommendations and their effect on the current study is presented in this chapter. A more detailed review of the FBR is presented in Appendix E.

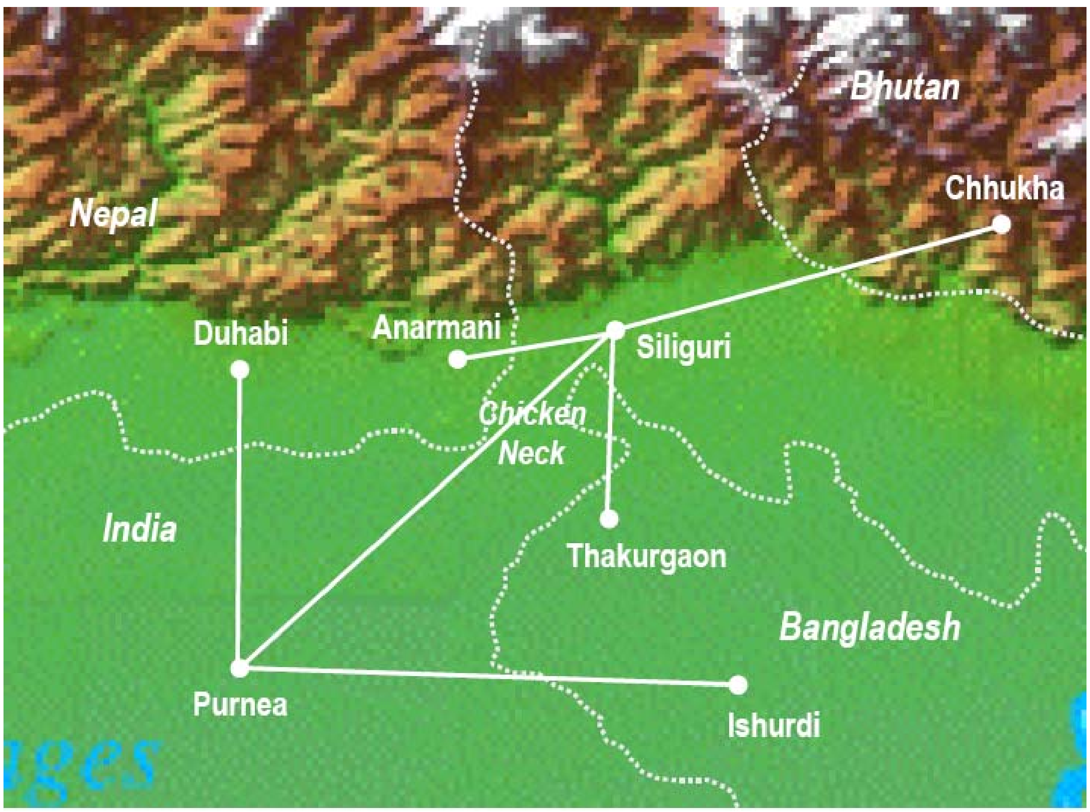


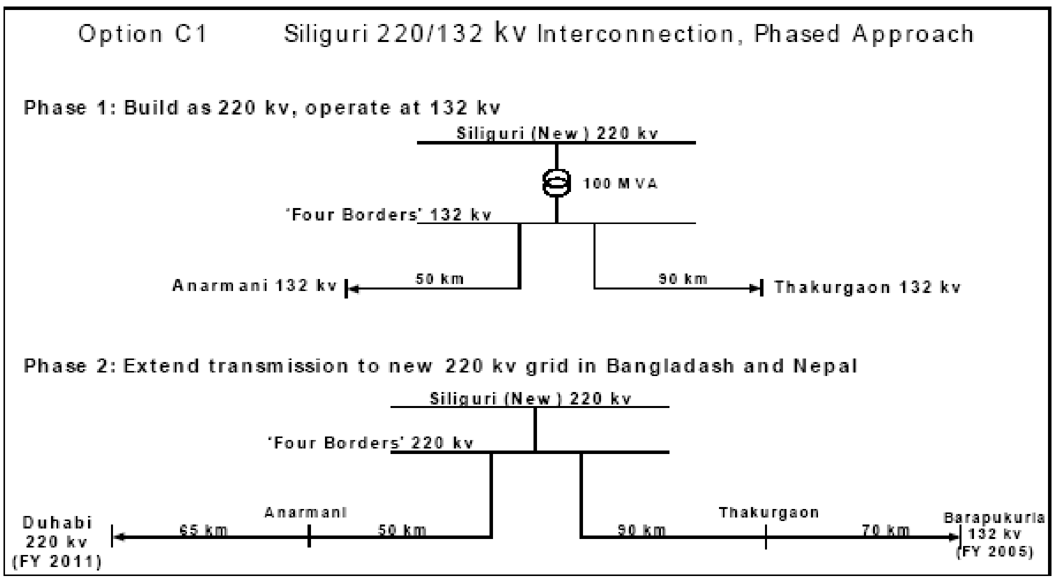
Figure 4.1- Location of Four Border Connection

4.1 Preferred Interconnection

The FBR recommended moderate power transfer with a phased development of a 132 kV system initially and upgrading it to a 220 kV system in conjunction with power sector developments in Bangladesh and Nepal allowing - for power exchanges up to 500 MW. The report recommended the main interconnecting substation to be located at Siliguri in West

Bengal, India. The scheme proposed was to be implemented in two phases. Under Phase-1, a 220 kV line would be built from the Anarmani substation in Nepal's east to the proposed 220/132 kV Four Borders Substation adjacent to the new 400/220 kV substation in Siliguri; simultaneously a 220 kV line from Siliguri to Thakurgaon in Bangladesh. The interconnection would be charged at 132 kV initially. Under Phase-2, the 220 kV line from Anarmani to Duhabi in Nepal (65km) and from Thakurgaon to Bakarpuria in Bangladesh (70km) with the assumption that national utilities in Nepal and Bangladesh would previously have built necessary 220 kV substations at Duhabi and Bakarpuria. This option shown below, presumes that the 132 kV facilities built under Phase-1 will be retired after construction of Phase 2.

The study apparently did not analyze stability of the interconnection and merely noted that a back-to-back HVDC interconnection was found to be too costly for the level of power expected to be transferred during the time frame of the study. The study calculated the transmission cost between 2.6 cents/kWh to 0.22 cents/kWh depending on the amount of power transferred.



The FBR concluded that:

- Transfer of surplus power available from hydropower plants in Nepal and Bhutan through this interconnection could help reduce power deficits in India and Bangladesh. The interconnection would improve system stability and reduce transmission system losses in the region by about 90 MW.
- The option assessed would permit the transfer of power from 50-500 MW depending on which option is selected up to approximately 500 MW. Investment requirements for these options would be low, ranging from approximately $9 million to $52 million.
- Estimated levelized transmission costs for the options range from 2.6 cents per kWh for power transfers of 50 MW to 0.2 cents per kWh for transfers of 500 MW.
- All of the options analyzed have positive rates of return, which increase significantly with the level of power transferred.
- All the options reviewed could be implemented between 2005 and 2010.

- All of the options would have a have minimal environmental impacts, as they rely extensively on existing facilities.

4.2 IRG's Observations on the FBR's recommendations

The interconnection options recommended in the FBR have been eclipsed by the passage of five years during which time Nepal has done little to enhance its power export capability and India has become concerned by its energy security. While many of the legal, regulatory and ownership issues and the next steps recommended in the FBR are logical and still remain valid options for implementing the project, the Government of India (GOI) has stated publicly that its energy policy with neighboring countries will be conducted only on a bi-lateral basis and that it does not support the FBR as a model for electricity trade. This point was reiterated by the Ministry of Power, GOI to IRG in a meeting in November 2005 (Appendix B). Owing to its geography and size, it will be difficult for any regional program to be successful without the cooperation of India. Indeed without the support of the GOI, the prospect for Nepali/Indian electricity trade to expand within a larger regional context is at best remote. This however in no way obviates the possibility for additional bilateral trade between the two countries with the active involvement of both nations' private sectors.

5.0 POWER MARKET ANALYSIS

The present and future peak power and annual energy demand in Nepal and India are discussed in this section in the context of commercial power trade between the two countries.

5.1 Power market in Nepal

5.1.1 Demand forecast

As part of its Power System Planning Studies, NEA prepared a load forecast for major consumer groups (residential, industrial, commercial, irrigation, and others) using several economic parameters including (GDP), population statistics, income and price elasticity etc. Forecasts for selected years are shown in Table 3.3. NEA's recent demand forecast is reproduced in Table 5.1 below:

Table 5.1 Recent load forecast for Nepal

Year	Load Forecast NEA, 2004-05	
	MW	GWh
2010	822	3,599
2015	1,220	5,450
2017	1,398	6,367
2020	1,733	7,894
Average Growth rate for 2010-2020 % per year)	7.7	8.2

*Actual recorded for the year 2004-05

5.1.2 Load Profile in Nepal

Historic data for electricity sales indicate that 41% of consumption is in the domestic sector and 42% in the industrial sector. Consumption data for 2004 is shown in Table 5.2.

Table 5.2: Consumption by Sector (2004)

Sector	Annual consumption in 2004
Domestic	41%
Industrial	42%
Commercial	6.5%
Street Lighting	3.3%
Water Supply & Irrigation	1.9%
Other	5.3%

The load profile on a typical wet season (September) and dry season (December) peak and average days are shown in Figures 3.2 to 3.4.

Since the historic data indicate a lower rate of growth in the industrial sector compared to the domestic sector, and the GON is pursuing an accelerated rural electrification program, NEA expects no significant change to the daily load profile in the near term.

5.1.3 Generation

Available and proposed generation capacities are presented in Table 3.1. Table 5.3 summarizes estimated generation in 2010:

Table 5.3: Available and proposed generation capacities (2010)

Plant Details	Installed Capacity (MW) (1)	Capacity available at winter peak December (MW) (2)	Annual Energy available (GWh/Year)	Total NEA energy production plus purchase in 2004-05 (GWh)
Existing Hydro Plants of NEA (includes only grid-connected plants)	401.97	371.85	2,171.79	1522.90
Existing IPP Plants (all Hydro)	148.58	879.51	909.21	864.80
Sub- Total Existing (only Hydro)	550.55	461.36	3,081.00	2417.70
Thermal	56.69	43.80	(3)	13.7
Total Existing Generating Capacity (June 2006)	607.24	505.16		
Imports from India (2006/07)		72		
Total 2006 capacity		577.16		
Total : Existing + Proposed 2009/10 (excluding import)	772.0	702.2	4,105.0(4)	
Total : Existing + Proposed 2015/16 (excluding import)	1,686	1,533.1	9,500.0 (4)	

Sources: Data to compile the table were taken from several NEA documents as noted below
(1) NEA, 2005c
(2) NEA, 2006a
(3) Thermal units are used sparingly and only on an as needed basis; hence, annual energy availability is not meaningful
(4) Available energy includes surplus available at existing (2006) IPP plants

5.1.4 Future Generation Scenarios

IRG used "NEA Report on Transmission Planning Study 2005 (August 2005)" and "NEA Generation Report, Third Issue (August 2005)" as the basis for analyzing interconnection options and assumed that all Generation plants (Table 3.4) and Transmission reinforcements (Table 3.9) identified in these documents are constructed and connected to the INPS on a schedule identified in these reports. IRG estimates that surplus hydro energy in Nepal's system during 2009/2010 and 2015/16 will be respectively about 100 GWh and 520 GWh per month during monsoon (approximately 120 MW and 600 MW of capacity respectively).

In addition to NEA's generation planning assumptions, the private sector is contemplating development of several projects in the Eastern region. Among them, the lower Bhotekoshi projects (120 MW), other Khimti developments (80 MW), and Arun River developments (up to 1,000 MW) are noteworthy. These plants will be located in Nepal's principal economic development corridors. The Indian Ministry of Power is interested in large (>500 MW) dedicated projects for export such as the 750 MW West Seti project. Such plants might initially be connected to the Nepali system supplying perhaps 10-20% of its output to the Nepali system. However, smaller projects developed for domestic and export use will likely form a significant part of Nepal's exports. The NEA has been unable to realize its generation planning and transmission planning schedule in the past. However, given the variety of possible developments and the history of development of hydro projects in Nepal, IRG believes that the assumed future generation figures have a reasonable chance of implementation since alternative energy costs are soaring. Future governments will have no choice but to commit to and implement such hydro development projects to keep the country's economy from falling behind any further.

Nepal may have a peak power deficit of 100-150 MW in 2010 but will have approximately 580 GWh of surplus energy available for export during the months of May through November. Nepal may have a surplus both in peaking power and energy for export, once the proposed Upper Tamakoshi plant comes on-line by 2013/14. The peak power deficit until that time is most likely to be offset with imports from India.

5.2 Power market in India

5.2.1 Electricity Act of 2003 and power trading

Except for a few licensees from the pre-independence era (BSES, BEST, CSEC, AEC etc), and in two states where distribution has been privatized (Delhi and Orissa), the distribution of electricity in most parts of the country is still under the control of the SEBs and their spin-offs. The SEBs own and manage their generation, transmission and distribution assets. Private generating companies and central government owned generating companies sell electricity to SEBs (and in some cases some bulk consumers, distribution licensees, railways and power traders). Historically both central government and private agencies were allowed to fix their tariffs based on formulae that ensured a minimum return on investments. While the majority of the existing private plants are built under long term PPA, central government owned plants are built on a production allotment to beneficiary states at agreed prices. Prior to commencement of power trading in India, the unused quota of one state from a central sector project used to be allotted to another state while finalizing monthly/weekly and daily dispatch schedules. Now the beneficiary state has the option to sell its unused quota to any buyer in the market. The latest policies are oriented towards bringing about a competitive power market.

Transmission is a licensed activity in India and the private sector is allowed to build transmission lines. Licenses for inter-state transmission lines are issued by the CERC and licenses for intra-state transmission lines are issued by the respective SERCs or where they do not exist by the state authorities. The existing transmission lines are built on bulk transmission tariffs that ensure an agreed return on investment (14%) plus full recovery of operation and maintenance costs. The allowed O&M cost is based on the guaranteed availability of the transmission system. The licenses for new transmission licenses are issued on competitive bidding principles finalized by the CERC. The Electricity Act 2003 ensures open-access on the transmission system and that transmission system operators are not allowed to engage in power trading. According to the Electricity Act, generation does not require any license; but the new tariff policy envisages allotment of generation projects through competitive bidding in the future. Open distribution access for bulk consumers (with a minimum demand of 1MW and above) is underway and will introduce competition at the distribution level.

In the power market, both long term and short term contracts are operated; and day-ahead trading is expected to start soon. An ABT regime has been implemented across the country and all market participants who draw more than what is scheduled for them, pay much higher charges. This process is called "un-scheduled interchange charges" (UI Charges). UI charges are higher as frequency on the grid goes down. Some of the current UI rates are shown below:

Frequency	UI Rate
49.65 Hz.	\$0.063/kWh (\$1=INR44.37; NR1.6=INR1)
49.60 Hz.	\$0.067/kWh
49.26 Hz.	\$0.102/kWh
49.21 Hz.	\$0.108/kWh
48.90 Hz.	\$0.128/kWh

Since implementation of the ABT, grid discipline among the participants has improved contributing to higher levels of grid stability.

5.2.2 Price of electricity in India, ability to pay for Nepal's export

Exports to India will be through the PTC which is an established agent trading company and hence, payment for energy sold to PTC would be guaranteed at agreed to prices.

The only precedent for setting a purchase price for electricity sold across the border is the PTC agreement with the SMEC for the West Seti project. As reported in the news, this price is \$0.0483/kWh (2005) for long-term guaranteed power and energy delivery at the Nepal-India border. It is understood that the power will be transmitted several hundred kilometers to substations near New Delhi. Clearly, West Seti pricing is not a good example to estimate the possible price of Nepal's surplus energy which would be delivered at a local substation in India. The lowest off-peak price in India is currently around \$0.022 (INR1.00) per kWh; peak energy values are as high as \$0.11 (INR5.00) per kWh. The average domestic tariff in India which was around \$0.435/kWh in 2002 is now nearly \$0.065 (INR3.00) per kWh. An average price of \$0.0435 (INR2.00) per kWh appears not unreasonable for Nepal's surplus energy.

Since the volume of any energy sale to the PTC must be guaranteed, it is logical to assume that a portion (say 70 percent) of the estimated annual surplus energy could be guaranteed for delivery while the rest of the actual surplus could be sold in the open market at available ABT prices. Since this quantum of energy cannot be guaranteed for any length of time, a lower average sale price of \$0.03/kWh is considered reasonable. Thus the average price of surplus energy is estimated at \$0.04 (INR1.82) per kWh and used as a base case in the financial analysis of the various options described in Section 6.

5.2.3 Mechanism for selling Nepal's energy to India

NEA does not have the mandate to export energy to India. Therefore IRG believes that the private sector or a PPP should be allowed to run this business since it is in a better position

(1) to conclude the requisite operating agreements for the purchase of surplus energy from the NEA and the numerous IPPs in Nepal, (2) to negotiate wheeling charges with the NEA and other transmission line owners for transmission of the surplus energy to the border transfer point, (3) to take the supply risk arising from having to guarantee a designated portion of the surplus energy to the PTC, (4) to monitor the market, and (5) to trade actively in the Indian market to maximize the value of energy sold on ABT basis. International power trade is an evolving business in the region and requires trading, risk management, and contract negotiating expertise on a 24-hour basis. The rewards are commensurate with the risk and should be left to the private sector. IRG recommends that any transmission interconnection between Nepal and India be developed and operated by the private sector or public-private partnership mechanisms such as the Tala transmission line system developed by the Tatas and PowerGrid.

5.2.4 Private Sector Interest in Nepal-India Power Trade

IRG held extensive discussions with IPPs on both sides of the border regarding their views on the quantity, availability, quality, pricing methodology etc of power available for sale/purchase between the two countries. IRG assessed IPP interest in the design, construction and operation of TL (s) for use by IPPs, NEA and other market participants. IRG also explored alternative investment/financing/ownership arrangements of the TL (s) with the IPPs both in Nepal and India. Despite the clear economic benefits that will accrue to each country as a result of new electricity transmission links, political perceptions on each side of the border continue to cloud their implementation.

The IPPAN was very enthusiastic about a transmission link between the two countries, a lack of which currently hampers surplus energy sale from existing IPP plants. The IPPAN believes that power trade options with India are increasingly attractive and will prove an impetus for further IPP development. The possibility of power trade on ABT basis provides an exciting opportunity for the Nepali private sector to increase the value of its investments in Nepal.

Major local IPPs are clearly excited about the prospects of their involvement in the development of large (>300 MW) and medium sized projects. Many of these projects would likely be developed to meet a combination of domestic demand and for exports. Such projects may not all have dedicated transmission lines for export and may well be through a system of strengthened national grid supplemented by several interconnections with the Indian Grid.

IRG traveled to India to meet with senior Government officials and leading private entrepreneurs involved in the electricity sector. A summary of our meetings and IRG's conclusions are presented below. Appendix B provides a more detailed discussion of our deliberations.

India is currently interested in bilateral power deals with its neighbors not in multilateral approaches such as presented in the FBR. The Ministry of Power (MOP) is interested in purchasing power from Nepal even on a seasonal basis if prices are competitive but its key interest is in large scale (in excess of 500 MW) hydroelectric projects. The MOP is interested in concluding agreements with Nepal on lines similar to the Bhutan model. Small scale projects are of less interest to India since they do not address India's fast growing power needs. There is a sense of resignation among Indian entrepreneurs and government agencies that Nepal is not committed to any significant export of energy to India. One reason for the view is the agonizingly slow progress on the West Seti and other large projects such as the Upper Karnali despite a number of years of effort. Another reason appears to be the lack of public understanding of the benefits arising from power trade and the slanted stories in the Nepali Press regarding private sector participation in power sector.

Nevertheless, private sector developers such as Tata Power and Reliance Energy stated that they are very interested in partnering in a generation or transmission project if there is genuine interest and commitment for accelerated implementation. The PTC stated that it is interested in purchasing large or small quantities of energy from Nepal as long as the supply is guaranteed. Both the PowerGrid and Tata Power were enthusiastic about a public-private partnership to build transmission line projects for cross-border trade.

With improved political situation in Nepal, several international IPPs such as the Tatas, Reliance Power, and GVK Group of India, and investment groups from China, USA, and Norway have expressed serious interest in developing large (1,000+ MW) hydro projects in Nepal in association with larger local IPPs.

In IRG's opinion, it is necessary for Nepal to change its historical view point of its hydropower resource and undertake and implement quickly one project, even if small, to demonstrate the benefits that can accrue to the country. The time is now. A strong candidate for such "pilot" project is a transmission line link to facilitate cross-border power trade, initially to trade surplus energy. In our opinion, such a project, especially, with some financial assistance from the donor community, would go a long way to alleviate the nagging, albeit inaccurate, perception of mistrust between the two countries on such trade. The private sectors in both countries are best positioned to build a bridge of trust through mutually beneficial commercial transactions. Private sector in both countries have not only expressed commitment for such projects but are also, in our opinion, best placed to influence respective governments and regulatory bodies and effect decisions based on meaningful and sound economics.

6.0 OPTIONS FOR TRANSMISSION LINKS BETWEEN NEPAL AND INDIA

6.1 Introduction

The primary objective of this study is to identify and to evaluate the techno-economic feasibility of additional transmission link options between Nepal and India that will enable Nepal to export its surplus energy to India while meeting its short-term and long-term demands. Based on a review of NEA's Generation and Transmission plans, the potential available energy for export, and the availability of Indian market for these exports (Sections 5.1 and 5.2) IRG identified several transmission link options to provide a transmission link that would facilitate power transfer and energy sales between the two countries.. The following sections describe the studies carried out, the merits and drawbacks of the options, and the analyses carried out. Finally a preferred option is recommended for detailed study and implementation.

6.2 Power System Modeling Studies

6.2.1 Approach to Modeling

A review of NEA's existing transmission system model (PSS/E version 24) was presented in Section 3.1.8. IRG solicited and obtained assistance from NEA staff to run this model and calibrated it using the actual data recorded on November 27, 2005 at NEA's Load Dispatch Center by IRG. The calibrated model was run by NEA staff, under guidance and direction from IRG to simulate various scenarios to examine the load-flow of interconnected operations for several of the proposed transmission link options. There are many ways to interconnect the transmission systems of Nepal and India and modeling is labor intensive. Hence, IRG initially identified the most likely locations for a transmission link by examination of the INPS, the major generation and load centers in Nepal and the major strengths and weaknesses of the INPS. A discussion of this screening analysis is set out in Section 3. Following preliminary screening, IRG identified transmission links that were promising for more detailed study and classified the options by export capacity as follows:

- Capacity up to 100 MW (by year 2010/11)
- Capacity between 100 MW and 500 MW (by year 2015/16)
- Capacity above 500 MW (beyond 2016)

Assumptions concerning future generation scenarios (Section 5.1.4) are necessary to model the need to strengthen NEA's transmission system to facilitate exports from selected points in addition to building transmission lines to evacuate power from these generation plants for domestic consumption. The modeling does not require each generation source to be specified and the modeling results would be reasonably robust and valid even if individual power projects were not commissioned as planned as long as comparable generation was available in the transmission line corridors.

For 2010/11 and 2015/16, IRG carried out load flow studies for the wet and dry seasons for both Peak and Off-peak situations covering a number of different options for exports up to 500 MW. For each option and scenario studied, the simulation provided power flows on important transmission lines including the transmission links, voltage profiles, and internal system improvements required within INPS.

The results are discussed in Section 6.4 below and are shown in schematic diagrams in Appendix F.

6.2.2 Transmission Line Assumptions

The transmission lines listed on Table 3.9 are considered to be available in the years indicated for the purposes of this study.

Transmission of electrical energy inevitably leads to losses of power and this is shown by reduced voltages along the length of a transmission line. Often the voltage at the receiving substation falls below reasonable operational limits so that connected customers have an unacceptable quality of electrical supply. One means of supporting the voltage so that it does not fall below acceptable limits is to install Capacitor compensation on the system, normally at the receiving transmission substation as the compensation should be near to the demand to be effective. NEA plans its system to include necessary capacitor compensation to support the voltage on the system. Table 6.1 shows the Capacitor Compensation planned and assumed to be available on the system at different substations during FY 2010-11 and FY 2015-16:

Table 6.1: Planned capacitor compensation

Substation	2010-11 (MVAr)	2015-16 (MVAr)
Lamahi	0	30
Dhalkebar	20	20
Lahan	20	20
Duhabi	10	52.2
Anarmani	0	25
Hetauda Cement	20	20
Simra	45	60
Parwanipur	30	50
Birgunj	10	50
Siuchatar	30.2	30.2
Balaju	35	30
Lainchour	10	10
Chabahil	15	15
Bhaktapur	0	40
Baneswor	15	35
Patan	10.2	20.2
K-3	0	60
Total	**270.4**	**567.6**

6.2.3 Generation Assumptions

The generation plants listed in Table 3.4 are assumed to be commissioned in the years indicated.

6.2.4 Load Forecast Assumptions

Load forecast for the NEA system assumed to be as set out in Table 3.3

6.2.5 Energy Export

Several scenarios were modeled to provide for an export capacity of 100 MW in 2010 and 500 MW in 2016. Actual energy exports will likely be concentrated during the wet season. Almost no energy will be exported during dry months. Based on available surplus energy (Table 5.) and the transmission system's capacity for export of 100 MW in 2010/11 and 500 MW in 2015/16, the likely amount of available energy for export is shown in Table 6.2. In order to take account of individual plant's "no overload" criterion, prudent operating parameters and procedures set forth in individual project PPAs and licenses, IRG has reduced these export figures by 20% in the financial analysis of the options

Table 6.2: Table of Saleable surplus energy: 2009/10 and 2015/16

	Saleable surplus energy GWh		
Month	**2009/10**	**2015/16 and 2019/20 at 420 MW limit**	**2015/16 and 2019/20 at 500 MW limit**
July	59.5	250.0	297.6
August	59.5	250.0	297.6
September	57.6	241.9	288.0
October	59.5	250.0	297.6
November	18.0	241.9	288.0
December	0.6	85.3	85.3
January	0.3	24.6	24.6
February	0.4	5.9	5.9
March	0.8	32.5	32.5
April	2.1	89.2	89.2
May	38.9	203.6	203.6
June	57.6	241.9	288.0
Total	**354.9**	**1916.8**	**2197.9**

6.2.6 Modeling Limitations

While it was not possible to model variations of each option in the study because of time and budget constraints; most major alternatives were analyzed. For year-round exports significantly in excess of 100 MW it will be necessary to build more generation plants than currently planned. Dedicated export projects will likely have their own transmission lines or have transmission reinforcements with the national grid. Such developments will affect the power flows on the INPS and may affect the best way to interconnect the Nepali and Indian systems. Consideration of such developments is outside the scope of this study. However, for an export capacity in excess of 100 MW, it will be most cost-effective to use a voltage level above 132 kV. Also, exporting in excess of 500 MW will require a substantial increase in generation capacity, far above any level plan developed by the NEA. Options for such large level of exports have not been modeled because of the significant uncertainty in selecting generation projects and the unlikelihood of significant strengthening to the existing transmission system. Nevertheless, we believe that that our approach and analysis provide sufficient basis for replication and expansion of the options for such large scale exports.

As described in the TOR, modeling the Indian system was excluded from this study. It is assumed, based on discussions with the PTC and other agencies regarding India's huge power deficit, that the Indian system will absorb all available exports from Nepal as long as the commercial terms and conditions are negotiated by mutual agreement and that a technically adequate system of continuous interconnection is available. Because the Indian system was not modeled, the stability analyses of any AC interconnection are assumed and will need to be confirmed during the TL design phase.

The obvious candidate voltages for Nepal-India transmission links are 220 kV and 400 kV because they are used widely in India.

6.3 Choice between AC or DC

To trade commercial energy successfully requires a continuously connected transmission link so that trading can take place throughout each 24 hour period as opportunities arise. Adequate power trading arrangements have to be agreed upon between Nepal and India to effect this trading. In some countries, power trading takes place on a half-hourly (or even shorter) basis throughout the day and such arrangements enables the best and most efficient use of the transmission link.

It is essential that the transmission link be permanent. The most fundamental issue is whether the two systems should be permanently connected synchronously (by an AC connection) or asynchronously (by a DC connection). Currently the Nepali power system is not operationally interconnected permanently to any other power system. As noted, parts of the INPS are sometimes disconnected from the INPS and connected to the Indian grid; and similarly parts of the Indian grid can be disconnected from the main Indian system and connected to the INPS. While this allows mutually beneficial power exchanges between the two countries the two systems are not synchronously connected.

6.3.1 AC Connection

The simplest and cheapest way to interconnect the Indian and Nepali systems is with an AC connection either via a 132 kV or 220 kV overhead line; these voltages are chosen because they are the standard transmission voltages in the region. An AC connection, however, will cause problems for the Nepali system for several reasons:

- An AC synchronous connection will allow faults from one system to propagate to the other and the Nepali system is so much smaller than the Indian that the Nepalese are worried about the effect of a major fault in India on their system
- Although the two networks have identical nominal system frequencies, the operating norms and practices differ so that the actual system frequencies vary substantially.

Currently the Nepali system uses frequency as a control parameter i.e. generation is adjusted to keep the frequency close to 50 Hz. If the frequency is less than 50 Hz, generation is increased; if greater than 50 Hz, generation is decreased. In fact, the Nepali system operators attempt to keep the system frequency somewhat above 50 Hz, so that the frequency will not fall to dangerously low levels in the event of a loss of generation. However, on the Indian side, particularly in the Northern region, the frequency usually varies between 48 and 49 Hz. The Nepali system is currently set to initiate load shedding if the frequency falls below 49.50 Hz with the final block of load shedding at 48.75 Hz. The Indian Grid is, thus, mainly operating at frequency levels below the load shedding trigger in Nepal.

If an AC transmission link is constructed, then using frequency as an operating control parameter will not be possible; the frequency will be governed by the Indian system. If the Indian system is running at a low frequency, (the normal case), then increasing Nepali generation will increase exports to India, possibly overloading the transmission link. If the system frequency is high, then reducing Nepali generation will result in increasing imports over the transmission link. Instead, Nepal will need to adopt “tie-line control.” This means that Nepali generation will need to be adjusted so that the imports/exports over the transmission link continue to meet a pre-set target.

Furthermore, Nepal has numerous industrial customers who complain to the Load Dispatch Centre (LDC) if the NEA frequency drops. NEA understands that their machines cannot cope with the low frequencies currently seen on the Indian side of the border and their processes may be seriously affected if the frequency falls to the levels on the Indian system. These concerns need to be addressed if an AC synchronous connection is made between Nepal and India.

6.3.2 DC Connection

The two systems can be connected by a HVDC link allowing the INPS to be operated independently of the Indian grid while remaining permanently connected. The HVDC link requires two converter stations, which would convert the AC electricity in one system frequency to DC, before converting it back to AC at the other system’s frequency. The HVDC converters have an added advantage of acting as a barrier, preventing short circuit faults on one system propagating into the other system. This technology may be adopted either with a HVDC converter station located at each terminal substation (i.e. one in Nepal and one in India) with a DC link between them or the two converters can be located on the same substation, in a back-to-back arrangement with an AC link between Nepal and India.

If the transmission link is HVDC, then the power flow on the transmission link can be independently controlled by automatically adjusting the power flow to meet a set target. The system frequency on the INPS can therefore continue to be controlled in the current manner.

HVDC technology was first used commercially over 50 years ago and is now widespread throughout the world. There are many reasons for its use, some of which have been explained above, but normally HVDC links are used:

- For connecting areas with different grid frequencies, or
- For high power transmission over very long distances.

Several states in India are already connected through HVDC links so the technology is not new to the region. There is, however, a large cost associated with constructing HVDC converters which is offset by the lower cost of the DC link as DC lines or cables are cheaper to construct than AC lines or cables (i.e. DC links need less conductors). However the economic cut-off is over 500 km of transmission line so, in considering a proposed link between India and Nepal, all HVDC links would be considerably more expensive than an equivalent AC link.

An HVDC connection between autonomous regions has some operational advantages over an AC interconnection but, for economic reasons, it is almost always preferable to choose an AC connection unless the technical or political issues are insurmountable. To determine whether or not an AC connection is technically feasible requires detailed stability studies to be carried out on both systems which are beyond the scope of this study.

DC connections cost are high, on the order of $200,000/MW. This cost is in addition to the AC transmission lines and other strengthening of the system. For a 100 MW export project, the HVDC cost alone is $20 million, which is on the order or in excess of the cost of AC lines and strengthening requirements. It is therefore necessary to assess the pros and cons of AC and DC connections carefully before making any decision.

6.4 Transmission Link Options

As described above, this study has examined a number of different options for interconnecting the two systems, these are classified below into 2 (two) groups:

- Capacity below 100 MW
- Capacity between 100 and 500 MW

For all options, only standard voltages and overhead line construction currently in use in the region have been considered as this makes integration of systems and future maintenance and spare parts requirements easier. Since the cost of a DC connection will be the same for comparable alternatives, the discussion below refers only to an AC connection. The financial analysis, however, considers both AC and DC connections as alternatives.

6.4.1 Options for Capacity below 100 MW

A capacity below 100 MW can be achieved with a 132 kV transmission link and normally this voltage line will have the cheapest construction cost assuming that an AC connection can be made.

There are currently 3 (three) existing 132 kV circuits interconnecting Nepal and India and these are discussed in Section 3. They have low capacity and operate in a radial (asynchronous) mode but it may be possible to upgrade these links relatively cheaply. In 1999, Nepal and India carried out feasibility studies for power exchange between the two countries and identified 3 (three) possible additional 132 kV transmission link routes, namely:-

- Butwal – Anandnagar
- Birgunj – Motihari
- Dhalkebar – Sitamadhi

Any of these proposed new routes can be used to interconnect the two systems and, if an appropriate type of construction is chosen at the outset, each of these proposals could easily be upgraded as power export potential increases. NEA and the PowerGrid carried out the feasibility work for these connections operating on a radial (asynchronous) mode basis but, as described above, a permanently connected link is required to facilitate commercial power trading. IRG re-examined these connections as part of this study.

The PowerGrid and the NEA had conducted studies on a 132 kV transmission link in the East from Anarmani in Nepal to Siliguri in India. The connection would serve the purpose of import from India to supply Nepal's deficit East. IRG has not considered this transmission link for possible export, since other interconnections appear more attractive.

6.4.2 Options for Capacity up to 500 MW

As described in Section 3, the best place for a transmission link with India is in the central region between Butwal and Dhalkebar. The termination point of such a circuit on the Nepali system could be any 132 kV substation between Butwal and Dhalkebar, ideally between Butwal and Hetauda/Parwanipur.

The termination point in India will need to be at a 220 kV substation with the ideal points at Muzaffarpur (in Bihar) or Gorakhpur (in Uttar Pradesh). Muzaffarpur is about 100km from either Parwanipur or Dhalkebar, and Gorakhpur is about 110km from Butwal (or Bardhgat).

A further option is to connect Duhabi with Purnea in India, although this is not considered to be the "best place" to connect Nepal with India, this location is further to the east and there is currently no large generation facilities planned near here

6.4.3 Options for Capacity above 500 MW

If more than 500 MW is to be exported, then there needs to be a significant increase in installed generation in Nepal. The current and projected INPS is not capable of being used to transfer such large quantities of power from the generation sites to the border and such an interconnection needs to be incorporated into the generation planning process. It is likely that a dedicated transmission line will be required with some integration into the INPS to provide power inside Nepal as well. The alternative is a massive reconstruction of the INPS. Since there are no definite plans for development of large generation projects at this juncture, we have not conducted modeling studies. However, as noted in Section 6.2, our approach provides a basis for future replication and expansion of exports.

6.5 Discussion of Options

There are existing 132 kV transmission links that could be upgraded and connected synchronously between Nepal and India. It is possible to build an transmission link with export capacity up to 100 MW in a number of places on the INPS and three of these have already been examined by NEA and PowerGrid. Any one of these proposed transmission links are feasible for connection in a radial (asynchronous) mode and two of them are located in the Central region that load flow studies have confirmed are the best place for a transmission link. As discussed in Section 3.1.8, the Mahendranagar - Tanakpur interconnection in the West and the Duhabi - Kataiya interconnection in the East were not considered suitable for our study's objectives.

IRG examined the existing third 132 kV transmission link Bardghat – Gandak - Ramnagar (Option 1B, see Table 6.3). Load flow studies show that the Gandak - Ramnagar transmission link could potentially be upgraded by addition of capacitor compensation. This would allow 100 MW transfer for less than a $2M investment but the stability of this link in AC mode has not been established. Also, there is no prospect of expanding the export capability to 500 MW. Hence, this alternative is not considered a good long term prospect but, as it could be implemented quickly for operation in radial mode as now, upgrading this link could be an inexpensive and quick way of improving Nepal's short term power deficit.

As noted, the NEA and PowerGrid considered a 100 MW transmission link between Anarmani at the Eastern end of Nepal to Siliguri in India but its primary purpose would be for imports as there is no power deficit in India in that location and little Nepali generation currently exists there. This would be a sensible way for Nepal to overcome its anticipated power shortage but it does not meet the primary purpose of this study which is to investigate export potential of 500 MW or more. Although a transmission link at the Eastern end of Nepal could be expanded if generation is built there, this study indicated that substantial reinforcement of the INPS, would be disruptive to power supplies in the Eastern part of Nepal. This alternative is, therefore, not considered.

Thus the three potential export links in the central region further considered are all located between Butwal and Dhalkebar namely, moving from West to East, Butwal- Gorakhpur (Option 1A), Dhalkebar - Muzaffarpur (Option 1C), and Parwanipur-Muzaffarpur (Option 2B).

Each of these transmission links may be constructed in phases minimizing the initial investment while power trading is established and experience gained in operating and trading over a continuously connected transmission link. Assuming that an appropriate type of construction is chosen for the first phase, each of these transmission links can then be expanded at a later date as increasing levels of power become available for export.

Load Flow studies show that the Parwanipur - Muzaffarpur link is not capable of exporting more than 240 MW without substantial upgrading of the INPS which would be expensive and disruptive to power supplies in the area. For this reason, this option is not recommended.

The two remaining options the Butwal - Gorakhpur and Dhalkebar - Muzaffarpur interconnections and several sub-options were studied for different line capacities.

<u>Cost Estimates</u>

IRG prepared cost estimates of different options based on current information using NEA's cost for local construction, relevant WB and NEA reports, and vendor information on large equipment (e.g. HVDC back-to-back stations). Details of item costs are included in Appendix F for each option. The costs are in 2006 US dollars.

A summary of the modeling results for these two options and sub-options are shown in Table 6.3

Table 6.3 Options Summary

Option Description	System study Line size/length/stability	Survey findings (major items only)	Line details	Cost without HVDC	Major conclusions/problems
Option 1A Butwal – Anandnagar 132 kV **Or** Butwal-Gorakhpur 220 kV	1. Load Flow study carried out 2. Route walkover survey carried out	1. Route length: 79km – Butwal-Anandnagar; 117 km – Butwal-Gorakhpur 2. Anandnagar substation expansion constrained by low height residential buildings and existing roads. 3. Terrain mostly flat and cultivated 4. Part of route through community forest which will have to be cut 5. Four river crossings (short spans)	Four sub-options considered: **1A-1**: Butwal-Anandnagar Double circuit 132 kV construction, Single Bear conductor; **1A-2**: Butwal-Anandnagar Double circuit 220 kV construction, Double Bison, charge at 132 kV initially **1A-3**: Butwal-Anandnagar Double circuit 220 kV construction, Double Bison strung single circuit, charge at 132 kV initially **1A-4**: Butwal-Gorakhpur Double circuit 220 kV construction, Double Bison strung single circuit, charge at 220 kV	**1A-1**: $14.1M **1A-2**: $24.0M **1A-3**: $15.1M **1A-4**: $28.4M	1. Inter- connector location attractive; option 1A-1 is the cheapest but not amenable for expansion 2. Options 1A-2 and 1A-3 form basis for expansion to 500 MW link as export potential grows 3. Option 1A-4 involves greater initial investment for construction all the way to Gorakhpur 4. Expansion of Anandnagar substation may be a problem, residential properties to be cleared; hence, expansion to 500 MW may require disconnecting Anandnagar 5. Capacitor compensation required up to 30MVAr at Butwal and 20MVAr at Anandnagar 6. AC Link stability not established. 7. HVDC may be required; study will be needed to confirm requirements.; option 1A-4 may cost $100M initial investment for HVDC 500 MW)
Option 1B Birgunj – Motihari 132 kV	1. Load Flow study carried out	1. Route not surveyed	Existing line between Gandak – Ramnagar – Bettiah – Motihari – Muzaffarpur	$1.9M	1. AC Link stability not established. 2. HVDC may be required, study will be needed to confirm requirements. HVDC expected to add $20M to cost estimates for 100 MW transfer 3. No prospect for expansion

Table 6.3 Options Summary (Cont'd)

Option Description	System study Line size/length/stability	Survey findings (major items only)	Line details	Cost without HVDC	Major conclusions/problems
Option 1C Dhalkebar – Sitamadhi 132 kV **or** **Dhalkebar-** Muzaffarpur 220 kV	1. Load Flow study not carried out for Dhalkebar – Muzaffarpur	1. Route Length: 125km to Sitamadhi. 138km to Muzaffarpur 2. Terrain mostly flat and cultivated 3. Adequate space at Dhalkebar for expansion 4. Sixteen River crossings – Max span 250m	Two sub-options considered **1C-1**: Double circuit 220 kV construction Dhalkebar – Sitamadhi, Double Bison, strung single circuit, charged at 132 kV **1C-2**: Double circuit 220 kV construction Dhalkebar – Muzaffarpur, Double Bison, strung single circuit, charged at 220 kV	**1C-1**: $17.6M **1C-2**: $33.8M	1. Transmission link in Central area, best place for link. 2. Option 1C-1 and 1C-2 form basis for expansion to 500 MW link as export potential grows 3. Capacitor compensation required up to 100MVAr at Dhalkebar, and 280MVAr at Sitamadhi or Muzaffarpur 4. System capable of up to 180 MW 5. Link stability not established. 6. HVDC may be required, study will be needed to confirm requirements. HVDC expected to add $20M to cost estimates
Option 1D Duhabi – Kataiya 132 kV	1. Existing line 2. System Study not carried out	1. Route not surveyed	1. Existing Line	Not estimated	1. Existing transmission link operates in radial (asynchronous) mode 2. Poor location for Transmission link (too far East) 3. Current level of export 50 MW but system voltage low at Duhabi. Potential exists to increase level of import/export by installing capacitor compensation at Duhabi and Kataiya 4. No prospect of expansion to 500 MW 5. Link stability not established. 6. HVDC may be required; study will be needed to confirm requirements. HVDC expected to cost $20M (100 MW)

Table 6.3 Options Summary (Cont'd)

Option Description	System study Line size/length/stability	Survey findings (major items only)	Line details	Cost without HVDC	Major conclusions/problems
Option 2A Butwal – Gorakhpur 220 kV	1. Load Flow study carried out 2. Route walkover survey carried out	1. Route Length: 122km. 2. Terrain mostly flat and cultivated 3. One additional river crossing - 300m span 4. Part of route through community forest which will have to be cut	Five sub-options considered: **2A-1**: Expansion of 1A-2. Double circuit 220 kV construction Anandnagar - Gorakhpur, Double Bison, No connection at Anandnagar **2A-2**: Expansion of 1A-3. Double circuit 220 kV construction Anandnagar - Gorakhpur, Double Bison, String two circuits from Butwal – Gorakhpur, No connection at Anandnagar **2A-3**: Expansion of 1A-2. Double circuit 220 kV construction Anandnagar - Gorakhpur, Double Bison, Connection at Anandnagar **2A-4**: Expansion of 1A-3. Double circuit 220 kV construction Anandnagar - Gorakhpur, Double Bison, String two circuits from Butwal – Gorakhpur, Connection at Anandnagar **2A-5**: Expansion of 1A-4. Double circuit 220 kV construction, Double Bison, String two circuits from Butwal – Gorakhpur, No Connection at Anandnagar	**2A-1**: $32.7M **2A-2**: $40.9M **2A-3**: $35.9M **2A-4**: $44.1M **2A-5**: $27.2M	1. Transmission link in Central area, best place for link. 2. Integrated with Options 1A-2 and 1A-3 form sensible phased approach minimizing financial exposure and risk as export potential grows 3. Maximum export likely to be limited to 420 MW without substantial reinforcement of INPS 4. Capacitor compensation required 100MVAr at Butwal, 260MVAr at Gorakhpur 5. Link stability not established. 6. HVDC may be required; study will be needed to confirm requirements. HVDC expected to add $84M to cost estimates
Option 2B Parwanipur – Muzaffarpur 220 kV	1. Load Flow study carried out	Route not surveyed Route length approximately 140km	Double circuit 220 kV construction Parwanipur - Muzaffarpur, Double Bison	Not established since link export capability only 240 MW without extensive reinforcement of INPS however route is similar length to Dhalkebar route and is likely to be similar cost	1. Transmission link in Central area, best place for link. 2. Load flow studies show that link not capable of exporting more than 240 MW without substantial reinforcement of INPS. 3. Link stability not established. 4. HVDC may be required, study will be needed to confirm requirements. HVDC expected to add $48M to cost estimates

Table 6.3 Options Summary (Cont'd)

Option Description	System study Line size/length/stability	Survey findings (major items only)	Line details	Cost without HVDC	Major conclusions/problems
Option 2C Dhalkebar – Muzaffarpur 220 kV	1. Load Flow study carried out 2. Route walkover survey	1. Route Length: 138km. 2. Terrain mostly flat and cultivated 3. Sixteen river crossings - max 250m span	Four sub-options considered **2C-1**:Expansion of Option 1C-1, Double circuit 220 kV construction Sitamadhi – Muzaffarpur, Double Bison, string second circuit Dhalkebar - Sitamadhi – Assumes Upper Tamakoshi connected in 2015 **2C-2**:Expansion of Option 1C-2, Double circuit 220 kV construction, string second circuit Dhalkebar - Muzaffarpur – Assumes Upper Tamakoshi connected in 2015 **2C-3**:Expansion of Option 1C-1, Double circuit 220 kV construction Sitamadhi – Muzaffarpur, Double Bison, string second circuit Dhalkebar - Sitamadhi – Assumes Upper Tamakoshi **NOT** connected in 2015 **2C-4**:Expansion of Option 1C-2, Double circuit 220 kV construction, string second circuit Dhalkebar - Muzaffarpur – Assumes Upper Tamakoshi **NOT** connected in 2015	**2C-1**:$32.3M **2C-2**: $18.6M **2C-3**: $41.4M **2C-4**: $28.3M	1. Transmission link in Central area, best place for link. 2. Can be constructed in phased manner minimizing financial exposure and risk as export potential grows 3. First phase expected to be capable of 180 MW export. Second Phase maximum export likely to be about 800 MW without substantial reinforcement of INPS 4. Some redundant equipment in expanding from Phase 1 – Phase 2 5. Capacitor compensation required 10MVAr at Dhalkebar, 500MVAr at Muzaffarpur 6. AC Link stability not established. 7. HVDC may be required, study will be needed to confirm requirements. HVDC expected to add $100M to cost estimates
Option 2D Duhabi - Purnea 220 kV	1. Load Flow study carried out	1.Route not Surveyed	Route length approximately 100km Double circuit 220 kV construction Duhabi – Purnea, Double Bison	Not established as Load Flow studies indicate extensive reinforcement of INPS required.	1. Maximum capacity limited to about 250 MW without substantial reinforcement of INPS 2. Link stability not established. HVDC may be required, study will be needed to confirm requirements. HVDC expected to add $100M to cost estimates

6.6 Selection of preferred option

The first phase of each link can be charged at either132 kV or 220 kV. For a synchronous AC connection, the initial cost of the first phase charged at 132 kV will be lower. Thus, it a 132 kV capacity may be the best option for the first phase (Option 1A-1). However if the link is an asynchronous HVDC connection, then a 220 kV should be chosen because, when the link is upgraded in a few years, the 132 kV converter equipment will become redundant. If 220 kV is chosen for the first phase, the expansion may be done by adding extra modules to the existing converters. The cost differential between a 132 kV and 220 kV for first phase is marginal (approximately $1 million) and hence, 220 kV construction in phase 1 is preferred. Table 6.4 shows cost comparison of the two options:

Table 6.4 Cost estimate of Alternatives – AC Connection

Option	Phase 1 Cost	Phase 2 Cost	Total
220 kV Butwal – Gorakhpur	1A-2: $24.0M 1A-3: $15.1M 1A-4: $28.4M	2A-1: $32.7M 2A-2: $40.9M 2A-5: $27..2M	$56.7M $56.0M $55.6M
220 kV Dhalkebar – Muzaffarpur	1C-1: $17.6M 1C-2: $33.8M	2C-1: $32.3M 2C-2: $18.6M 2C-3: $41.4M 2C-4: $28.3M	$49.9M - $52.4M (Upper Tamakoshi connected) $59.0M - $62.1M (Upper Tamakoshi not connected)

As noted earlier, the stability of any of the AC links has not been established in this study. The NEA is rightly concerned about connecting its system synchronously with the larger Indian system because of potential stability, power flow, and frequency issues. These issues need to be addressed urgently and costs of remedial actions need to be included as project development cost.

The cost of HVDC equipment for asynchronous interconnection is considerable. IRG received budgetary estimates from reputed vendors of such equipment. The cost of such equipment is on the order of $200,000 per MW of transmission line capacity. Thus the project cost is likely to increase triple to over $150 million for a 500 MW interconnection.

Load flow studies (Appendix F) indicate that the Butwal – Gorakhpur link can transfer a maximum of 420 MW without significant reinforcing of the INPS other than the addition of compensation capacitors at the terminal substations. Any transfer above this level will require updating of the Butwal – Bardghat 132 kV overhead line which adds to the cost and complexity of construction of the link.

Load flow studies for the Dhalkebar - Muzaffarpur link show that in excess of 500 MW, probably up to 800 MW, may be exported on the proposed 220 kV link without overloading any transmission lines in the INPS.

<u>Topographic Surveys</u>

IRG surveyed both the Butwal - Gorakhpur and Dhalkebar - Muzaffarpur line routes and found similar terrain. Both routes have a number of road and river crossings. The Butwal - Gorakhpur route is considered slightly more onerous because of its longer length and more river crossings; however no river crossing is judged to be difficult since all crossing are expected to have less than 300 m spans. Detailed engineering assessment of each river crossing will have to be made during the link construction. A short report on the topographic survey and the details of collected data is included in Appendix F.

Environmental Analysis

Preliminary environmental analysis of the Butwal - Gorakhpur and Dhalkebar - Muzaffarpur line routes were made using data collected during the field surveys. For much of the routes, the proposed lines follow existing transmission corridors in the area. No major adverse effect is anticipated with the construction of the proposed transmission lines. Descriptive environmental analyses of the two routes are presented in Appendix G.

Preferred Option

IRG recommends the Dhalkebar - Muzaffarpur interconnection as the preferred option. The Butwal - Gorakhpur interconnection may be considered as the next link for additional power trade.

6.7 Project implementation

Project development and operation

The most important step in the implementation of the project will be an unequivocal commitment from the GON for accelerated, large scale power export to India. Without such a commitment, no power trade is likely to materialize with private sector participation or public-private partnership. The POWERing Nepal- Connecting Markets witnessed GON statements for large scale power export to India. Such commitments should be enshrined through legislation of the proposed new Electricity Act and the NERC Act.

As a utility, the NEA has the primary mandate to meet the demand of its domestic consumers. Exporting energy is not an impetus for the NEA. As a sole buyer of third-party energy and the owner/operator of the national grid, the NEA has a significant responsibility and authority in shaping up the generation and transmission expansion plans in Nepal which will likely conflict with an energy export portfolio. In the near term, it is unlikely that the GON or the NEA will be able to mobilize funds to construct a transmission link. The GOI has offered financial assistance for transmission interconnection but has maintained that such assistance will be based on viable contractual mechanisms.

The mandate of the HDP 2001 for large scale power export suggests that a national entity such as the DOED, and not the NEA, be the custodian for hydropower development for exports. The HDP 2001 further suggests formation of independent generation, transmission, and distribution businesses, at some point in time, for improved sector performance. Hence, in our opinion, any transmission link between Nepal and India should be operated by the private sector on a BOOT-type mechanism with the project eventually transferring to the national grid operator at the end of a 20-year license. The private sector would have the incentive to make such a venture successful under prevailing market conditions without domestic or export constraints on either side of the border. A private venture would also provide incentives to existing and future small and medium sized hydropower development in Nepal to optimize their plant size and operation on a combined domestic and export market for power. We consider a public-private partnership in the development of such interconnection as a clear possibility, given the urgent need to develop transparent and workable power trading arrangements between Nepal and India to effect continuous trading.

Project Schedule

Given the high interest level of the private sector in both countries for power trade and the fact that the major constraint to such trade is the lack of a transmission line link, the following schedule for the project implementation is considered feasible:

- Complete system studies and prepare model contracts: Jan-Jul 2007
- USAID/donor commitment for project development assistance: Apr-Jul 2007
- Effect necessary regulatory reforms/changes/laws: Jan-Jul 2007
- Prepare contract documents, invite and receive bids, evaluate bids and award: Jul-Dec 2007
- Project construction - Phase 1: Jan 2008-Jul 2010; Phase 2: 2011-2012

6.8 Financial Analysis

Project finance options

The POWERing Nepal – Connecting Markets Seminar (Appendix H) provided strong indication that private sector (or public-private partnership) would likely come up with the needed investment, particularly if the two systems may be connected synchronously. However, if the two systems cannot be connected synchronously without significant cost of remedial measures, the increased cost of asynchronous connection may deter private sector investment since commercial power transactions between Nepal and India are still perceived to have significant political/commercial risks. In our opinion, a package of incentives comprising a donor/GDA type grant or as low-interest debt for the project, to the project developer would serve as the missing catalyst for accelerated project implementation and realization of the long-awaited commercial power trade between Nepal and India. In the financial analysis below, we have analyzed options of outright grant on the order of 10% of the project's cost and a low debt-interest (6%).

Price of Energy Sales to India

With ABT trading, operational discipline of the Indian grid has significantly improved. The price offered for Nepal's surplus energy will be based on the alternative energy cost to the Indian system which varies during the day from $0.022 (Indian rupee INR1) to $0.11 (INR5) per kWh for stabilizing system frequency. IRG estimates that Nepal's surplus energy can command an average price of about $0.04 (INR1.8) per kWh, provided a workable trading norm is established in Nepal to increase the confidence of the Indian buyer on the quality, quantity, and availability of energy exports.

Cost of Surplus Energy Purchase in Nepal and Wheeling Charges

While cost of generating the surplus energy is almost zero, it is anticipated that both the NEA and the IPPs will be prepared to generate and sell this energy for some low price but not for free. In addition, the NEA will collect a wheeling charge for the transmitting this energy through its system to the interconnection point. Our discussions indicate that IPPs would be willing to sell the excess energy, which has currently no market in Nepal and unlikely to have any for a long time, for a nominal $0.015 (Nepali rupee NR1 or INR0.7) per kWh. This price is about 33 percent of the off-peak price currently paid by the NEA. IRG has assumed that the NEA will be willing to sell its surplus energy at a nominal price of $0.005/kWh. In addition, based on NEA's reported transmission costs, we have assumed a wheeling charge of $0.005/kWh for all exported energy as acceptable.

Financial analysis of the Butwal - Gorakhpur and the Dhalkebar - Muzaffarpur options were conducted using EXCEL spreadsheet. Based on industry practice, IRG has used the following parameter values for these analyses. All prices are in current dollars:

Project Investment

- Equity: 20%
- Debt: 80%
- Alternative grant (GDA/donors) $20,000,000 if HVDC is required

Debt Parameters

- Debt interest rate 10%
- Alternative low cost interest 6% considered for case with HVDC
- Debt term 10 years
- Interest during construction 9%

Cost of Operations

- O&M costs 2% of capital costs
- Cost of Energy purchase (base case)
  - From NEA $0.005/kWh
  - From IPPs $0.015/kWh

Discount rate, escalation rates

- Discount rate 10%
- Annual escalation rate:
  - Energy purchase 4%
  - Energy sales 3%
  - NEA's Wheeling charges 4%
  - O&M costs 4%
  - Capital costs 5%

Project revenue

- Average sale price of energy to India $0.04/kWh

Financial analysis calculates the net benefit/cost ratio on a present value basis and the internal rate of return (IRR) on present value of net benefits, over a typical operating license period of 20 years (2010-2029). Tables 6.5 and 6.6 provide comparative details of the two options analyzed. In addition, several variations of financial parameters were analyzed to assess the robustness of the preferred option in Table 6.7. All parameter changes in the sensitivity analyses are made from the base case individually. Selected detailed analyses are included in Appendix I.

Table 6.5 Comparative Financial Analysis of the final options Synchronous connection

Description	**220 kV Dhalkebar - Muzaffarpur TL link** 138 km long; max power transmission capacity 500 MW	**132/220 kV Butwal - Gorakhpur TL link** 117 km long; max power transmission capacity 420 MW
Synchronous connection (base case)		
Total cost	$52.4 million	$55.6 million
B/C ratio	2.2	2.0
IRR (NPV)	26.1%	25.4%

B/C – Benefit/cost; IRR – Internal rate of return; NPV- net present value

Table 6.6 Comparative Financial Analysis of final options Asynchronous connection

Description	**220 kV Dhalkebar-Muzaffarpur TL link** 138 km long; max power transmission capacity 500 MW	**132/220 kV Butwal-Gorakhpur TL link** 117 km long; max power transmission capacity 420 MW
Base case		
Total cost	$152.4 million	$139.6 million
B/C ratio	1.4	1.4
IRR (NPV)	9.2%	7.7%
With donor grant of $20 million for project development		
Total cost	$132.4 million	$119.6 million
B/C ratio	1.5	1.4
IRR (NPV)	13.3%	11.9%
With discounted debt interest at 6%		
Total cost	$152.4 million	$139.6 million
B/C ratio	1.4	1.3
IRR (NPV)	10.2%	8.8%

B/C – Benefit/cost; IRR – Internal rate of return; NPV- net present value

Table 6.7 Dhalkebar-Muzaffarpur TL Link - Sensitivity Analyses

Description	Cost $	Grant	Net cost $	B/C ratio	IRR NPV
Synchronous connection	52,400,000	0	52,400,000*	2.2	26.1%
Energy purchase price doubled for IPPs	52,400,000	0	52,400,000*	2.1	24.9
Energy sales price increased to $0.05/kwh	52,400,000	0	52,400,000*	2.7	33.5
Synchronous connection – needed remedial measures assumed to cost additional $20,000,000	72,400000	0	72,400,000	1.9	17.5
Accelerated capacity addition by 2 years (2013)	52,400,000	0	52,400,000	2.2	34.3
Asynchronous connection – base case	152,400,000	0	152,400,000	1.4	9.2%
Asynchronous connection - with donor assistance	152,400,000	20,000,000	132,400,000	1.5	13.3%
Asynchronous connection - with low cost debt	152,400,000	0	152,400,000	1.4	10.2%
Energy purchase price doubled for IPPs	152,400,000	20,000,000	132,400,000	1.4	12.4%
Energy sales price increased to $0.05/kwh	152,400,000	0	152,400,000	1.7	15.8
Energy sales price increased to $0.05/kwh	152,400,000	20,000,000	132,400,000	1.9	21.1%
Accelerated capacity addition by 2 years (2013)	152,400,000	20,000,000	132,400,000	1.5	14.3%
HVDC Costs 10% lower (No donor grant)	142,400,000	0	142,400,000	1.4	10.4%

* Nominal debt interest of 10%   **Low debt interest of 6%

6.9 Conclusions and Recommendations

6.9.1 Conclusions

Based on our study described in the previous sections, IRG concludes the following:

1. Transmission line link for power trade between Nepal and India is technically feasible and appears financially viable for immediate implementation; the proposed Dhalkebar - Muzaffarpur link may be used successfully for export of Nepal's spill energy as well as for short-term imports from India
2. Without a firm and unequivocal policy commitment from the GON for large scale power export to India, no serious and significant development is possible
3. The GON should take the "Build and they will come" approach to Nepal's transmission grid expansion

4. Nepal's energy is marketable readily in Indian market at attractive prices. There is considerable interest among private investors and entrepreneurs in Nepal and India to implement a commercial transmission line link between the two countries.
5. A transmission line link appears feasible with the export of only available spill energy. Successful implementation of the proposed project would set the stage for additional significant private sector participation in generation and transmission projects. Availability of a transmission line link will also promote more efficient use of generating capabilities on both sides of the border through power trade in both directions, leading to increased energy security of the region.
6. The interconnection link may be used to import power to Nepal, as needed on a short-term basis. Such increased use of the link will further improve the attractiveness of the project.
7. GON/NEA will need to plan for transmission grid expansion in line with generation planning expansion and seek funding for the complete system for optimal use of the resources through a combination of private sector, public-private partnerships, and government initiatives.
8. The two alternative commercial transmission links – Butwal/Gorakhpur and Dhalkebar/Muzaffarpur are comparable; however, the latter is preferred because of its physical location close to proposed generation projects in Nepal and its potential for larger export capacity
9. The first commercially operated transmission link between Nepal and India will need GDA/donor assistance to move forward quickly, particularly if the two systems cannot be connected synchronously. The assistance will act as a catalyst for development
10. A private or a public-private partnership mechanism will be the most suitable for implementing the project. The project should be operated on a BOOT type mechanism by the private sector
11. A set of key system studies, regulatory reform actions, and contractual mechanisms need to be completed immediately for project implementation in the next 4 years. USAID/donor commitment for these efforts as well as for a grant (or low cost debt facility) will be necessary to carry the project to fruition

6.9.2 Recommendations

Based on our study and discussions at the POWERing Nepal – Connecting Markets Seminar, IRG recommends the following time-bound actions:

1. Immediate Actions

- Form Champion teams comprising IPPAN, IPP Association of India (IPPAI), American Chamber Commerce (AMCHAM), Confederation of Indian Industries (CII), Federation of Nepal Chamber of Commerce and Industry (FNCCI), and other interested organizations and individuals to facilitate:
  - Streamlining/reforming regulatory regimes in Nepal and India for power trade
  - Assistance to potential developers on both sides to meet regulatory, legal, and administrative requirements

- Development of public-private partnerships, match making among developers, investment communities, financial institutions, consultants, equipment manufacturers, software/hardware developers, and contractors

  The POWERing Nepal seminar has initiated the process for forming Champions teams.

- USAID should consider funding the following technical activities
  - System stability studies in India and Nepal to confirm if synchronous or asynchronous transmission link should be made
  - Develop model third party energy sales contracts in India and Nepal to facilitate cross-border power trade and obtain approval from the relevant GON and GOI agencies and institutions for such contracts

2. Actions to be taken in the next 5-6 months

- The Champions teams, with possible donor/GON/GOI funding, should facilitate
  - Legislation of the new Electricity Act and the NERC Act in Nepal
  - Amending Indian Electricity Act 2003 for cross-border wheeling for short-term contracts Obtaining regulatory approvals in place in Nepal for power trading; wheeling through NEA TL system and third party power sales contracts
  - Obtaining regulatory approval in India for wheeling Nepal's power through Indian grid (for short term) for third party power sales
- NEA should establish a mechanism and procedures to ensure appropriate connection and system controls, the ability to monitor power flows, and to enact billing systems for power wheeling
- USAID should consider funding the following technical activities
  - Assist GON/GOI entity to solicit and obtain donor grant for implementation of the project and secure such grant. We recommend that $20 million to be provided as donor grant to implement the project if asynchronous interconnection link is required. If synchronous interconnection becomes the choice, we recommend donor-funding of the entire cost of system remedial measures (subject to a maximum of $20 million) to be undertaken in Nepal and India to facilitate synchronous interconnection
  - Assist GON/GOI to solicit and obtain alternative low-cost debt for project implementation from multi-lateral financial institutions such as WB and the ADB. We recommend a debt-interest of no more than 6%

3. Actions to be taken the next 12 months

- NEA, DOED, and the GON to prepare/confirm plans for generation and TL strengthening of Nepal's integrated power system
- NEA, DOED, and GON conduct focused discussions with donor community, multi-lateral financing institutions, and IPPs for timely development to fund generation and

other proposed TL projects under NEA, private, or public-private partnership arrangement

- USAID should consider funding the following technical activities
  - Detailed design of the selected alternative and preparation of contract documents for implementation of the project under a BOOT mechanism by private sector or public-private partnership
  - Establish grid code conformity for transactions in both countries
  - Support the NEA, DOED, and the GON in their endeavor in planning generation and TL expansions and in negotiation of financing and contracts arrangements for such development

References

1. NEA, 2003. North-South 132 kV Transmission Line Study
2. NEA, 2005a. Generation: Third Edition, NEA, August 2005
3. NEA 2005b. Long Term Generation Planning Study, 2004/05. NEA, June 2005
4. NEA 2005c. Report on Transmission Planning Study, NEA, 2005
5. NEA 2005d. Fiscal Year 2004/05: A year in Review, NEA, August 2005
6. NEA 2006a. Fiscal Year 2005/06: A year in Review, NEA, August 2006
7. NEA 2006b. Near-Term Generation Planning Study, 2006/07-2010/11 (unpublished), NEA, February 2006
8. Norconsult. 1998. Power System Master Plan for Nepal, Financed by ADB under TA 2614-NEP.
9. CEA, 2001. 16th Electric Power Survey. CEA, 2001

Cost Estimates

APPENDICES

Appendix A

Terms of Reference for the Study

APPENDIX A

Terms of reference for the Transmission Line Study

Objectives

(1) To study the existing Nepalese transmission line system and the corresponding Indian system to identify and confirm private public, and/or partnership interests in developing a transmission line link between Nepal and India; to identify 1-2 alternative terminal points on the Nepalese and Indian systems and possible transmission corridors for an inter-connector; to identify likely inter-connector details, anticipated transmission system upgrades on the Nepali side; and to identify a preferred inter-connector for further study; and

(2) To prepare a feasibility report for the recommended inter-connector.

The scope of the proposed study is divided into the following tasks:

Task 1 Collect and review the T/L expansion plans and current status of Nepal Electricity Authority (NEA) and the relevant expansion/interconnection plans of Indian entities (Grid Corporation of India, PTC), and other private sector entities in India); review 4-border power study by SARI/E consultant Nexant Inc.

IRG consultants will collect relevant documents and carry out the following activities:

Review relevant reports including the following:

- The Four Borders Project: Reliability Improvement and Power Transfer in South Asia – prepared by Nexant Inc under SARI/E Program of USAID
- Economic and Social Benefits Analysis of Power Trade in the South Asia Growth Quadrangle Region – prepared by Nexant Inc under SARI/E Program of USAID
- Other relevant reports prepared by USAID, WB, Asian Development Bank (ADB), Japan Bank for International Cooperation (JBIC), Norwegian Agency for Development (NORAD) etc

- Review Power System Expansion Plan(s) of the NEA particularly generation and transmission plans over a 20-year planning horizon
- Review IPP plans for hydroelectric development in Nepal over a 20-year planning horizon
- Review power system expansion plans of India particularly the transmission system development plan in the Eastern Region
- Review system analysis status and capability of NEA identifying shortcomings, if any, in power system model
- Review of statistics of power generation and dispatch from major power stations in Nepal during the past 5 years

- Review operational statistics of transmission system of NEA during the past 5 years

Task 2. Discuss with IPPAN, FNCCI, CII, and Indian entrepreneurs, NEA, Grid Corp, PTC, Indian SEBs, and others as required to obtain additional background data, information on existing system operations

IRG consultants and staff will visit Nepal and India and carry out the following activities:

- Conduct discussions with as many of the stakeholders as possible; a tentative list of stakeholders is provided below:
    - NEA management, transmission line department staff, including central load dispatch center officers
    - HMGN agencies including the Ministry of Water Resources (MOWR), Water and Energy Commission (WEC), and the Department of Electricity Development (DOED)
    - Independent Power Producers Association of Nepal (IPPAN), Federation of Nepal Chamber of Commerce and Industry (FNCCI) and Nepal-US Chamber of Commerce and Industry (NUSACCI); other IPPs
    - Central Electricity Authority (CEA) and Ministry of Power in India
    - Central Electricity Regulatory Authority
    - Power Grid Corporation of India Ltd (POWERGRID)
    - PTC and other power trading entities in India
    - State Electricity Boards (SEBs) in Indian states adjacent to Nepal
    - IPPs and industry associations in India such as Confederation of Indian Industries (CII) and Indian Chamber of Commerce and Industries (ICCI)
    - WB, ADB, JBIC, NORAD, and other donor agencies
- Prepare data base to be used for our analysis and confirm with NEA, IPPAN, and others regarding of the accuracy and validity of the data, assumptions to be made in our analysis, and suggestions to improve data base
- Conduct a 1-day workshop in Kathmandu to discuss the database to be used in the analysis
- Revise database as required

Task 3: IPP interest on both sides of the border for power sale/purchase (quantity, availability, quality, pricing methodology etc); possible IPP interest in design, construction and operation of T/L (s) for use by IPPs and others; include alternative investment/financing/ownership arrangements:

IRG consultants would conduct discussion forums in Nepal and India with IPPs, IPPAN, FNCCI, CII, ICCI and similar entities to assess realistic interest and expectations to develop, design, build, and operate transmission line(s) to export power from Nepal to India using data developed under Tasks 1 and 2 under current (or proposed) regulatory, economic, and environmental regimes in Nepal. IRG will identify US entities interested in development/financing of T/L projects for power exports from Nepal to India. Such entities will be invited for discussions in the US, Nepal, or India.

Task 4: Prepare a preliminary report and identify and rank up to 3 T/L corridors; recommend one corridor for conducting a feasibility study

IRG consultants will carry out the following activities under this task:

- Carry out power system modeling to:
  - Review, validate or update transmission expansion plans to match the generation expansion plans of NEA;
  - Simulate different options for interconnections with India under the following scenarios of generation expansion plans in Nepal: (i) to export presently available surplus power during monsoon season to India – say up to 100 MW; (ii) with limited generation expansion in Nepal in the medium term (say in 10 years) to export up to 500 MW to India; and (iii) under optimistic scenario of increased investment in power sector in Nepal (say in 20 years) to export about 1,000-3000 MW to India
  - Identify the required transmission system reinforcement within Nepal under each of the above three scenarios
  - Identify two or three viable transmission interconnections between Nepal and India to meet the requirements under the above scenarios, identify anticipated infrastructure reinforcements on the Nepalese systems and appropriate inter-connector design
  - Develop design parameters for any system upgrade on the Indian side
- Using existing digital and/or other maps, identify alternative corridors and line routing to prepare a preliminary environmental fatal-flaw analysis and to prepare a nominal cost estimate of alternatives
- Identify and detail mechanism(s) for alternative financing/ownership arrangements keeping in mind Nepal's existing BOOT Act provisions
- Prepare an interim report including recommendations for stakeholder review
- Present the findings and discuss the results in a 2-day workshop in Nepal including a recommended corridor
- Summarize workshop proceedings, conclusions and method to address comments

  The system modeling included in this phase of the work requires a reasonably up to date existing model of the NEA system. We understand from our discussion with the NEA that such a model is available with the NEA and that the model will be available for use/upgrade by IRG. The model with upgrades, if any, will be handed over to the NEA at the conclusion of our study. IRG has assumed that no modeling of the Indian transmission system will be necessary at this stage because of the following:

- That relatively small export potential (1000-3000 MW) exists in the planning horizon (20 years) compared to the size of the integrated Indian grid; and

- That the Indian system will absorb all amount of export energy available from Nepal when available

Task 5: Conduct a feasibility study of the selected corridor (after approval by the Client and HMGN/GOI entities, IPPs on both sides etc) - the study should include technical evaluation of current T/Ls, the proposed new T/L(s) (including a revised power flow study), field survey of alignment(s), technical design of the lines, towers etc; a cost estimate and time schedule for construction. Clearly identify and assess potential elements of risk in: market, source for power, construction/financing and provide risk management recommendation(s); identify potential US interest in construction, finance/operation of a T/L

IRG consultants will conduct a feasibility study for the preferred T/L option discussed in the Interim Report, with appropriate modifications resulting from the stakeholder comments. Our efforts will include the following tasks:

- System design of the transmission inter-connection (voltage, power flow, tower configuration, terminal equipment, control, communication and protection schemes etc); design will be restricted to Nepalese side of the lines; inter-connector design parameters will be developed for the Indian side of the T/L
- Preliminary route survey and soil investigation including estimation of quantities of towers, conductor, other tower accessories and line materials, and quantities of civil work;
- Initial environmental examination to identify major potential effects;
- Stability studies using the power system model for the Nepal grid;
- Development of institutional and technical operation strategies for the interconnected system;
- Estimation of construction cost estimates including costs for potential environmental mitigation efforts;
- Estimation of operation and maintenance cost;
- Project implementation strategies – schedule of construction, investment plan etc;
- Revenue analysis under different scenarios of power trading;
- Risk analysis;
- Financial (FIRR) and economic (EIRR) analysis to determine the project viability;
- US interest in development/financing of the project
- Recommendations for next steps forward

Task 6: Prepare a feasibility report

IRG will prepare a Draft Feasibility Report including technical details, preliminary design, alignments, support facilities, O&M requirements, capital and O&M costs, investment options, and schedule for construction; benefit cost ratio analysis for review by USAID, HMGN agencies, and other stakeholders. Specific activities will include:

- Prepare a draft feasibility report including recommendations for stakeholder review including US interests
- Present the findings and discuss the results in a 2-day workshop in Nepal
- Summarize workshop proceedings, conclusions and method to address comments
- Revise the report for approval by USAID/HMGN

Current Nepalese laws require that a full-blown environmental impact assessment of the transmission line may be carried out only by the developer. In our opinion, an EIA should be prepared by the developer closer to the time when such development is feasible. Hence, we propose to perform only an initial environmental examination is proposed to be performed to identify fatal-flaw issues, major potential effects, and likely mitigation measures. Similarly, only limited survey of the selected route/corridor and soil investigations are planned to identify major cost elements such as long-span towers.

Task 7: Make presentations to individual and joint private sector and HMGN teams in India and Nepal that may be interested in participating in the project.

IRG consultants would prepare technical, financial, and regulatory summary of the potential T/L development and make 2 presentations to stakeholder groups in Nepal and India

IRG will need assistance and cooperation of USAID/N, USAID/I, HMGN agencies, IPP Association of Nepal IPPAN), Federation of Nepalese Chamber of Commerce and Industry (FNCCI), Nepal-USA Chamber of Commerce and Industry (NUSACCI), and counterpart Indian entities to collect and review available information, to discuss current and future developmental activities, to discuss interest and opportunities for investment in transmission line development, and to review and comment on the Interim Report. We are confident that such assistance and cooperation will be forthcoming.

<u>Deliverables</u>

1. One-day working session to discuss available data, methodology for analysis in Nepal
2. Interim report
3. Two-day workshop in Nepal with stakeholders from Nepal and India to discuss Interim report
4. Draft and final Feasibility reports
5. Two-day workshop to discuss draft Feasibility report
6. One presentation each in Nepal and India

Appendix B
Summary of Meetings with Indian Agencies, Entrepreneurs, and Industry Associations

APPENDIX B

Summary of Meetings with Indian Agencies, Entrepreneurs, and Industry Associations

Despite the clear economic benefits that will accrue to each country as a result of new electricity transmission links, political perceptions on each side of the border continue to cloud their implementation. In an attempt to better understand Indian views, the IRG team traveled to India to meet with senior Government officials and leading private entrepreneurs involved in the electricity sector. In this paper, IRG has attempted to express the views as we heard them. We make no representation either that the views are fair or that we agree or disagree with them. Rather we see their presentation as a way to help Nepali government officials and private sector entrepreneurs better understand each other and hopefully overcome their concerns so that the benefits of enhanced trade can occur.

B.1 Indian Perspectives on Nepali Hydroelectric Power Development

The following observations were made by Indian governmental authorities and business executives in the power sector during discussions that occurred in November /December 2005:

(1) India is currently interested in bilateral power deals with its neighbors not in multilateral approaches such as the Four Borders Interconnection Report;

(2) The GOI is interested in purchasing power from Nepal even on a seasonal basis if prices are competitive but its key interest is in large scale (in excess of 500 MW) hydroelectric projects. It simply reflects the size India's power need as evidenced by its Mega project strategy and the reality that while Nepal dithers India is looking to Bhutan and elsewhere and I think Nepali policy makers need to hear this.

(3) Small scale run of the river projects are of little interest to India except in border regions on a seasonal basis since they will not meet India's fast growing power needs.

(4) Both the Power Grid Corporation of India Ltd (Power Grid) and Tata Power stated that they stand ready to construct any transmission line on the Indian side of the border necessary to connect with Nepal side on terms that make commercial sense (i.e. at prices that are competitive with Indian alternatives)

(5) Indian electricity regulatory authorities will not allow downstream irrigation, flood control or other benefits to be considered as part of electricity tariff negotiations. If the benefits are real, they should be negotiated on a bilateral basis by the relevant government agencies/Ministries of the two countries

(6) India believes that upstream "costs" such as those arising from the resettlement of populations as a result of hydroelectric development should be negotiated separately and should not complicate tariff negotiations;

(7) Project environmental costs will have to be included in the required tariff to make it economic: if for a particular project, the required tariff is therefore higher than alternatives available to India it will not purchase from such projects and the project will not get a PPA

(8) Nepal is not perceived as interested in enhanced bilateral energy trade. Indian officials note that while discussions were held with Nepal about two years ago to construct a 132kV transmission link the project was abandoned since Nepal could not commit even to seasonal exports for 5 years. Similarly, while an MOU was signed between Snowy Mountain Engineering Corporation, Australia (SMEC) and the Power Trading Corporation of India LTD to develop the 750 MW West Seti Project, the Nepali side has been slow in moving the project forward. Since our discussions, it is reported the GON requested the ADB and the ADB agreed to provide approximately 10 percent of project cost as loan to the GOIN for equity investment in the project.

(9) The National Hydroelectric Power Corporation of India Ltd (NHPC) also studied the feasibility of developing hydroelectric power in Nepal and signed MOUs but the response from the Nepali side has been very slow or not forthcoming.;(In contrast, India has successfully negotiated over 1,500 MW with Bhutan with another 7,000 MW under discussion. Indian power and industry officials are confounded at the slow progress of enhancement of electricity trade.

(10) While India (and its agreements with the GON) allots 12% of the power from any hydroelectric power plant to the local districts in which the plant is located, Nepal insists on 15%. India willing to negotiate the difference but only if Nepal ensures that part of this benefit goes to the villages/regions where the project is located

Additionally, Indian IPP developers and industries needing power raised the following points. Clearly, ensuring adequate generation capacity is a long-term problem in India providing impetus for enhanced electricity trade with Nepal. However, it is difficult to convince the NTPC, PTC and the bankrupt, heavily subsidized SEBs that these opportunities are pressing when owing to a long term lack of investment in electricity transmission and distribution there are thousands of megawatts of existing Indian generation capacity that can not be evacuated to major load centers. This lack of T&D capacity and the financial and technical deterioration of the SEBs have led to a situation where so much "captive" power has been developed that it now accounts for nearly 25%-50% of India's total generation capacity. In the view of the Ministry of Power and some SEBs , this situation forces the GOI to try to meet base load demand by building more generation plants while completely ignoring the "peak load" shortages prevailing in many parts of the country which could be reduced, but not eliminated, if more investment went into T&D allowing India's generation capacity (both on and off grid to be evacuated to meet this demand where technically feasible. This is not to say that enhanced T&D investment, given India's burgeoning energy demand, will alone solve India's electricity crisis but is noted here to suggest that even among Indian decision makers there is no consensus on how policy towards Nepali exports should proceed. The problem is complicated further by the fact that India has emphasized generation expansion rather than T&D expansion since much of the responsibility for the latter is under the authority of the SEBs; in addition lengthy legal disputes over land ownership and land tenure make the siting of T&D investments extremely difficult.

Furthermore, as long as the GOI and SEB's subsidize retail prices rather than adopt a cost plus pricing model, there is no incentive for entrepreneurs to sell their power at low retail prices since there is little financial benefit since in the best of circumstances they may make a 12-13% return on their risk capital rather than the 20% plus return available in many other sectors of the Indian economy with little or no investment risk. While most regulatory agencies have required that subsidies be overtly identified and paid to the utility by the state/central government; in reality transfer payments are slow and in some cases do not occur at all. This is especially true in the poorer states such as Bihar and UP which border Nepal making it difficult to get entrepreneurs to invest in either Indian or Nepali projects serving these regions. In the view of these entrepreneurs only when power can be wheeled to wherever it is needed and a decent financial and economic return can be made will it make sense to invest in certain parts of India and in Nepal where political, economic and social risk is perceived as "very high." Again this is what was said, While the Indian Electricity Act 2003 allows such wheeling inside India, without an effective transmission network, market driven SEBs and cost reflective tariffs, purchasing power from Nepal is perceived to have large political risks without attendant financial returns. From discussions with Power Grid, PTC and Tatas, it is apparent that what we have is a classic chicken and egg problem. All three companies are willing to build transmission links to the Nepali frontier if they can be assured that there is a financially sound developer in Nepal and an offtaker in India. They are worried that the political climate in Nepal and the financial condition of most Indian SEBs makes it extremely risky to assume that an offtaker in India will be allowed to wheel power through these states economically even though Indian law allows it.

Another issue cited by Indian power officials and IPP developers is that the Government of Nepal and NEA continues to believe that Nepal can only sell energy during the monsoon . If this "mind set" persists, Indian investors have only limited interest since they will have to view such sales against other alternatives such as developing more capacity inside India especially in the west, south and northern regions of the country where acute shortages exist. The Ministry of Power noted that to protect its energy security India is exploring numerous options: (1) enhanced power purchases from Bhutan, (2) pipeline natural gas imports from Bangladesh, Myanmar, Iran and Turkmenistan," (3) mega projects" based on imported coal, (4) LNG , (5) nuclear power and (6) enhanced energy efficiency to meet its growing energy needs. While several of these alternatives are expensive and may have considerable risk in implementation, India believes that it is essential to diversify its energy mix both by fuel type and by source. Consequently, it is within this context that Nepal must review its national interest and decide on whether to engage in large scale energy exports to India at available market prices. Only a firm decision from Nepal with supporting legislative and other actions will energize meaningful investment in the sector from the IPPs. Nepal needs to define and codify in the pending new Electricity Act its intentions to export on a large scale. This point is important because if Nepal decides to export power only in the east during the monsoon season when India has surplus power it will obtain a lower price than if it builds a transmission network capable of exporting further to the West where the Northern Grid has a power deficit.

In contrast to the views of the MOP, Indian entrepreneurs believe that current market conditions in India provide unique opportunities for investors if the GOI and GON will make necessary market reforms. This arises from the fact that while the average selling price of electricity in India is between $.045 and $.05/kWh, peak power sells at prices up to $.0825 per kWh delivered to key interconnection points between the northern states while spot market peaking sales routinely occur at $.07-$.075/kWh making power from Nepal extremely attractive if appropriately priced.

However, because Indian industrialists do not see Nepal as able to sell to southern or western markets for the foreseeable future owing to transmission constraints, key considerations in buying Nepali hydropower will center on price, quality and reliability. It was noted that in Indian industries such as aluminum, soda, textiles, and cement etc where power can account for between 60-70% of total production costs, Nepal could find a valuable market if it is able to compete on price and demonstrates that it is a reliable supplier. The industrialists noted that because of India's insatiable demand for power they often take a longer term view than the government which seldom looks beyond the current Five Year Plan. Consequently, companies such as Tata, Reliance, Torrent, and some hydroelectric power developers while remaining interested in Nepali hydropower may have to look at other alternatives if critical policy decisions on enhancing hydropower exports are not forthcoming

The view was also expressed that Nepali power planners must pay more attention on regional markets and realize that a country has large as India has many different options to meet its energy needs. It was noted that Nepal needs to be aware of market conditions not only in its eastern regions where it currently exports and imports small volumes of power but also those prevailing in other markets being considered as sources of fuel supply by India. For example, currently average retail power costs in both Bangladesh and Northeastern India where demand is low are around $.03/Kwh. While western Bangladesh needs power, for Nepal to wheel power through India to serve this market it will have to take these market conditions into consideration. However, if Nepal had power surplus to its needs that was otherwise being spilled and the transmission capacity, it would make economic sense to sell Bangladesh power even at low "netback" prices rather than recover nothing from this valuable asset. Likewise while in the past LNG imports had to be priced between $4.00-$4.50 per MMBTUs to be competitive in Indian base load power generation skyrocketing world gas prices and the soaring price of oil now make LNG for base load generation "extremely attractive" at $5.50 per MMBTUs and even up to $6.00 per MMBTUs according to Indian industrialists and power officials. Consequently, if Nepal were able to export power from points father to the west and ultimately have the power wheeled to demand centers in Gujarat and Mumbai it might be able to command a premium price for its power especially for future projects with large storage capacity. However for this to occur Nepal will have to build large dedicated transmission lines for select projects; however, if carefully planned these can also serve as vital links in an expanded Nepali transmission grid that can bring power to power starved regions of the country.

Given these market complexities and the risks and expense of developing transmission facilities especially in remote regions, the conclusion of most Indian industrialists and power officials is that the involvement of the World Bank, ADB, or other large bilateral donor would facilitate the private financing of such a transmission line. Alternatively, those interviewed said that if the WB were to finance a large hydroelectric generation export facility then Indian investors might be willing to finance the transmission line assuming that the WB's involvement in the line would ensure the sanctity of any contracts between the industrialists and the GON and would reduce the risk of nationalization. Finally there was consensus that India is increasingly concerned about its "energy security." While supply diversification is thus clearly a part of India's strategy, Nepal should understand that all Indian domestic options will be pursued before any imported option is examined. Following this, all import options will be compared on both price and a perception of the security of the imported source of energy.

B.2 Views of PowerGrid and PTC

Owing to their pivotal role in any power sale or purchase between the two countries, the views of these two entities are extremely important in determining the success/failure of any power generation or transmission project. While the Ministry of Power has given PowerGrid the "green light" to facilitate power sales between the two countries, PowerGrid does not believe that there are a significant number of buyers willing to rely on Nepal exports given the past history of inaction by the GON. For example, two years ago PowerGrid at the request of the GOI examined the feasibility of transmission interconnections with Nepal identifying three 132 kV lines (1.Anandnagar-Butwal; 2.Motihari-Brihand; 3.Sitamahi-Doklivadi for radial mode operation allowing power imports from Nepal. However,, the inability of the GON to commit to the long term availability of power for export did not make any of these projects economically feasible.. While the West Seti project seems to be moving forward, until Nepal's political crisis resolved, investors will be reluctant to conclude the project. PowerGrid also believes that too many "experts" are analyzing the wrong problem. While their focus is on building new generation to meet India's burgeoning power demand, the real problem lies in India's lack of investment in transmission and distribution especially by the bankrupt SEBs. This means that thousands of megawatts of existing generation can not be evacuated to where the power is needed. In PowerGrid's view by 2012, India will have all the generation capacity it needs especially in its eastern region. While market forecasters continue to argue that power demand in this region is growing at between 5-6% per annum, in reality, it is growing at 2.5% per year. Furthermore, there is no political consensus among the central government and the states that would be involved in moving power from the eastern to the northern region. PowerGrid insists the real issue is not adequate transmission facilities but the lack of planning and politics. Once the central government, the state governments, the SEBs, NTPC, BHEL, NHPC and NDPL shed their parochialism where they only look out for their own interests and not those of the country as a whole, there is the possibility that with the proper investment 30,000 MW of inter-regional electricity trade inside India could occur. If Nepal wants to enter this market, it will only be able to do so if its power is reliable, of good quality and is competitive in price.

In PowerGrid's view there has not been a thorough study conducted of how best to connect the electricity systems of Nepal and India in a way mutually beneficial to both countries. In PowerGrid's view this may require building a HVDV back to back connection (500MW HVDC B/B station at a cost of $ 50-60 million. Furthermore, PowerGrid noted while in India the passage of the Electricity Act 2003 guarantees open access this is not the case in Nepal where siting transmission lines create intractable problems with local communities, creating lengthy delays and uncertainty in the minds of investors as to the degree of commitment by the GON. Even in India difficulties in siting transmission lines and gaining access for transmission corridors mean that small lines are often not economic which has an adverse affect on small scale power exports from Nepal and generates little interest from investors. Consequently, India is only interested in having lines capable of moving large volumes of power.

The Power Trading Corporation (PTC) was nominated by the Power Exchange Committee, consisting of officials from Nepal and India, to serve as the nodal agency for the exchange of power between the two countries. The PTC has repeatedly expressed interest to the GON in buying power assuring the GON that any seller of power from Nepal will be treated in a transparent manner and given the same terms as any seller in India. Despite overtures from PTC, the GON has not pursued PTC's proposal to build transmission lines inside Nepal to the Indian border; earlier Power grid Corporation (PGC) had agreed to build transmission lines from the Nepal border if PTC would pay transmission charges within India but this was not acceptable to PTC suggesting hindrances to electricity trade are not only bilateral in nature.

When PTC approached the GON about purchasing power from Nepal and sought information on the quantities and quality of available power, it was not provided by the Ministry of Water Resources, or the NEA. As a result, it was impossible for PTC to discuss specific price commitments. Nevertheless, PTC stated that if Nepal could confirm the availability of 100 MW of power (or more) delivered on a twenty four hour seven days per week basis it was prepared to sign take or pay contracts at indicative delivered prices at the border of $.05 kWh at Bareilly or $.04 kWh at Siliguri. PTC emphasized that the ultimate delivered price to India's network intertie would depend on the quality of the power, the precise point of delivery, and the period of commitment. PTC agreed in turn to commit to transmission charges linking the Nepali border and the Indian network on the same basis.

PTC noted that the failure of Nepal to respond means that the existing capacity of both power systems (India and Nepal) for radial mode power transfer to India is only 25 MW which is too small to be of much interest to PTC. In contrast, PTC noted that in the proposed 750MW West Seti Project the power developer (SMEC) has agreed to build the transmission system up to the Indian border with PowerGrid building the Indian link to its power network. PTC expressed frustration that it is unclear who is in charge of such negotiations in Nepal and why the Government takes so long to respond to serious inquiries.

Appendix C

Stakeholder Meeting Presentation
November 25, 2005

Study of Transmission Line Link between Nepal and India

Stakeholders Meeting
Kathmandu, Nepal
Nov 25, 2005

G. Krish Krishnan, IRG

USAID
FROM THE AMERICAN PEOPLE

IRG

Meeting Objectives

To disseminate information and solicit input from stakeholders on:

- Scope of study
- Data for study
- Power trade perspective from Indian stakeholders
- Power export goals
- Schedule for study

USAID FROM THE AMERICAN PEOPLE

IRG

Study of Transmission Line Link between Nepal and India:
Scope of the study

- To study Nepalese and adjacent Indian transmission systems:
  - To assess technical options for cross border trade in short, medium, and long term
  - To identify likely terminal points in the Nepal and India
  - To identify preferred inter-connector details and necessary transmission system upgrades in Nepal; and to assess options and risks for financing such a TL link
  - To recommend preferred inter-connector arrangements

USAID FROM THE AMERICAN PEOPLE

Study for Transmission Line between Nepal and India:
Scope of the study

Methodology to be employed:

- Collect and review operating data and expansion plans relating to power systems from NEA, IPPAN, others in Nepal; and Powergrid, SEB's et al in India
- Analyze power systems of Nepal and in adjacent Indian States to identify transmission constraints and power transfer capability
- Identify weak and strong points on Nepal system and identify likely transfer points and corresponding points in India
- Prepare report and present to stakeholders
- Receive and review stakeholder comments and prepare final report
- Presentations in Nepal and India

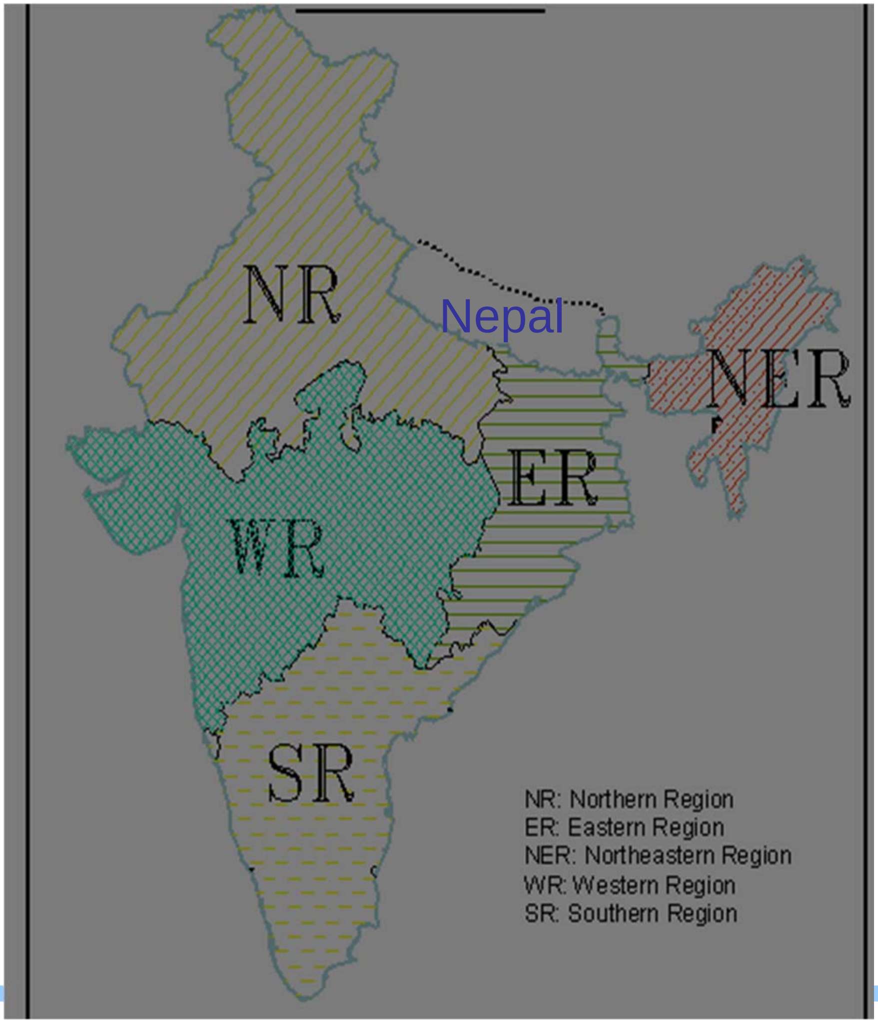
NEA Power System

- Constraints in system for full utilization; 132 kV is highest voltage
- Peak Load 550 MW (Winter) – Available: 420 MW
- Peak load 520 MW (Monsoon) – Available: 540 MW
- Available power for export – Minimal now (20-40 MW including possible IPP surplus)
- Annual energy consumption 2,650 GWh

Study for Transmission Line between Nepal and India:
Overview of the Indian Power System

- Indian power system is operated as five regional grids:
  - Northern Region (31,348 MW) - experiences power shortage always
  - Southern Region (30,318 MW) - experiences power shortage always
  - Western Region (32,740 MW) - experiences power shortage always
  - Eastern Region (17,909 MW) - experiences power surplus always
  - Northeastern Region (2,357 MW) - experiences seasonal surplus
- Inter-regional transfer capacity - 9,500 MW (To be augmented to 37,000 MW by 2012)

Study for Transmission Line between Nepal and India
Geographical Location



Study for Transmission Line between Nepal and India: Role of key players in the Indian Power System

- Ministry of Power – Central Ministry with responsibility for power policy
- Central Electricity Regulatory Commission (CERC) - regulates interstate power trade (formed in 1998)
- 19 states have constituted State Electricity Regulatory Commission (SERCs); another 5 are in the process of establishing SERCs – regulate intra-state power transmission
- Central Electricity Authority – Central planning authority for the country
- Power Grid Corporation of India (Powergrid) - responsible for bulk transmission of electricity across the states

Study for Transmission Line between Nepal and India: Role of key players in the Indian Power System

- Central government agencies - NTPC, NHPC, NPC,DVC own and operate generating plants
- State-owned SEBs generate, transmit, and distribute electricity with in the states
- IPPs generate and sell mostly to SEBs
- Several private distribution companies exist: Tatas, Reliance, BEST, CESC, BSES etc; some own generation and transmission facilities as well

USAID FROM THE AMERICAN PEOPLE

Study for Transmission Line between Nepal and India: Some Key Steps taken by CERC/MOP

- CERC frames norms for competitive bidding for issuing licenses for private transmission lines
- Separate agency for system operation is being setup
- CERC issued power trading licenses to 12 agencies and trading was initiated in 2001/2

Study for Transmission Line between Nepal and India: IRG Meetings with Key Indian Agencies in Nov 05

IRG team meetings in Nov 2005

- Ministry of Power, Government of India (MOP)
- Central Electricity Regulatory Commission (CERC)
- Power Grid Corporation of India (Powergrid)
- PTC India Ltd (PTC)
- Confederation of Indian Industry (CII)
- Tata Power Company Ltd (TPC)
- Reliance Energy Ltd (REL)
- Independent Power Producers Association of India (IPPAI)

Study for Transmission Line between Nepal and India: IRG Meetings with Key Indian Agencies in Nov 05

Key findings:

- MOP reiterated the interest of Government of India to purchase electricity from Nepal on commercial terms
- Electricity is not a free-trade commodity across borders; government to government agreement is required before private/public agencies can engage in trading in electricity
- In view of system demand characteristics and consequent lower energy price, run-of-river projects may not be of great interest
- India is interested in buying seasonal surpluses

Study for Transmission Line between Nepal and India: IRG Meetings with Key Indian Agencies in Nov 05

Key findings (continued):

- Power purchase agreements may follow Bhutan model or other mutually acceptable models
- Pricing of electricity based on quantity, location, timing, duration, and availability
- Transmission charges within India is regulated by the CERC
- Powergrid is willing to construct transmission line on the Indian side for interconnection with Nepal, on commercial terms
- Other benefits (irrigation, flood control etc) cannot be part of electricity tariff in India; governments of Nepal and India may negotiate such benefits outside of power trade agreements

Study for Transmission Line between Nepal and India: IRG Meetings with Key Indian Agencies in Nov 05

Key findings (continued):

- PTC Ltd is the nodal agency in India for electricity trade with Bhutan and Nepal; others may become involved later

- Transmission constraints exist for export from Eastern region to Northern region (present capacity: 700 MW – to be increased to 10,950 MW by 2012); capacities for export from Eastern region to Western and Southern regions are also limited

- Eastern and Northeastern regions in India experience power surpluses during the same period as Nepal; the unmet demand in India will be mainly in Northern region; Southern and Western regions fall short of only peaking power during monsoon

Study for Transmission Line between Nepal and India: IRG Meetings with Key Indian Agencies in Nov 05

Key findings (continued):

- The existing capacity for power transfer to India is about 25 MW; too small for IPP and power trading interests

- Tata Power Company (TPC) owns and operates both hydroelectric and thermal plants in India; also owns transmission lines and distribution companies

- TPC in joint venture with Powergrid owns and will operate the first public-private partnership transmission system in India for evacuation of power from Tala Project (1,060 MW) in Bhutan (1200 km of 400kV lines from Bhutan border to Delhi to be completed by March 2006)

Study for Transmission Line between Nepal and India: IRG Meetings with Key Indian Agencies in Nov 05

Key findings (continued):

- TPC is interested to work on private and private-public partnership basis
- TPC is experiencing a shortage of 200 MW in Mumbai now and will be interested to buy from Nepal if the delivered price is competitive
- North Delhi Power Ltd (NDPL), the distribution company in Delhi owned by TPC, may be interested to buy electricity from Nepal
- TPC would also be interested in investment in IPP projects in Nepal

Study for Transmission Line between Nepal and India: IRG Meetings with Key Indian Agencies in Nov 05

Key findings (continued):

- REL is interested in purchase of electricity from Nepal;
  - long term purchase from a dedicated plant in Nepal
  - purchase of seasonal power surplus in Nepal

- REL is interested to invest in large bulk transmission systems from Nepal (like the Tala System)

- For importing seasonal surplus, building a new transmission link may be economically feasible if “viability-gap funding” is arranged from governments or donors

Study for Transmission Line between Nepal and India: IRG Meetings with Key Indian Agencies in Nov 05

Summary of findings

- Demand exists in India but interconnections pose constraints
- Need clear commitment for export in terms of quality, quantity, duration and location
- Pricing is competitive and is available to all suppliers
- Additional project benefits may be negotiated outside of power trade agreement

Study for Transmission Line between Nepal and India: Options to export

Four options to export power

- Move electrical Boundary; connect more of India to Nepali system: good for up to 50MW
- Interconnect with HVDC back to back link: good for up to 500 MW
- Synchronise systems: for export over 500MW
- Connect power plant in Nepal direct to Indian system

USAID FROM THE AMERICAN PEOPLE

IRG

Study for Transmission Line between Nepal and India: Vision

- Near term Move boundary, export up to 50MW when surplus (including IPP surplusses)

- Short term Add HVDC back to back converter, export up to 250 - 500MW (with several small new plants that may come up if transmission backbone is strengthened and export commences)

- Long term Build 220kV inter-connector, synchronise systems, export 500+MW (with large plants and several more small plants)

Study for Transmission Line between Nepal and India:
Schedule of Study

Schedule for study:

- Analysis of NEA system and modeling study :18 February 2006
- Interim report : 03 March 2006
- Stakeholder meetings : Late March 2006
- Draft final report : 15 May 2006
- Final report : 31 May 2006
- Presentations in Nepal and India : 1-7 June 2006

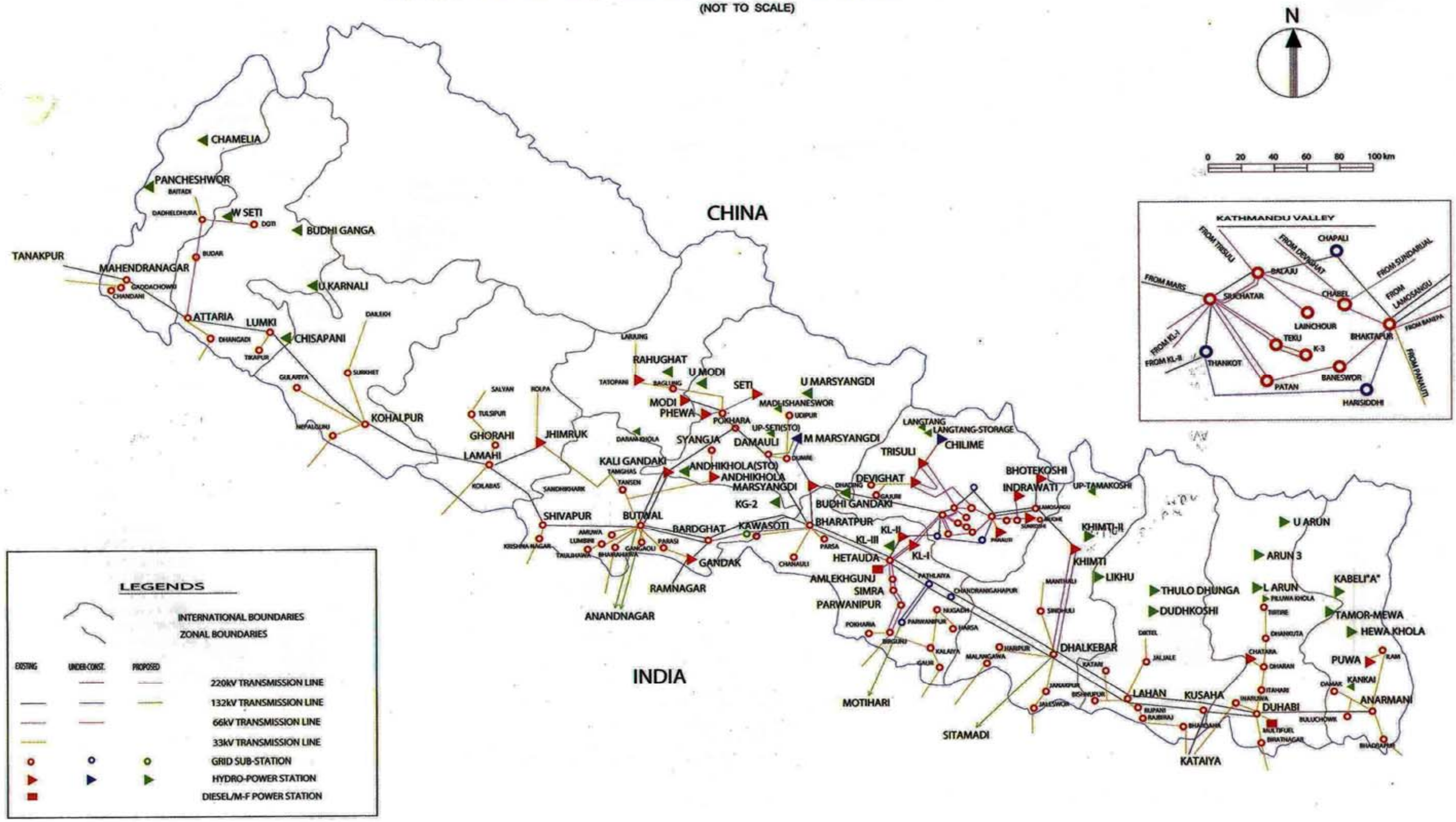
Thank you

Email: gkrishnan@pshdp.wlink.com.np

POWER DEVELOPMENT MAP OF NEPAL

MAJOR POWER STATIONS ,TRANSMISSION LINES & SUBSTATIONS

(NOT TO SCALE)



USAID FROM THE AMERICAN PEOPLE

IRG

Appendix D

Observations made during visit to NEA's Load Dispatch Center, November 27, 2005

APPENDIX D

Observations made during visit to NEA's Load Dispatch Center, November 27, 2005

NEA has a state-of-the art control centre, adjacent to Siuchatar substation to the east of Kathmandu. The equipment was supplied by Siemens. This control centre is responsible for generation dispatch, load shedding, and for 132kV switching. IRG Consultants visited the control centre on Sunday 27 November 2005. The visit was timed from 16:00 until 18:30 in order to cover the evening peak. In Nepal, Sunday is a normal work day; and the load profile observed was that of a typical weekday.

System Frequency

System frequency was controlled manually and hovered around 50.5 Hz for the entire 3 hours, falling to about 50.2 Hz and rising to 50.9 Hz. This utilization pattern is probably a sensible strategy (assuming one is not trying to ensure that the average frequency is 50Hz) as it reduces the risk of plant tripping leading to unacceptably low frequencies. The consultants were told that they have load-shedding on under-frequency relays set at 48.75 Hz and 48.5 Hz

In comparison, the system frequency in India in the northern region, at the equivalent time of day on the following Tuesday varied between 48.6 Hz and 49.5 Hz[1], while in the eastern region it varied between 49.2 and 49.8 Hz[2].

Demand

Demand changed over time during the consultant's visit.

- 16:13 Load was 324 MW
- 17:19 Load was 452 MW
- 18:07 Load was 558 MW (with about 5 MW of load shed at Birgunj)

The load at 18:07 was close to system peak. Load shedding at Birgunj occurred owing to transformer overloading, not a shortage of generation capacity. To put this in another perspective, the system demand increased from 60% to 100% in 2 hours.

Generation

The major IPP plants were operated as base-load plants owing to "take or pay" clauses in their power purchase agreements. Other smaller run-of-river plants also were operated at full capacity at all times. Only 3 major NEA plants (144 MW Kali Gandaki, 69MW Marsyangdi[3] and 60MW Kulekhani-1 have water storage facilities) are operated on

---

[1] Information available on www.nrldc.org

[2] Information available on www.erldc.com

[3] These plants are described as "peaking run-of-river" – does this mean that they have a daily storage facility?

AGC[4] (Automatic Generation Control) mode - dispatch can be matched to real-time demand. Kaligandaki, Kulekhani 1 & 2, Marsyangdi and the NEA's thermal plants (multi-fuel plants at Duhabi and DG sets at Hetauda) are operated as peak load units.

Khimti (60 MW) and Bhotekoshi (30 MW) IPP plants to the east of Bhaktapur have poor indications on the SCADA system. On Sunday November 27, they were producing 46 MW and 25 MW respectively. The voltage at Lamosangu (the pooling point for these two plants) was operating at 138 kV (1.045 p.u.), so it can be inferred that the power stations were producing a reasonable amount of reactive power.

Table D.1: Generation details on 27 November 2005

Time	Kulekhani		Kaligandaki	Marsyangdi	Duhabi Multifuel	Total
	1	2				
16:13	8.2	1.6	90.5	56.0	0.0	156.3
17:19	48.5	21.8	104.0	43.2	11.2	228.7
18:07	60.5	27.5	128.0	70.0	22.3	308.3

The total system load at peak (18.07 hours) is given in Table A.2

Table D.2: Generation details at system peak on 27 November 2005

Item/Plant	Generation (MW)
NEA's Hydro plants with AGC (3 nos)	259.0
Other Hydro plants of NEA	80.5
Major IPP plants	117.0
Small Hydro plants connected to Grid	7.0
NEA's Thermal: Multi-fuel at Duhabi DG sets at Hetauda	22.3 6.0
Import from India	66.5
Export to India	1.5
Total System Load	**558.3**

Import/Export with the Indian System

At 16:00 all the Nepali system load was supplied from Nepal, and in addition Nepal was exporting 1 MW from Gandak to Ramnagar in India[5]. This export increased to 1.5 MW at peak. In addition, there were small transfers on 33 kV and 11 kV feeders. At about 16:55 a circuit breaker at Kohalpur, in the west of the country, was opened and about 7 MW of

---

[4] Reji – We never ascertained if they were normally run in this mode (and if so, what was the target frequency? 50.5 Hz?) I intend to find out more in February.

[5] It is probable that this represented 6MW of Indian load, less 5 MW of generation at Gandak.

load was disconnected. This load was then connected to the Indian system and picked up by the generator at Tanakpur in Uttar Pradesh. At peak about 16 MW was imported. At about the same time, the bus-coupler at Duhabi was opened. Load at Duhabi and Anarmani at the eastern extremity of the country was lost (approx. 15-20 MW). This load was then connected to the Indian system (importing on the 132kV circuit from Kataiya). At about the same time, the multi-fuel plant at Duhabi was started (0 MW at 16:13, 11 MW at 17:13, 22 MW at peak). Total imports from India at peak were 66.5 MW and exports to India were 1.5 MW.

Voltage Profile in the Nepali System

Voltage profiles observed on various segments of the system were generally poor, and very poor at the peak. Only a few bus-bars close to generating plants were running at over 1.0 p.u.; the 132kV nominal bus-bars were typically at 120 - 126 kV (0.9 to 0.95 p.u.) and the 66kV bus-bars were also low. At Siuchatar 66kV the voltage varied between 60 and 62 kV, while at Birgunj the 66kV voltage hovered around 50 kV (0.67 p.u.) between 16:00 and 18:00. Kathmandu 66kV voltages were also low.

At Birgunj there are two 66/11 kV transformers supplying an 11 kV bus bar, and 2 66/33kV transformers, each one supplying a separate feeder. (It appears that the 33kV feeders could be paralleled through a 33kV bus-bar, but in fact this did not happen). The two 66/11 kV transformers were rated at 7.5 or 10 MVA, and were both overloaded. This is not surprising, considering the voltage at Birgunj 66kV bus-bars was only 50 kV (0.7 p.u), so that each transformer was only carrying about 7 MW. At about 17:00, one of the five outgoing 11 kV feeders was disconnected to shed load; then about 45 minutes later a second feeder was disconnected and the first one reconnected.

During this time, one of the Hetauda – Birgunj 66kV feeders tripped, presumably owing to transformer overloading, and was quickly restored to service. At peak, the 66kV double circuit Hetauda-Birgunj lines were carrying 57 MW but operating at 52 kV. Similarly, the 132kV lines between Dhalkebar – Lohan – Duhabi - Anarmani were operating at 123-117 kV at peak.

Transformers

There are six 132/66 kV transformers that supply the Kathmandu/Hetauda/Birgunj area. These were all heavily loaded, as seen in Table A.3 below.

Table D.3: Transformer details on 27 November 2005

Time	Power flows through Transformers (MW)			
	Hetauda 1 &2 (20 MVA each)	Siuchatar 1 &2 (36 MVA each)	Belaju (45 MVA)	Bhaktapur (16.5 MVA)
16:13	28.3	30.6	11.2	19.4
17:19	29.1	36.6	14.3	28.3
18:07	24.7	47.5	19.0	36.9

The 2 transformers at Hetauda, and the 2 at Siuchatar were all at tap 9 (probably centre tap out of 17). Indications were not available for the other two transformers. Although it is normal practice to adjust transformer tap changers to control the voltage profile, this facility appeared not to be used by NEA.

In general the system seemed to be operated very competently. One concern was the apparent failure to utilize the tap-changers on the 132/66 kV transformers to raise the 66kV system voltage.

Appendix E

Review of Four Borders Interconnection Report

APPENDIX E

Review of Four Borders Interconnection Report

In 2000, USAID launched the South Asia Regional Initiative for Energy Cooperation and Development (SARI/E) program to build energy linkages among the countries of South Asia – initially Bangladesh, Bhutan, Nepal, India, Sri Lanka and the Maldives; later Pakistan and Afghanistan were added. SARI/E's goal is to promote energy sharing and cooperation to improve the regional energy supply-demand balance thereby enhancing the energy security of the individual states and the region. The SARI/E program organized activities promoting regional power exchanges and development of a regional power transmission network to provide access to untapped energy resources and to enhance regional energy security. Under SARI/E, USAID in 2001 prepared a pre-feasibility study establishing electricity transmission interconnections across the four-border region of Bangladesh, Bhutan, Nepal and India. The major findings and recommendations of this study were published as "Four Border Interconnection Report" (FBR). A summary of the report's recommendations is presented in this chapter. A more detailed review of the study is presented in Appendix D. Since the focus of IRG's analysis is on the implications of the FBR on enhanced transmission links between India and Nepal, the presentation of detailed data used in the FBR is limited to these countries.

E.1 Background and assumptions of the study

The assumptions of the FBR were:

1. "Due to the close proximity of the four countries in the four boarders area, a regional electricity interconnection could be developed with minimal technical challenges and at minimum cost";
2. "Several stakeholders consulted confirmed the technical challenges posed by the interconnections can be resolved with minimum cost".

The FBR reviewed the power system data of all four countries; however since it was a pre-feasibility study, no detailed analysis of the individual countries was conducted. Details of the power system data utilized by Neat Inc are given below.

Supply/Demand Situation in Nepal

The FBR considered an annual average demand growth rate for power of 8.25% (including exports and domestic use) in Nepal and relied on NEA's 2001-2012 capacity addition plan of 811 MW which included the projects listed in Table 4-1.

Table E-1: Projects envisaged in 2001 in Nepal and present status

Project Name (All Hydro)	Capacity (MW)	Scheduled Completion (as of 2001)	Present Status (As of June 2006)
Khimti Khola - II	27	2006	No firm program yet
Kulekhani – III	42	2006	50 MW project is expected to be completed by 2010
Likhu-4	40	2007	No firm program yet
Upper Karnali	300	2008	No firm program yet
Arun-3	402	2012	No firm program yet
Total	811		

The FBR assumed installed capacity of Nepal would rise to more than 1,400 MW by fiscal year 2011/2012 resulting in a wet season surplus of about 550 MW and a dry season surplus of about 475 MW which could be exported to India and Bangladesh.

Supply/Demand Situation in India

The FBR utilized the demand forecasts of India's 16-th Electric Power Survey of the Central Electricity Authority (CEA) which is still used by India in 2006 for power system planning. India's supply/ demand balance considered in the FBR is presented in Table 4-2.

Table 4-2: India's Supply/Demand Scenario through 2012

Region	Demand 2001 (MW)	Projected Demand 2012 (MW)	Planned Capacity Addition By 2012 (Central Govt.) (MW)	Surplus or Shortfall (MW)
Northern	21,000	49,000	14,000	(-) 14,000
Southern	20,400	42,000	10,000	(-) 12,000
Western	24,900	46,000	16,000	(-) 21,100
Eastern + Northeastern	8,750	19,000	23,000	(+) 12,750
Total	75,050	156,000	63,000	(-) 34,250

According to the above projections, the surplus power in the East and Northeast regions will not be adequate to meet the gap in demand. Consequently, India's generation expansion plan includes imports of power from neighboring countries. The 2006 scenario is not much different than the assumptions of the FBR, except that in 2002, India launched a program called "Power for all by 2012" under which it aims to add 100,000 MW by 2012. However, actual capacity additions up to March 2006 equal only 27,000

MW with another 32,000 MW under construction. Even if India manages to add 100, 000 MW by 2012, most parts of the country will still experience both peak power and energy shortages. The FBR assumed that both Bhutan and Nepal will have surplus power by 2010 (about 1,300 MW in Bhutan and 550 MW in Nepal), whereas India and Bangladesh will suffer from power shortages (1300 MW in Bangladesh and 4500 MW in India). Therefore a system interconnection in the Four Borders Region could help address this regional supply/demand imbalance.

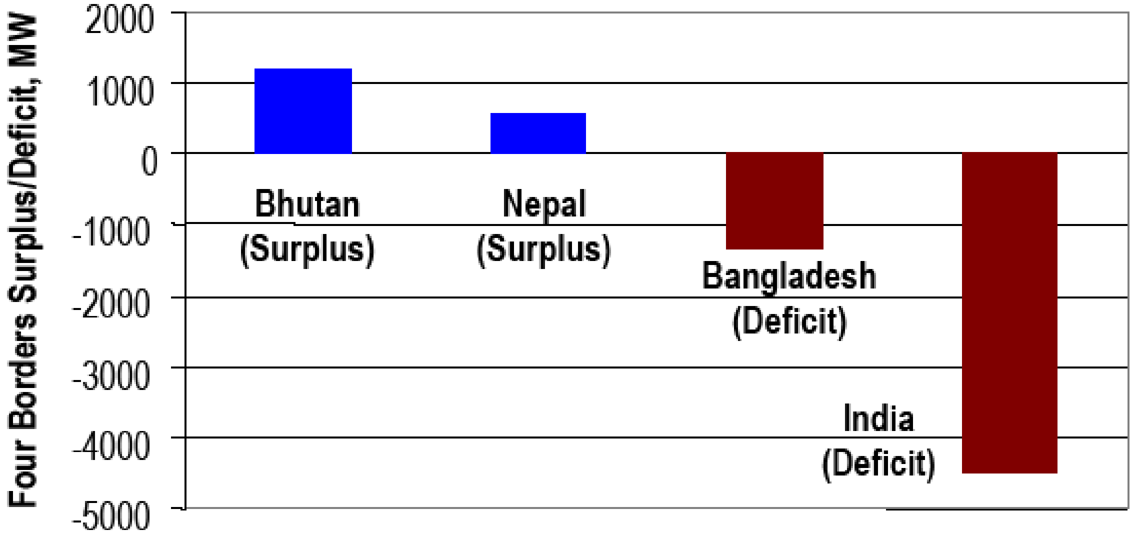


Figure E.1: Forecast Surplus/Deficit in 2010

E.2 Interconnection options evaluated in FBR

Against this background, the FBR analyzed three options for the transmission interconnection facilitating that would facilitate multilateral power exchanges. These options were:

Option A: Limited Power Transfer – based on a 132 kV system allowing power exchanges up to up to 150 MW;

Option B: Moderate Power Transfer with Accelerated Development – based on developing a 220 kV system (in advance of power the system developments in Nepal and Bangladesh) allowing for power exchanges up to 500 MW;

Option C: Moderate Power Transfer with Phased Development – based on developing a 132 kV system initially, which would be upgraded to a 220 kV system in conjunction with power sector developments in Bangladesh and Nepal allowing - for power exchanges up to 500 MW.

All these options were analyzed with two variants – locating the main interconnecting substation at Siliguri (West Bengal) or at Purnea (Bihar) in India. Figure E.2 shown below depicts the geography of the four borders region as well as various interconnection points considered under the three options.

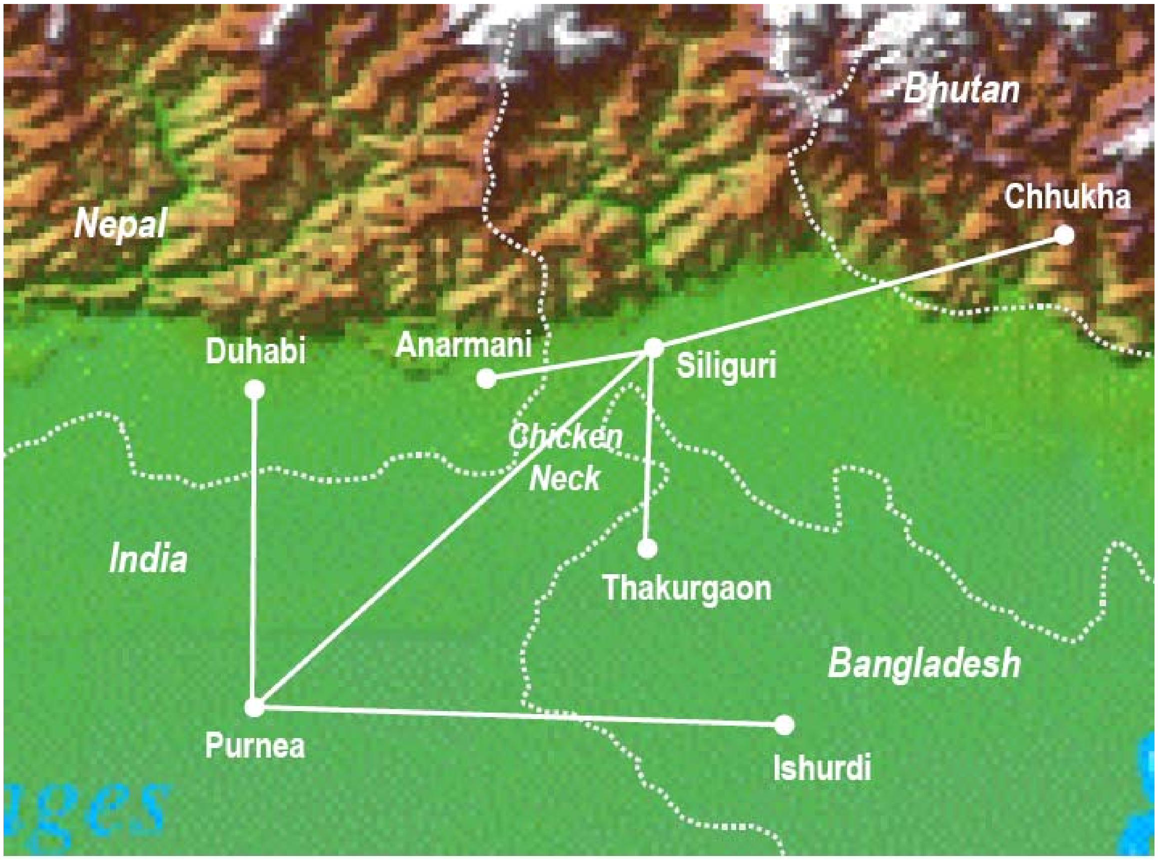
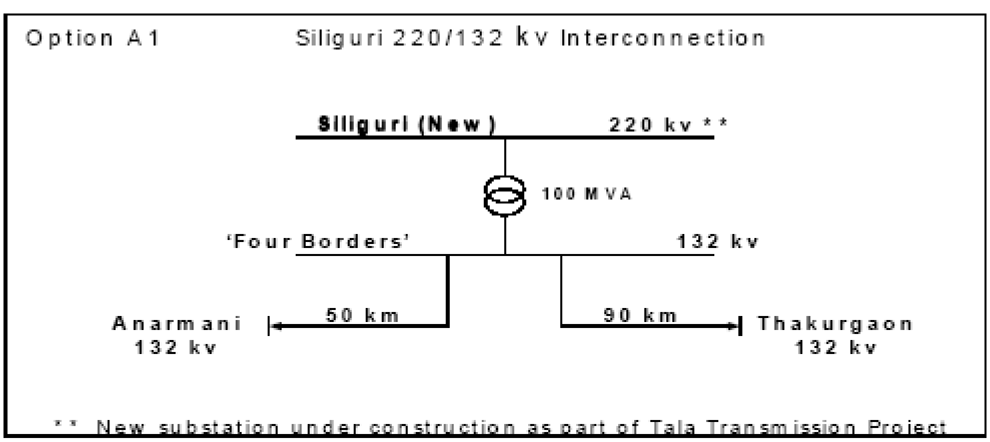
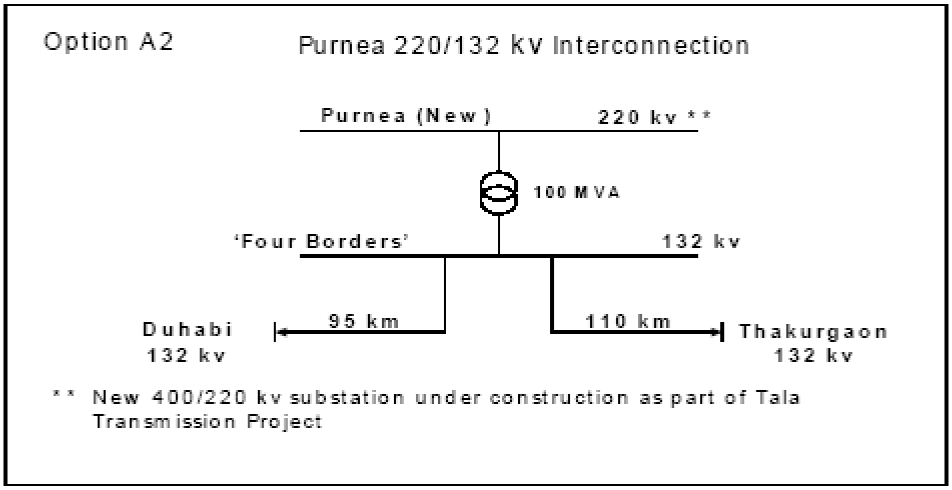


Figure E.2: Location of Four Border Connection

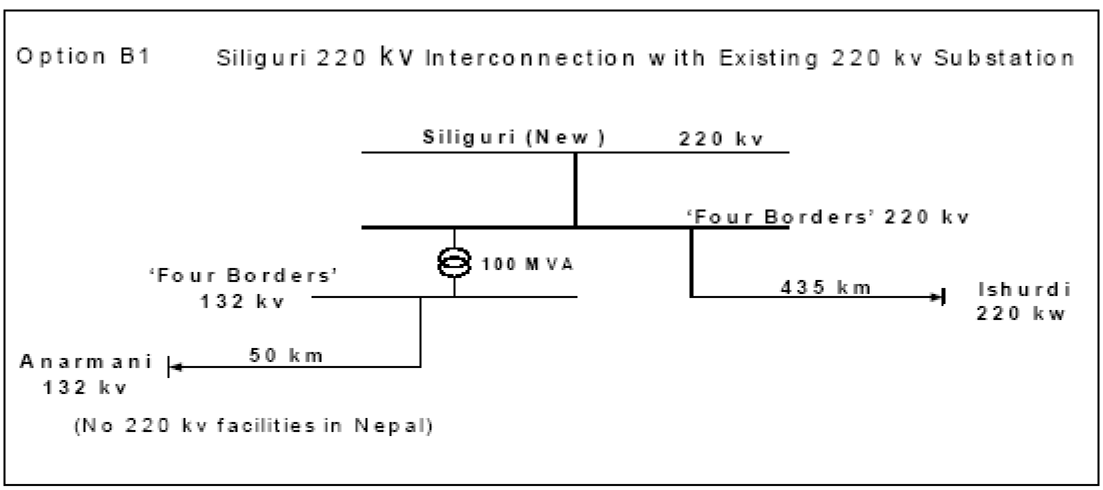
Option A1: This option envisaged building 132 kV lines from the existing 132 kV Anarmani substation in the eastern end of the Nepali grid to Siliguri in India (50 km) and from Siliguri to the 132 kV substation at Thakurgaon in Bangladesh (90 km). It involves construction of a 220/132 kV "Four Borders substation" adjacent to the new 400/220 kV substation at Siliguri.



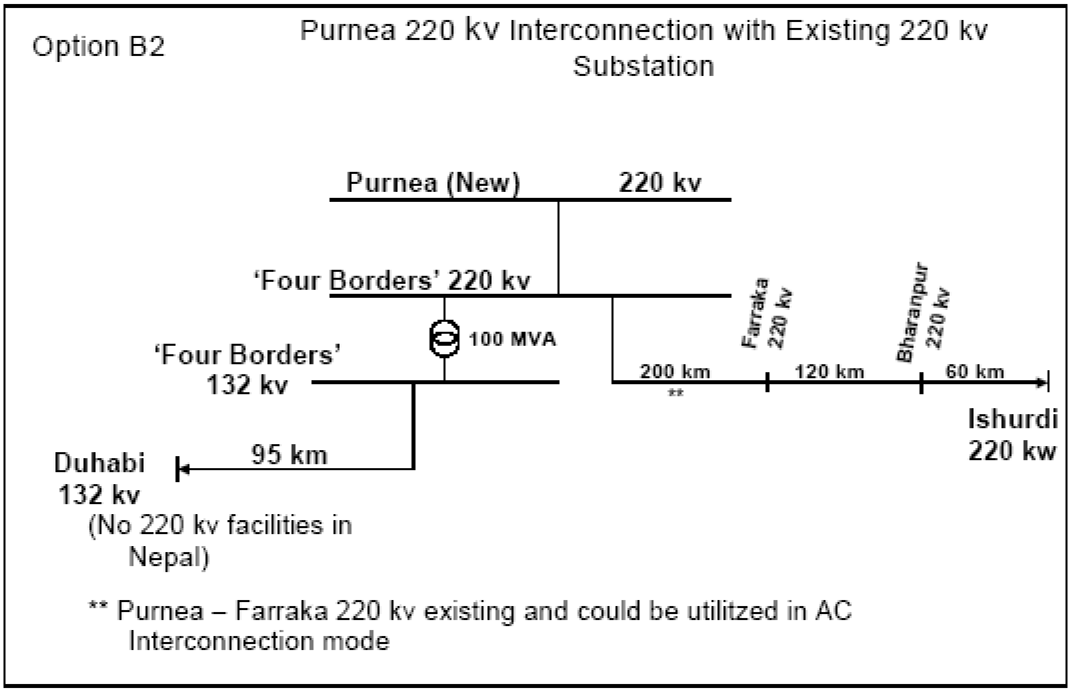
Option A2 involves construction of: This scheme envisaged building a 132 kV line from Duhabi in Nepal to Purnea (95 km) in India and connecting Purnea with Thakurgaon in Bangladesh (110 km). It also includes construction of a building a new 220/132 kV substation adjacent to the new 400/220 kV substation at Purnea.



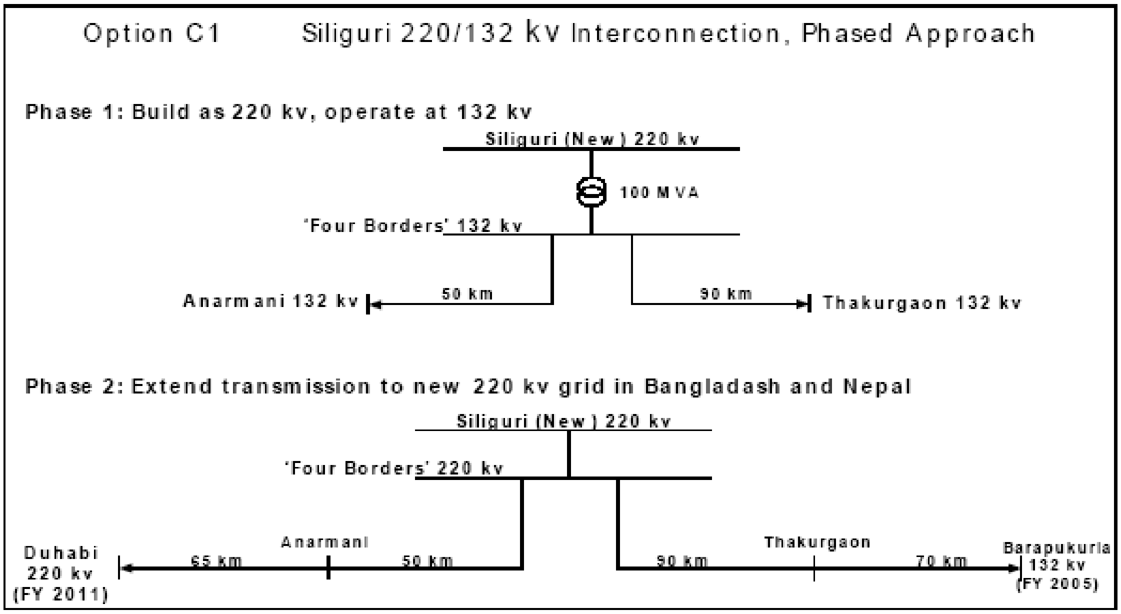
Option B1 proposes: This scheme proposed a 132 kV line from Anarmani to Siliguri (50kM) and a 220 kV line from Siliguri to Ishurdi in Bangladesh (450 km!).



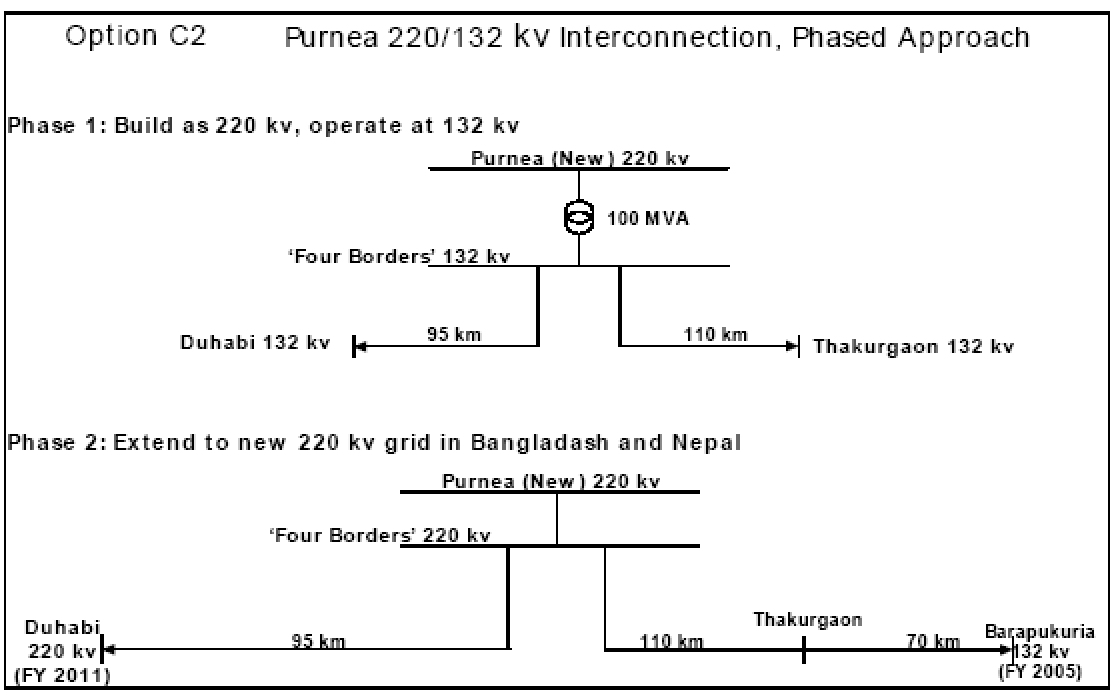
Option B2: This scheme involves envisaged connecting Duhabi with Purnea through a 132 kV line (95km) and extending the existing 220 kV Farakka – Purnea line to Ishurdi by building 180 km of 220 kV line; and using the 220 kV Farakka – Purnea line for power transfers between Purnea and Ishurdi.

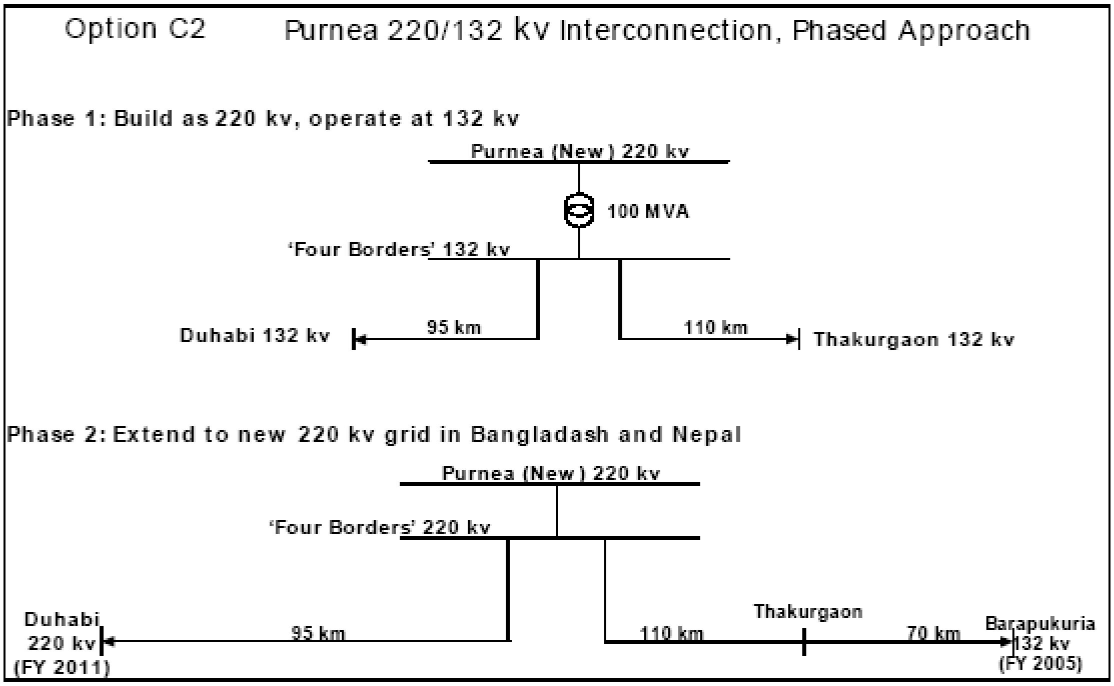


Option C1 was proposed to be executed in two phases. Under Phase-1, a 220 kV line would be built from the Anarmani substation to the proposed 220/132 kV "Four Borders Substation" adjacent to the new 400/220 kV substation in Siliguri; simultaneously, and building a 220 kV line from Siliguri to Thakurgaon in Bangladesh; and charging the entire the interconnection at 132 kV. Under Phase-2, it proposed to extend the 220 kV line from Anarmani to Duhabi in Nepal (65km) and from Thakurgaon to Bakarpuria in Bangladesh (70 km) with the assumption that national utilities in Nepal and Bangladesh would previously have built the 220 kV substations at Duhabi and Bakarpuria. . This option presumes retiring the 132 kV facilities built under Phase-1.



Option C2: This scheme is a variant of option C1 with an interconnection point at Purnea. This Option envisaged construction of a new 220/132 kV Four Border substation adjacent to the 400/220 kV Purnea substation and building a 220 kV line from Duhabi to Purnea (95 km) and from Purnea to Thakurgaon (110 km). It would to be operated at 132 kV in Phase-1. During Phase-2 proposed 220 kV transmission line would be extended from Thakurgaon to Bakarpuria (70 km) and would connecting the system to the 220 kV substations in Duhabi, Purnea and Bakarpuria; and retiring the 132 kV facilities at Purnea and Thakurgaon.





A back-to-back DC interconnection was found to be too costly for the level of power expected to be transferred through the Four Borders project within the time frame of the study.

Cost estimates of the various options considered are presented in Table 4-5 while Table 4-6 compares these costs.

Table E.3: Cost Estimates for all Options ($ Millions USD)

Option	**Variant 1 (Siliguri)**	**Variant 2 (Purnea)**
Option A: Limited Transfer	Option A1 $ 9.45	Option A2 $1E.18
Option B: Moderate Transfer	Option B1 $52.35	Option B2 $27.23
Option C: Phased Development Phase I Phase II *Total Option C*	Option C1 $16.65 $1E.95 $31.60	Option C2 $23.80 $ 7.80 $31.60

Table E.4: Comparison of the options

Options	Four Borders Substation at	Advantages	Disadvantages
A1	Siliguri	Least cost	Low power transfer capability, up to 150 MW
A2	Purnea	Higher cost than A1	Low power transfer capability, up to 150 MW
B1	Siliguri	High power transfer capability, up to 500 MW	Highest cost
B2	Purnea	High power transfer capability, up to 500 MW	High cost but much less than B1
C1 Phase I Phase II	Siliguri	 Low initial cost Low incremental cost. High power transfer capability, up to 500 MW	 Low initial power transfer capability, up to 150 MW
C2 Phase I Phase II	Purnea	 Incremental cost lower than C1. High power transfer capability, up to 500 MW	 Initial cost higher than C1. Low initial power transfer capability, up to 150 MW

Based on the above assessment, the FBR recommended Option C as the preferred option for interconnection and calculated the transmission cost between 2.6 cents/kWh to 0.22 cents/kWh depending on the amount of power transferred.

- The FBR concluded that: Transfer of surplus power available from hydropower plants in Nepal and Bhutan through this interconnection could help reduce power deficits in India and Bangladesh. Preliminary power flow analysis indicates that the proposed interconnection would improve system stability and reduce transmission system losses in the region by about 90 MW.
- The options assessed would permit the transfer of power from 50-500 MW depending on which option is selected up to approximately 500 MW.
- Investment requirements for these options would be minimal, ranging from approximately $9 million to $52 million.
- Estimated levelized transmission costs for the options range from 2.6 cents per kWh for power transfers of 50 MW to 0.2 cents per kWh for transfers of 500 MW.
- All of the options analyzed have positive rates of return, which increase significantly with the level of power transferred.
- All the options reviewed could be implemented between 2005 and 2010.
- All of the options would have a have minimal environmental impacts, as they rely extensively on existing facilities.

The FBR report concluded that Option C, incorporating a phased approach to developing the proposed Four Borders' Project is the best option for establishing a regional interconnection point at the lowest possible costs.

E.3 Prospective Legal and Regulatory Needs

The FBR proposed the establishment of stable legal, regulatory, and trade frameworks to enable:

- The construction of generation projects designed to provide power for cross-border trade and transfer;
- Construction of dedicated transmission and distribution facilities to support power exports;
- Creation and enforcement of contracts for cross-border trade based on commercial terms and conditions;
- Creation and transfer of security interests in project assets;
- Taxation of property and earnings of cross-border projects;
- Enforcement of eminent domain or expropriation of land for transmission rights-of-way;
- Participants to understand what governments expect them to do;
- Participants to understand what they can expect governments to do;
- Build a comfort level among the participants that the regimes will not be arbitrarily changed; thereby protecting private investments while reducing perceived risk.

The legal/regulatory issues needed associated with each phase of development are addressed in the FBR as below:

Phase I (Power Transfer)

The FBR established the viability of providing regional power transfers for up to 500 MW in the Four Borders Region. This limited increase in power transfer capability could be implemented readily by expanding the scope and role of the Power Exchange Committee between India and Nepal so that it becomes a truly regional entity with the addition of Bhutan and Bangladesh. To do so, a Memorandum of Understanding, signed by concerned parties in Bangladesh, Bhutan, India, and Nepal, could be executed building upon the original terms of reference of the 1992 India-Nepal Power Exchange Committee and the salient principles of the Power Trade Agreement executed between India and Nepal in 1997.

Phase II (Power Trade)

With additional transmission capacity available beyond that provided by Phase I it would be possible to expand power trade on an incremental basis by drawing upon the lessons learned in other regions.

- Inter-Utility Agreements (Southern African Power Pool Model): A working committee mechanism formally organized through an Inter-Utility Memorandum of Understanding, similar to what was done by the Southern African Power Pool (SAPP) establishes the basic operating principles for coordination and cooperation in planning and the operation of the member systems to minimize costs while maintaining reliability in order to provide for full cost recovery and equitable sharing of benefits (i.e. reductions in required generation capacity and fuel costs; improved utilization of hydropower resources).
- Regional Power Trade Treaty (Central America Model): Eventually, governments might consider a formal regional organization created by treaty, whereby each country designates a regional power market agent, similar to the treaty agreement among Central American countries.

Regional power transfers require unprecedented coordination based on principles of cooperation and shared benefits involving government representatives and transmission system operators from Bangladesh, Bhutan, India, and Nepal. Regional power trade could be implemented by adapting memorandums of understanding and coordination agreements similar to those developed by other regional entities such as the South Africa Power Pool or the power trade treaty developed in Central and South America. Bangladesh, Bhutan, India, and Nepal should each designate the amount of power required or available for transfer and trade, and designate nodal entities and independent regulators responsible for cross-border power transfer.

E.4 Transmission Pricing and Ownership Options recommended in FBR

To establish the transmission tariff for the power exchanges under Phase-I, the FBR recommended addressing the complex pricing issues by adopting either of two methods:

No compensation but payment in kind - recipient provides similar transmission services at a later date so that wheeling costs even out;

- ***Split-the-savings*** **-** the wheeling utility is allowed a share (15-35%) in the savings of the transaction.

During Phase II where the ability to trade power through the interconnection is expanded, the FBR suggested consideration of a full range of available ownership and transmission pricing options as well as mechanisms to involve the private sector on commercial terms.

Ownership Options

Phase-I regional interconnections for the Four Borders Project will require modest capital investments that could be supported by the public sector (with or without multilateral donor/lender support). Accordingly, the initial regional interconnections could be developed without involving the private sector to finance the regional interconnections on a commercial basis. However, to provide for regional power trade under Phase-II, the FBR recommended consideration of new ownership options for cross-border power markets.

Cross-border projects can be developed as government-to-government projects, as IPP projects or by a public-private joint venture. The project development options include:

Ownership by Unbundled Public Utility Holding Companies: Holding company utility systems consist of separate (unbundled) utilities under the control of a single holding company. Typically, the system has interconnected generating, transmission, and distribution systems operating on a highly coordinated basis as a single system with central dispatch (similar to a tightly structured power pool); otherwise, a holding company can have utilities that are not interconnected as a single, integrated system but that operate as part of a larger power pool with other utilities through agreements that provide for common operation of facilities and joint planning of system expansion.

Joint Ownership: Inter-utility bulk power transactions can be conducted through joint ownership of generation or transmission systems (often through a special purpose company) to spread the cost and risks of new, larger facilities. In such schemes, one utility is designated as the operator, and power allocations to each of the members are regarded as bulk sales from the central operator. Otherwise, a separate entity can be created to own and operate the shared facilities. Each member is a shareholder in the new entity and transactions are treated separately, similar to transactions between utilities in a holding company.

Third-party Ownership: Another ownership option involves inter-utility bulk power sales from generation and transmission facilities owned by independent, third parties, usually in the private sector.

Ultimately, regional power trade requires an organized trading system supported by generation and transmission projects developed on a commercial basis and supported by power marketing contracts.

E.5 Recommendations and Next Steps in the FBR

To make the proposed Four Borders Project a reality, the FBR recommended that a Working Group be established consisting of regional stakeholders representing India, Bangladesh, Bhutan, and Nepal to review the proposed project, serve as a liaison with energy ministries and other sector stakeholders, and to develop and oversee an implementation strategy, which would include:

- Development and execution of an Inter-Governmental Memorandum of Understanding, establishing principles for power trade and transfer among the countries to promote an integrated regional transmission system for the benefit of all parties.

- Development and execution of an Inter-Utility Memorandum of Understanding for regional transmission system operators establishing the operating principles and rights and obligations of participants and the procedures for ensuring full cost recovery and the equitable sharing of benefits;

- Preparation of a detailed project report for the World Bank and the Asian Development Bank meeting all the requirements for developing, financing, and implementing the proposed regional interconnection; and

- Establishment of an Environmental Assessment Team with representatives from Bangladesh, Bhutan, India and Nepal to address environmental and social issues associated with this project and to coordinate with the Working Group.

E.6 IRG's views on FBR and present status of the recommendations

The interconnection options recommended in the FBR have been eclipsed by the passage of five years during which time Nepal has done little to enhance its power export capability and India has become concerned by its energy security. While many of the legal, regulatory and ownership issues and the next steps recommended in the FBR are logical and still remain valid options for implementing the project, the Government of India has stated publicly that its energy policy with neighboring countries will be conducted only on a bi-lateral basis and that it does not support the FBR as a model for electricity trade. This point was reiterated by the Ministry of Power, Government of India to IRG in a meeting in November 2005 (See Appendix D). Owing to its geography and size, it will be difficult for any regional program to be successful without the cooperation of India. Indeed without the support of the GOI, the prospect for Nepali/Indian electricity trade to expand within a larger regional context is at best remote. This however in no way obviates the possibility for additional bilateral trade between the two countries with the active involvement of both nations' private sectors.

IRG's Comments on the interconnection options

There are several technical issues in the FBR, outlined below, that IRG believes merit a more thorough analysis before a final interconnection option is adopted.

1. The FBR assumes that a single circuit 132 kV line can transport 150 MW and a single circuit 220 kV line can transport 500 MW which are more than double the usual power carrying capacities of normal 132 kV and 220 kV lines. It would be useful to have these assumptions reviewed in the light of current transmission technology.

2. The usual ideal length of 132 kV line is below 100 km while that of a 220 kV line can be in the range of 140-160 km. The FBR proposed 132 kV lines of 110 km and 220 kV lines of 435 km. Again it would be useful to examine these assumptions against the newest technological developments.

3. Option-B proposed a 132 kV single circuit connection between Nepal and India and 220 kV connection between India and Bangladesh. Since this study is limited to an examination of bilateral interconnections between India and Nepal we have not examined the practicality of the FRB's conclusions regarding these broader regional interconnection options but believe they may no loner be viable given developments over the last five years.
.
4. All options envisaged a "Four Border Substation" at either Siliguri or Purnea both which have both technical problems and questionable economics in light of current market conditions. There are existing 220/132 kV substations at both Siliguri and Purnea and new 400/220 kV substations are being built at Siliguri and Purnea for the Tala transmission system (from Bhutan). The FBR theoretically intended to utilize the Bhutan – India interconnection points at Siliguri or Purnea to make it a Four Border interconnection. However the proposal to build additional substations that would be retired in five years adjacent to the existing (and those under construction) facilities may no longer be technically or economically viable given changed market conditions.

The FBR report may not have paid enough attention as to whether AC or DC interconnections are the best option for linking the countries to insure the smooth operation of systems operating at varying voltage levels. While the FBR report was viewing regional interconnections on a multilateral basis, there are also critical issues affecting bilateral energy trade. Single circuit 132 kV links are inadequate to interconnect three grids for synchronous operation. As a general rule when two power systems are interconnected, the capacity of the interconnecting transmission line needs to be greater than the largest generating unit in the two power systems. Since the largest unit size in India is 500 MW, any interconnection line with lesser capacity can not ensure stable operation in a synchronous mode. In addition, details of the cost estimates and basis for the calculation of transmission charges are not furnished in the FBR; hence it is impossible to verify their accuracy.

In conclusion, since the Government of India does not support a regional transmission interconnection, it is important to build bilateral interconnections; once there are enhanced bilateral transmission links between India and Nepal, India and Bangladesh and Bhutan and India, power exchanges among all the countries can be upgraded creating the basis for a regional power pool.

Appendix F

Details of Model Analyses and cost estimates

APPENDIX F

Details of model Analyses and Cost Estimates

1 Detailed Description of Options for Capacity up to 100MW

1.1 Option 1A: 132kV Butwal – Anandnagar (or Gorakhpur)

In 1999 NEA and Powergrid identified three possible 132kV transmission connections between Nepal and India, one of which was the Butwal – Anandnagar line. In Section 3.2 of this report, IRG identified the best places for an import/export facility as being between Butwal and Dhalkebar in central Nepal. The Butwal – Anandnagar line route falls within this region and IRG have re-examined this route as part of this study both, as a possible 100MW export facility and as a possible 500MW export link as available energy is increased.

The proposed transmission line goes from Butwal to Sunauli on the Nepal/India border and then onto Anandnagar (Uttar Pradesh - UP), a total distance of 79km. Anandnagar is currently connected to Gorakhpur (UP) by a single 38 km long 132 kV circuit. Gorakhpur is connected to the Indian 220 kV and 400 kV systems.

Uttar Pradesh faces serious power deficit and could therefore benefit from power export from Nepal. Anandnagar substation is therefore considered to be an ideal interconnection link with Nepal as it has likely demand from UP as well as connections to the wider Indian system.

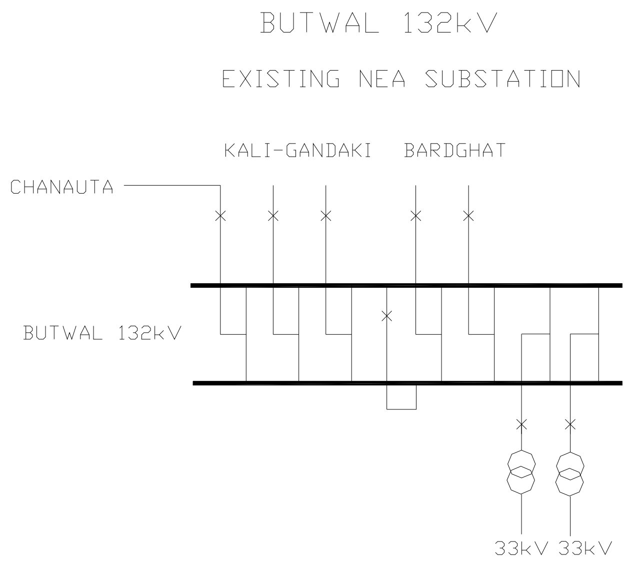
1.1.1 System Studies

The load flow analysis carried out by the IRG team indicates that this system is capable of transferring 100MW without overloading any transmission lines or transformers on the INPS however 30MVAr capacitor compensation, above that already planned by NEA, will need to be installed at Butwal and 20MVAr at Anandnagar.

IRG have been unable to carry out stability analysis but believe that the total impedance of this overhead line, plus the impedance of the transformers at Gorakhpur, makes it likely that such an AC connection will be unstable which means that a HVDC link is likely to be required. This will make a significant difference to the cost of this option. The analysis below considers both AC and DC connections.

1.1.2 Construction Details

The existing substation at Butwal is an 8 bay 132kV substation shown diagrammatically below:

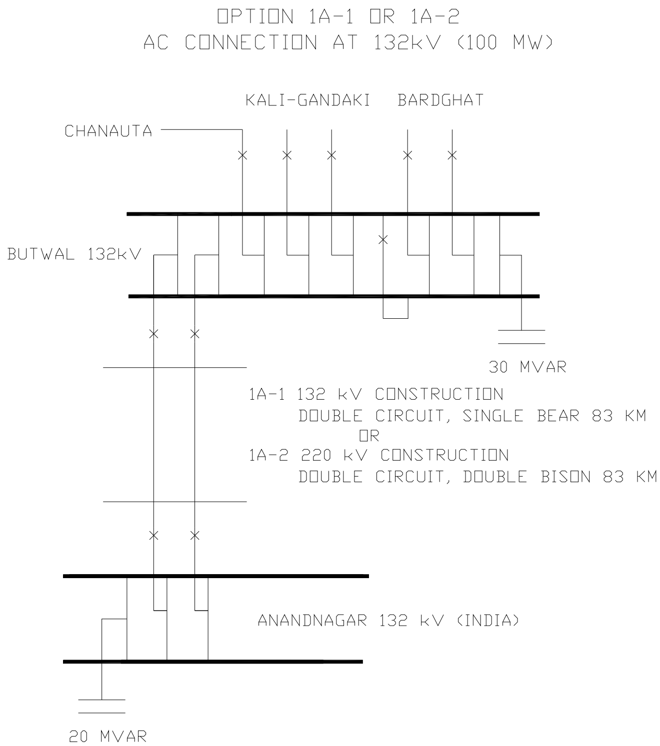


An overhead line to Anandnagar with 132kV towers and single 200 mm^2 ACSR Panther conductors per phase can carry about 100MW and this would be the cheapest form of construction for this option. The NEA/Powergrid feasibility study actually proposed Bear conductor which is a larger cross-section (326 mm^2) conductor. However this construction would not be easily expandable as power transfer increases in the future and a double circuit 220kV construction with twin 431mm^2 Bison conductor might be a better, albeit more expensive option. To defer costs, it is possible that a single circuit with twin Bison conductor bundle could initially be strung on double circuit towers and the second circuit strung as power transfer increases. This construction integrates easily and sensibly with a future need to connect at 220kV at Gorakhpur, discussed in option 2A below, whilst keeping initial costs as low as possible

A double busbar substation can easily be expanded by the addition of new switchbays to provide the connection for the interconnector circuits. IRG has examined the following options:

- 1A-1: Double circuit 132kV construction, single Bear conductor (as per the NEA/Powergrid proposal)
- 1A-2: Double circuit 220kV construction, double Bison conductor
- 1A-3: Double circuit 220kV construction, double Bison conductor, single circuit strung, charged at 132kV
- 1A-4: Butwal – Gorakhpur, Double circuit 220kV construction, double Bison conductor, single circuit strung, charged at 220kV

These options are shown diagrammatically in the figures below:



As the diagram shows, the expansion necessary for the interconnector (options 1A-1 and 1A-2) is described as follows:

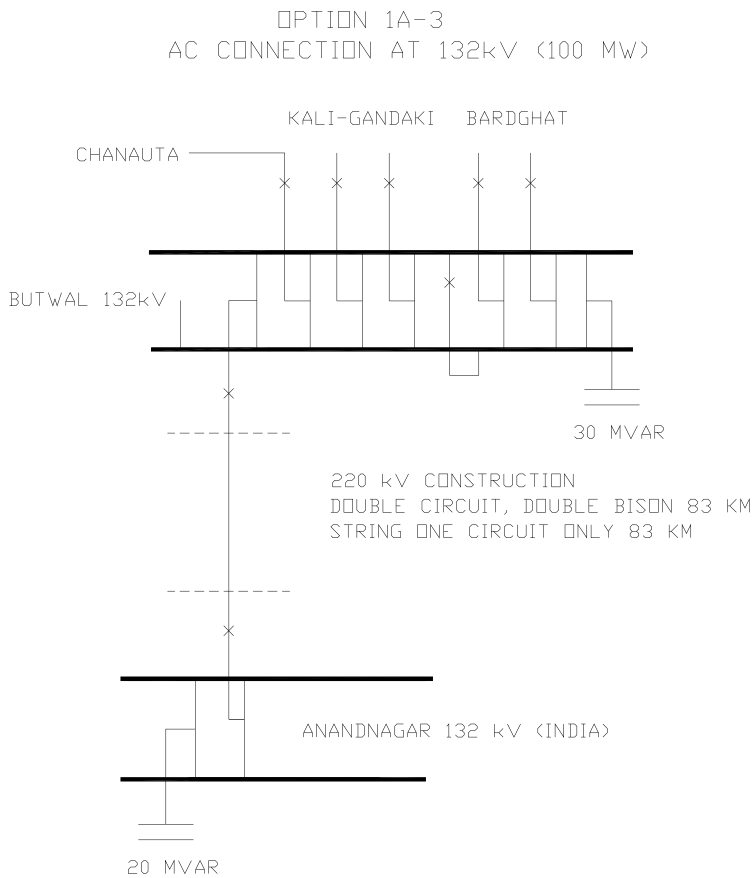
- 2 x 132kV double busbar line switchbays at Butwal
- 1 x 132kV double busbar capacitor bay at Butwal
- 30MVAr capacitor at Butwal
- Option 1A-1 132kV construction Double circuit, single Bear conductor

or

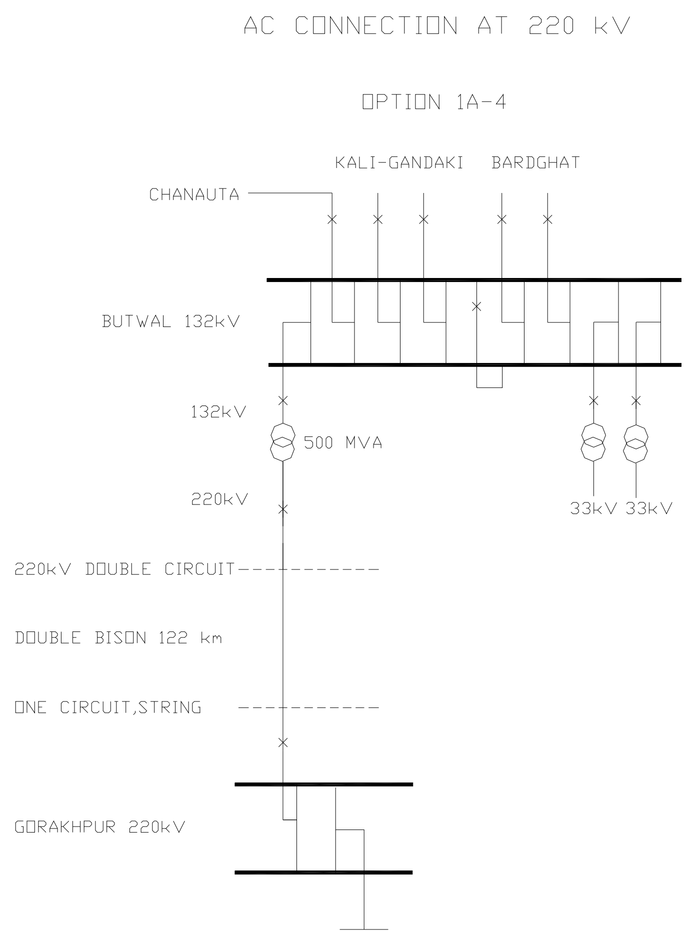
Option 1A-2 220kV construction Double circuit, double Bison conductor

- 2 x 132kV double busbar line switchbays at Anandnagar
- 1 x 132kV double busbar capacitor bay at Anandnagar
- 20MVAr capacitor at Anandnagar

The expansion necessary for option 1A-3 is similar to option 1A-2 but costs are lower because the option only requires one line switchbay at Butwal and Anandnagar. Option 1A-3 is shown in the figure below:



IRG have examined a fourth option 1A-4 which bypasses Anandnagar and connects directly to Gorakhpur at 220kV. There is a 132kV line already connected from Anandnagar to Gorakhpur and this would appear to be an unnecessary extravagance for 100MW export, however closer examination shows that, although option 1A-4 has the greatest initial phase cost, the overall cost after the implementation of Phase 2 is lower. IRG consider therefore consider this option worthy of further consideration and it is shown diagrammatically in the figure below:



The expansion necessary for option 1A-4 is described as follows:

- 1 x 132kV double busbar line switchbays at Butwal
- 1 x 132kV double busbar capacitor bay at Butwal
- 30MVAr capacitor at Butwal
- 1 x 220/132kV 500MVA Transformer at Butwal
- 220kV construction Double circuit, double Bison conductor, strung single circuit
- 1 x 220kV double busbar line switchbays at Gorakhpur
- 1 x 220kV double busbar capacitor bay at Gorakhpur
- 20MVAr capacitor at Gorakhpur

1.1.3 Cost Estimates

IRG have estimated the costs for this interconnector below:

Option	**Description**	**Cost**
1A-1	Butwal – Anandnagar, 132kV Double Circuit construction, Single Bear	$14.1M
1A-2	Butwal – Anandnagar, 220kV Double Circuit construction, charged at 132kV, Double Bison	$24.0M
1A-3	Butwal – Anandnagar, 220kV Double Circuit construction, charged at 132kV, Double Bison strung single circuit only	$15.1M
1A-4	Butwal – Gorakhpur, 220kV Double Circuit construction, charged at 220kV, Double Bison strung single circuit only	$28.4M

These cost estimates assume that an AC connection can be made. If it is determined that an HVDC connection is necessary then it will be necessary to add $25M to the cost estimate for each option.

1.1.4 Route Survey

As a result of the system studies, IRG considered that the Butwal – Anandnagar route, with the potential to expand to Gorakhpur, was very promising and IRG has therefore carried out a walkover route survey from Butwal to Anandnagar and onto Gorakhpur. A map of the surveyed route is shown below. The total length of the proposed alignment from Butwal substation to Anandnagar substation is 79.065 km. Its length in Nepali territory from Butwal to Indo-Nepal border is 25.513 km and that from the Indo-Nepal border to Anandnagar substation is 53.552 km. There are 229 tangent towers, 9 small angle towers, 11 medium angle towers and 7 large angle towers in this sector.

Expansion at Anandnagar substation appears to be difficult because low height residential buildings are located on its east and north sides and a metal road runs along its west and south sides. These buildings will have to be relocated to allow the substation to be expanded by the necessary three switchbays.

Along the proposed route, the terrain is flat and the soil type is silty clay. Most of the land is under cultivation. The alignment crosses a 4.53 km. long forest stretch near Butwal substation. Besides this, the alignment crosses medium voltage lines 35 times, low voltage lines 6 times, telephone lines once, non-electrified railway lines twice and different roads 65 times. It crosses small span canal 5 times, ponds once, small span gully once and rivers 4 times. The spans of the rivers are: Lapsi 12 m, Danda 32 m and Dudi 40 m and 80 m (two crossings). During monsoon, about 60% of land from Butwal substation to the Indo-Nepal border and about 80% of the land from the Indo-Nepal border to Sahajanwa Gorakhpur substation crossed by the alignment remains submerged.

1.2 Option 1B: Birgunj – Motihari

The key component of Option 1B is the existing transmission circuit to India in this area, from Bardghat to Ramnagar via Gandak. From Ramnagar there is also an existing 132kV line to Muzaffarpur, via Bettiah and Motihari.

This line operates in radial mode and can be used to facilitate a small increase in exports to India by moving the load at Bettiah and Motihari from the Indian system to the Nepali system. The amount of additional exports will depend on the load at Bettiah and Motihari, which varies throughout the day and year, but approximates 20MW at system peak. This can be achieved by moving the normally open point between Ramnagar and Bettiah, to between Muzaffarpur and Motihari. It is unlikely that this routing could be used for significant exports since it is not strong enough to allow the two systems to operate synchronously.

This interconnection could be strengthened significantly by constructing a 132kV transmission line from Parwanipur in Nepal to Motihari via Birgunj. The 40 km section between Birgunj and Motihari route is the shortest of the three proposed new routes. However, there is no 132kV system at Birgunj; the nearest point on the Nepalese 132kV network is at Parwanipur, 15 km from Birgunj (Parwanipur substation is currently under construction). Motihari is linked to Muzaffarpur by a single 132kV circuit 56 km in length.

The length of the new line would be approximately 55 km in length and would, probably be single circuit construction (although there could be benefits in making the construction double circuit between Parwanipur and Birgunj). The line would create a separate loop from Bardghat to Parwanipur via Gandak, Ramnagar, Bettiah and Motihari and would strengthen the Nepali system significantly by providing a second circuit in parallel with the existing Bardghat – Bharatpur – Hetauda–Parwanipur line. It would therefore have the same system effect as rebuilding the Hetauda – Bharatpur – Bardghat single circuit as a double circuit, but would be significantly cheaper. Motihari would become a stronger location on the Indian system, and the reliability of supplies to Ramnagar, Bettiah and Motihari would be improved.

In this arrangement, exports to India would flow via a single 132 kV circuit approximately 56 km in length (Footnote 2)from Motihari to Muzaffarpur. However, the impedance of this circuit may not permit synchronous operation and a back-to-back HVDC converter station would have to be installed at Motihari or Muzaffarpur. Assuming a HVDC converter station rated at 50MW, and after allowing for the Indian demand of 20MW1 at Bettiah and Motihari at time of Nepali system peak, this should allow imports of 30 MW, and exports of 70MW. The amount of imports/exports could be enhanced by increasing the capacity of the converter station. It would not support exports in excess of 100MW, owing to capacity limitations on the Motihari – Muzaffarpur circuit

1.3 Option 1C: Dhalkebar – Sitamari (or Muzaafarpur)

In 1999 NEA and Powergrid identified the Dhalkebar – Sitamari transmission route as a possible inter-connector between the two countries. The proposed Dhalkebar – Sitamari circuit is 60 km in length, of which 30 km is in Nepal. Sitamari is connected to Muzaffarpur by a single 132kV circuit, 79 km in length[2] . Just like Option 1A: Butwal – Anandnagar, this proposed interconnector falls within the region identified as being the "best place" to connect Nepal to India. It is also possible to connect Dhalkebar to Sitamari in such a way as to facilitate an easy extension to Muzaffarpur and upgrade to 500MW transfer at a later date. For these reasons this option is worth further investigation.

1.3.1 System Studies

The load flow analysis carried out by the IRG team indicates that this system is capable of transferring 100MW without overloading any transmission lines or transformers on the INPS however 100MVAr capacitor compensation, above that already planned by NEA, will need to be installed at Butwal and 280MVAr at Anandnagar however, the analysis shows that the system is then capable of exporting about 180MW.

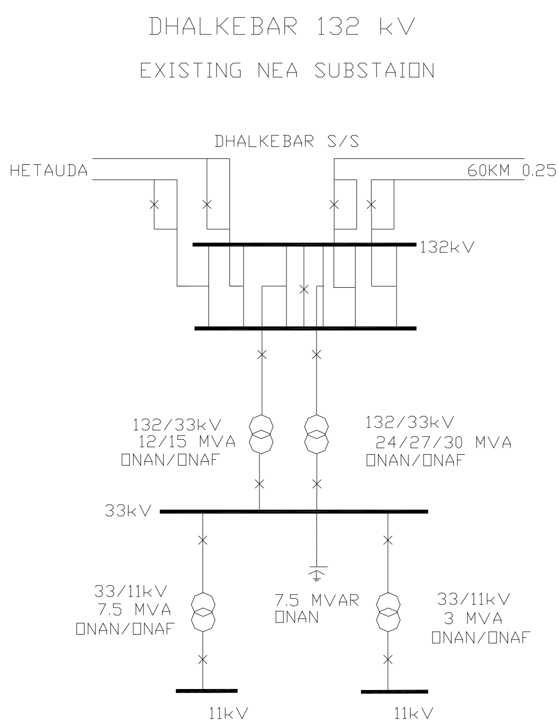
IRG have been unable to carry out stability analysis to establish whether the Dhalkebar – Sitamari or Dhalkebar lines are stable. This should be studied at the next stage of engineering feasibility and, if HVDC is found to be necessary, it will make a significant difference to the cost of this option.

1.3.2 Construction Details

The existing substation at Dhalkebar is a 7 bay 132kV double busbar substation configured as in the figure below:

[1] These values are guesses, values to be confirmed.

[2] BSEB System Diagram



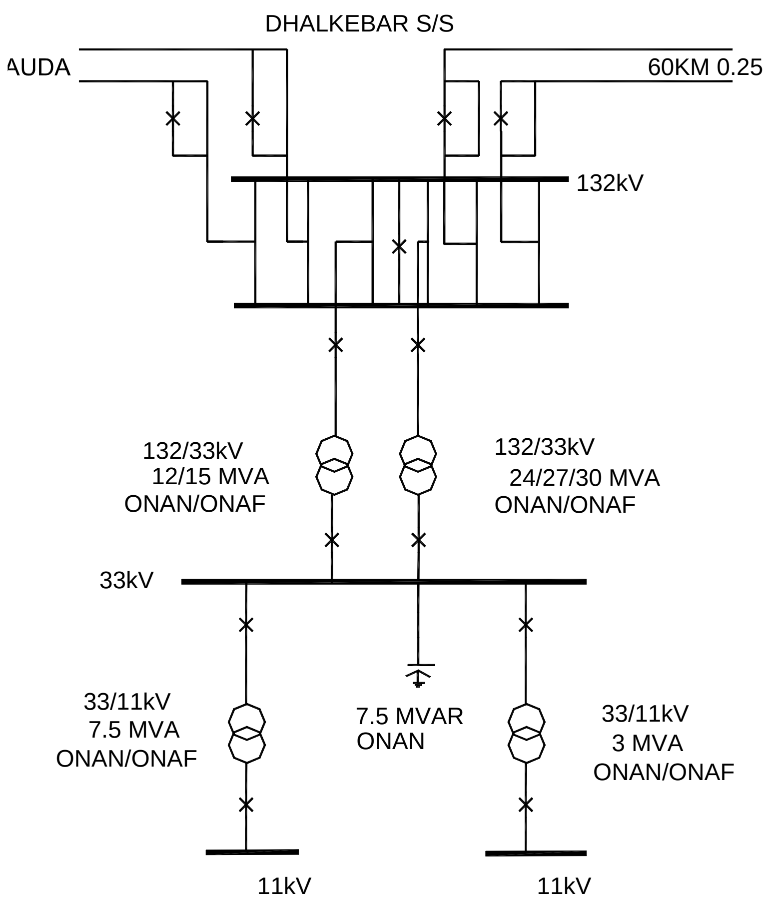
The double busbar substation can easily be expanded by the addition of new switchbays to provide the connection for the inter-connector circuits. It is possible to connect Dhalkebar to either Sitamari or Muzaffarpur to export 100MW and IRG have examined the following options:

- 1C-1: Dhalkebar – Sitamari Double circuit 220kV construction, Double Bison, strung single circuit, charged at 132kV
- 1C-2: Dhalkebar – Muzaffarpur Double circuit 220kV construction, Double Bison, strung single circuit, charged at 220kV

The construction necessary for these expansions are described below:

DHALKEBAR 132 kV

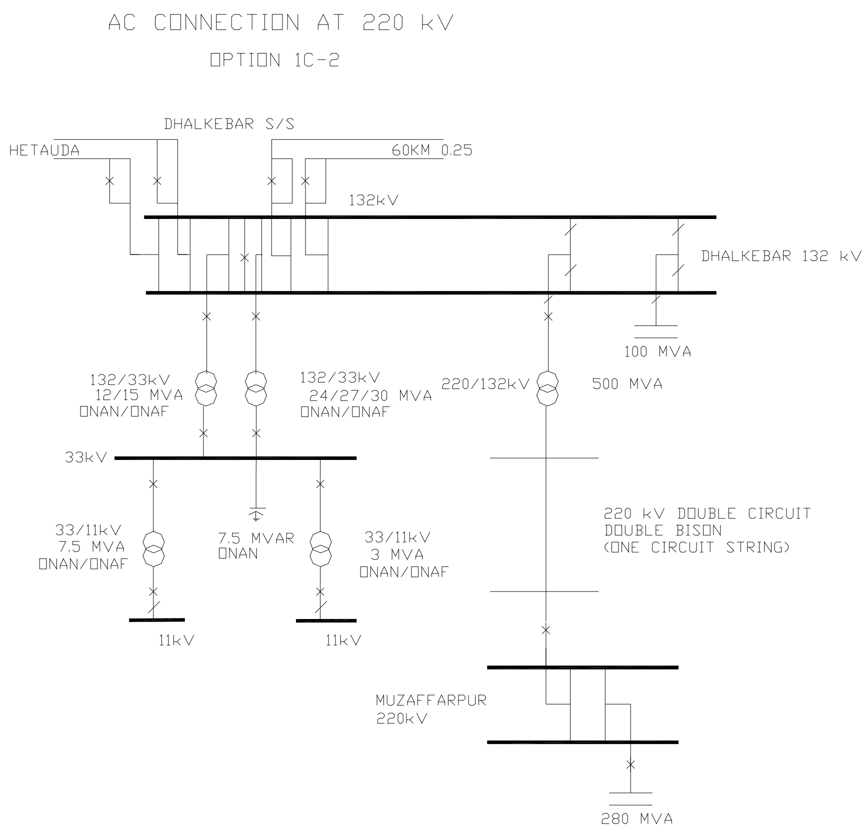
EXISTING NEA SUBSTAION



As the diagram shows, the expansion for the interconnector (option 1C-1) is described as follows:

- 1 x 132kV double busbar line switchbays at Dhalkebar
- 1 x 132kV double busbar capacitor bay at Dhalkebar
- 100MVAr capacitor at Dhalkebar
- Dhalkebar – Sitamari 220kV construction Double circuit, double Bison conductor, strung single circuit
- 1 x 132kV double busbar line switchbays at Sitamari
- 1 x 132kV double busbar capacitor bay at Sitamari
- 280MVAr capacitor

The alternative option (2C-2) bypasses Sitamari and connects directly to Muzaffarpur at 220kV as described below:



As the diagram shows, the expansion for the interconnector (option 1C-2) is described as follows:

- 1 x 132kV double busbar line switchbays at Dhalkebar
- 1 x 132kV double busbar capacitor bay at Dhalkebar
- 100MVAr capacitor at Dhalkebar
- 1 x 220/132kV 500MVA Transformer at Dhalkebar
- 220kV construction Double circuit, double Bison conductor, strung single circuit
- 1 x 220 kV double busbar line switchbays at Muzaffarpur
- 1 x 220 kV double busbar capacitor bay at Muzaffarpur
- 280 MVAr capacitor

1.3.3 Cost Estimates

IRG has estimated the costs for these options and the cost estimates are tabulated below:

Option	**Description**	**Cost**
1C-1	Dhalkebar - Sitamari, 220kV Double Circuit construction, Double Bison charged at 132kV	$17.6M
1C-2	Dhalkebar - Muzaffarpur, 220kV Double Circuit construction, , Double Bison charged at 220kV	$33.8M

1.3.4 Route Survey

As a result of the system studies, IRG considered that the Dhalkebar - Sitamari route, with the potential to expand to Muzaffarpur, was very promising and IRG has therefore carried out a walkover route survey from Dhalkebar to Sitamari and onto Muzaffarpur. A map of the surveyed route is shown below. The total length of alignment from Dhalkebar substation to Simara-Sitamari substation is 125.456 km. Of this, 42.819 km lies in Nepal while the remaining 82.637 km lies in India.

The line has 245 tangent towers, 6 small angle towers, 6 medium angle towers and 18 large angle towers. The alignment crosses medium voltage lines 23 times, low voltage lines 5 times, telephone lines 2 times, non-electrified railway 3 times and different roads 108 times. The alignment crosses 21 times, ponds 7 times, small span gulleys 10 times and rivers 9 times. The spans of river crossings are: Sukhajor 100 m and 190 m (two crossings), Aurhai 225 m, Dudhnati 30 m, Bigahi 125 m, Rato 250 m, Jumara 25 m and 50 m, Gobraya 10 m.

Expansion of substation at Simara Sitamari will not be necessary.

1.4 Option 1D: Upgrading Duhabi–Kataiya

There is a fourth option that would allow up to a 100MW power transfer and this is upgrading the existing 132kV circuit between Kataiya (in India) and Duhabi. Currently, there is a single circuit line from Purnia to Kataiya, where the Kosi hydro-electric power station (20MW) is connected. There is also a 132 kV single circuit from Kataiya to Kushaha, and two 33 kV circuits from Kataiya to Duhabi[3].

Normally the eastern part of the Nepali system (consisting of Anarmani and part of Duhabi substations) is run synchronously with the Indian system at system peak. However, the current capacity of this interconnection is no more than 50MW; and even with this level of transfer the voltage at Duhabi is poor (on 27 November 2005, there was 50 MW of imports to Nepal while the voltage at Duhabi was 120kV)[4]. Nonetheless, there is sufficient thermal capacity to increase imports up to 80MW (at peak) by adding capacitor compensation at the Duhabi substation and by moving the normally open point from Duhabi substation itself (currently half of the Duhabi load, plus the multi-fuel plant, is connected to the Nepali system, and half of the Duhabi demand is connected to India) to a point west of Dhalkebar.

This option would mean that the substations at Dhalkebar, Lahan, Kusaba, Duhabi and Anarmani, including the multi-fuel plant at Duhabi, would all be synchronized to the Indian system at peak. During off-peak since there is no need for imports, the connection with India would be disconnected, with the eastern part of the system re-synchronized with the INPS.

Capacity could not be increased above 80MW since there is no suitable location in which to split the Nepali system and it is too far east to act as an economic synchronous connection.

[3] The Bihar system diagram shows two 132 kV circuits, to Duhabi and Birpur

[4] The transfer capacity might also be increased by better management of reactive power on the Indian system.

2 Detailed Description of Options for Capacity up to 500 MW

If Nepal were to export more than 100MW this will require the building of significant additional generation over and above that already planned. This generation will have its own associated transmission reinforcements and will affect the power flows on the INPS. It will also affect the best way to interconnect the Nepali and Indian systems. Since, for an import/export capacity in excess of 100MW, it will be most cost-effective to use a voltage level above 132kV. The obvious candidate voltages (because they are used in India) are 220 kV and 400 kV

As described in Chapter 3, the best place for an interconnection with India is in the central region between Butwal and Dhalkebar. The termination point of such a circuit on the Nepali system could be any 132kV substation between Butwal and Dhalkebar. The termination point in India will need to be at a 220kV substation with the ideal points at Muzaffarpur (in Bihar) or Gorakhpur (in Uttar Pradesh). A further option is to connect Duhabi with Purnea in India, although this is not considered to be the "best place" to connect Nepal with India. All these options have been studied in detail using NEA's PSS/E model.

2.1 Option 2A: Butwal – Gorakhpur

Option 1A-2 and 1A-3 proposed an interconnector between Butwal and Anandnagar constructed at 220KV but initially charged at 132kV. Option 1A-4 proposed a line directly to Gorakhpur charged at 220kV from the outset. Although these options are initially more expensive than Option 1A-1, which was the same connection built with 132kV construction, the benefits of the more expensive construction are demonstrated when the transfer capability of over 100MW is required. Although the Butwal – Gorakhpur line could be built as one stage ready for 500MW transfer, due to the likely level of available energy in the early years, it is more cost effective to build it in a phased way starting with 1A-2, 1A-3 or 1A-4 and expanding later. This discussion assumes a phase approach and assumes that Option 1A-2, 1A-3 or 1A-4 has already been built by 2010 and that the expansion is constructed in 2015.

2.3.3 <u>System Studies</u>

The analysis carried out by the IRG team indicates that a 220kV line is capable of transferring up to 420MW from Butwal – Gorakhpur without reinforcement of the INPS beyond adding capacitor compensation at Butwal and Gorakhpur. Transfer above 420 MW level requires uprating of the Butwal – Bardghat line. For the purposes of this study it is assumed, therefore, that the export capability of this interconnector will be limited to 420MW. Results of load flow studies are included at the end of this appendix.

IRG have been unable to carry out stability analysis to determine whether the Butwal – Gorakhpur line is stable. This should be studied at the next stage of engineering feasibility and, if HVDC is found to be necessary it will make a significant difference to the cost of the option.

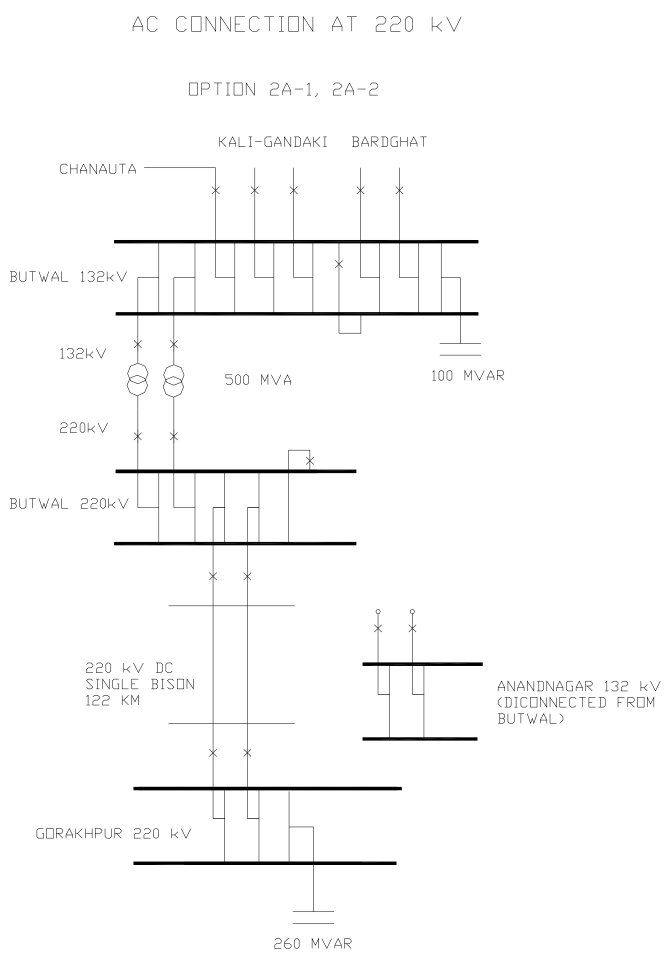
2.3.4 <u>Construction Details</u>

As described above, IRG have considered three main options for completion of the Butwal – Gorakhpur line as follows:

- 2A-1: This option is for an expansion of option 1A-2 which is assumed to be constructed by 2010.

- 2A-2: This option is for an expansion of option 1A-3 which is assumed to be constructed by 2010.
- 2A-5: This option is for an expansion of option 1A-4 which is assumed to be constructed by 2010

Option 1A-1 and 1A-2 establish a 132kV link between Butwal and Anandnagar. The expansion required for option 2A-1 and 2A-2 upgrades the connection to 220kV by establishing a 220kV substation at Butwal and extending the line to Gorakhpur. The existing connection at Anandnagar, established in Phase 1 is disconnected. The construction required is shown diagrammatically in the figure below:



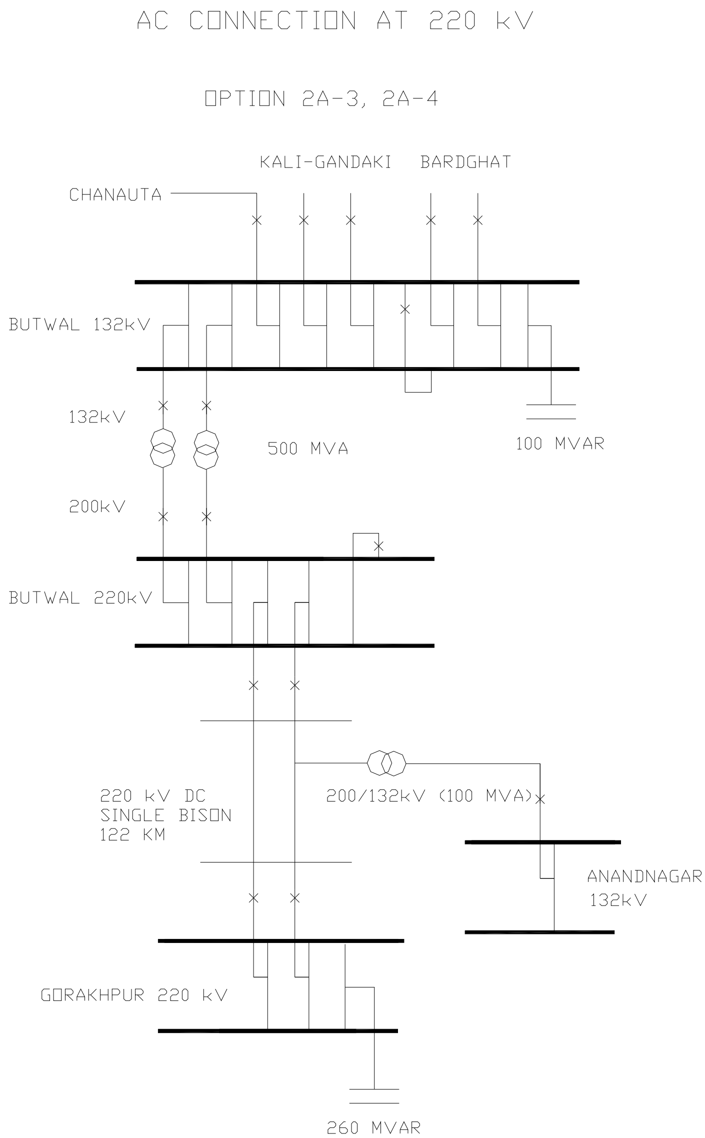
The expansion necessary for Options 2A-1 and 2A-2 is described as follows:

- 2 x 220/132kV transformers at Butwal
- 2 x 220kV double busbar transformer bays at Butwal
- 2 x 220kV double busbar line switchbays at Butwal
- 1x220kV double busbar bus coupler switchbay at Butwal
- 100MVAr capacitor at Butwal 132kV busbar
- Option 2A-1: 220kV Double circuit, double bison conductor extension to Gorakhpur(38km)

<u>or</u>

- Option 2A-2: Double circuit, double bison conductor extension to Gorakhpur(38km), string second circuit Butwal – Anandnagar (83km), 1x132kV double busbar transformer bay at Butwal
- 2 x 220kV double busbar transformer bays at Gorakhpur
- 1 x 220kV double busbar capacitor switchbay at Gorakhpur
    - 260MVAr capacitor at Gorakhpur

Both of these options assume that the substation at Anandnagar is be disconnected from the interconnector however the connection at Anandnagar can be maintained if the demand justifies the expense of maintaining the connection although this is unlikely as the demand at Gorakhpur is expected to be capable of taking all the capacity of the link. If a link is maintained at Anandnagar, the interconnector will be described diagrammatically as shown in the figure below:



The third main option (2A-5) is an upgrading of option 1A-4 by stringing the second circuit from Butwal to Gorakhpur. This additional construction required is described below:

- 1x132kV switchbay at Butwal
- 1 x 220/132kV transformers at Butwal
- 2 x 220kV double busbar transformer bays at Butwal
- 2 x 220kV double busbar line switchbays at Butwal
- 1x220kV double busbar bus coupler switchbay at Butwal
- 100MVAr capacitor at Butwal 132kV busbar
- Double circuit, string second circuit Butwal – Gorakhpur (121km),
- 1 x 220kV double busbar line bays at Gorakhpur

2.3.5 Cost Estimates

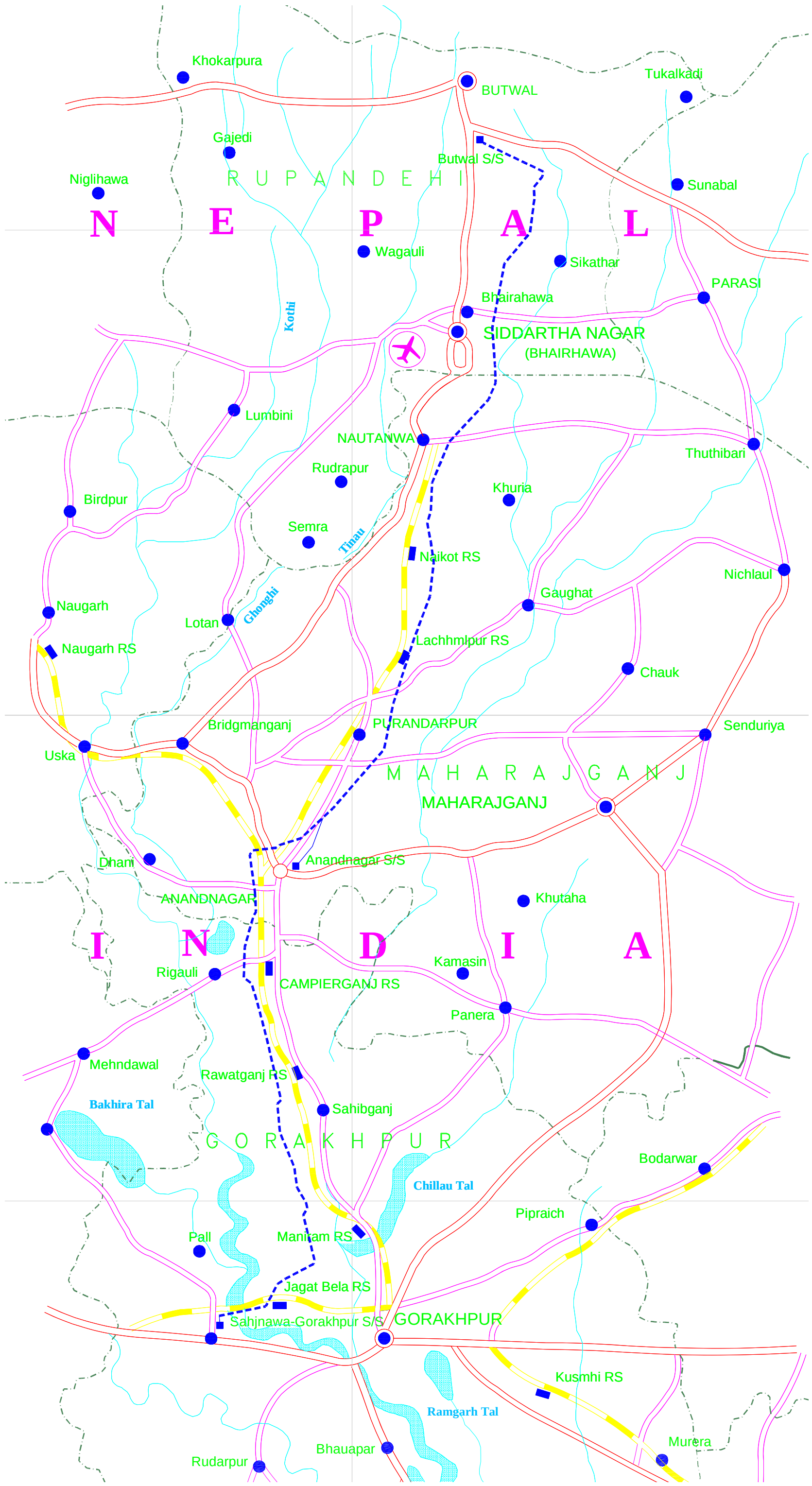
IRG has estimated the costs for these interconnector options below:

Option	Description	Cost
2A-1	220kV Double Circuit, Double Bison, Anandnagar – Gorakhpur, No connection at Anandnagar	$30.63M
2A-2	220kV Double Circuit, Double Bison, Anandnagar – Gorakhpur plus string second circuit Butwal – Anandnagar, No connection at Anandnagar	£38.8M
2A-3	220kV Double Circuit, Double Bison, Anandnagar – Gorakhpur, Maintain connection at Anandnagar	$33.87M
2A-4	220kV Double Circuit, Double Bison, Anandnagar – Gorakhpur plus string second circuit Butwal – Anandnagar, Maintain connection at Anandnagar	£42.04M
2A-5	220kV Double Circuit, Double Bison, string second circuit Butwal – Gorakhpur	$27.2M

These cost estimates assume that an AC synchronous connection can be made. If it is determined that an HVDC connection is necessary then it will be necessary to add $125M to the cost estimates for each option.

2.3.6 Route Survey

IRG consider this route to be a promising proposition for an interconnector and have carried out a walkover survey. The proposed route is shown in Figure NNN below:



The total length of proposed alignment from Butwal substation to Sahajanawa Gorakhpur Grid substation is 122.145 km. Its length from Butwal to the Indo-Nepal border is 25.513 km and that from the Indo-Nepal border to Sahjanawa Gorakhpur Grid substation is 96.632 km. There are 365 tangent towers, 16 small angle towers, 18 medium angle towers and 16 large angle towers along the entire route.

For expansion of the Butwal substation, certain parts of the forest adjoining the substation will have to cut. The Sahajanawa Gorakhpur substation does not need any expansion.

Along the proposed transmission line route, the terrain is mostly flat and cultivated. The soil type is generally silty clay.

About 4.53 km of the alignment passes through the forest near Butwal substation. It also passes through a 0.64 km long stretch of a forest near Anandnagar substation. Beside this, the alignment crosses high voltage line (132/220/400 kV) six times, medium voltage lines 55 times, low voltage lines 18 times, telephone line twice, railway lines 3 times and different roads 113 times. Along the route, the alignment crosses small span canal 27 times, ponds 3 times, small span gullies 4 times and river 5 times. The spans of the rivers crossed are: Lapsi 12 m, Danda 32 m, Dudi 40 m and 80 m (crossed twice) and Rapti 300 m. The alignment also passes through the edge of Gobraiya lake, Likhiya lake and Sariya lake.

The route runs approximately parallel to the existing 132 kV T/L from Sahajanawa–Gorakpur substation to the forest near Anandnagar. During monsoon, about 60% of land from Butwal substation to the Indo-Nepal border and about 80% of the land from the Indo-Nepal border to Sahajanwa Gorakhpur substation crossed by the alignment remains submerged.

2.2 Option 2B: 220kV Parwanipur–Muzaffarpur

Parwanipur presents another point in Nepal for interconnection to India. The transmission expansion plan of NEA envisages building 220kV facilities at Hetauda by 2008/09, a new substation at Parwanipur is also proposed by 2008/09. There are two 220kV substations in operation in Muzaffarpur; another 400kV substation belonging to Powergrid is expected to be commissioned at Muzaffarpur in 2006.

2.2.1 System Studies

This option envisages construction of a 220kV line from Parwanipur to Muzaffarpur, involving:

- Construction of 100 km 220 kV double circuit line between Parwanipur and Muzaffarpur
- Installation of a 220/132 kV transformer at Parwanipur
- Installation of 220kV bays at Muzaffarpur and Parwanipur

The load flow analysis carried out by the IRG team indicates that this line is not capable of exporting more than 240MW without significant reinforcement of the INPS. On this basis, IRG do not consider that this line is worthy of further consideration under the terms of this study.

2.3 Option 2C: 220kV Dhalkebar – Muzaffarpur

As described in section 3.2, Dhalkebar is one of the best places to connect a transmission interconnector between Nepal and India and a connection from Dhalkebar to Muzaffarpur would integrate very well with the development of the Upper Tamakoshi power plant (scheduled for 2014/15[5]). Associated with this large development (309 MW) is a 220kV overhead line from Upper Tamakoshi via Khimti to Dhalkebar, with a double busbar 200kV substation at Dhalkebar and 220/132 kV transformers at Khimti and Dhalkebar. Funding has been agreed for the Khimti – Dhalkebar section of this line which will soon be constructed as a 220kV double circuit line but initially charged at 132kV.

There are a number of ways in which the Khimti - Dhalkebar line could be extended to Muzaffarpur and the transmission interconnector integrated into the INPS and some of these are described in the sections below.

2.3.1 System Studies

The analysis carried out by the IRG team indicates that this system is capable of transferring up to 500MW from Dhalkebar – Muzaffarpur without reinforcement of the INPS beyond adding capacitor compensation at Dhalkebar and Muzaffarpur. (Results of load flow studies are shown later in this Appendix.

IRG have been unable to carry out stability analysis to determine whether the Dhalkebar – Muzaffarpur line is stable. This should be studied at the next stage of engineering feasibility and, if HVDC is found to be necessary it will make a significant difference to the cost of the option.

2.3.2 Construction Details

The explanation of these options assumes that Upper Tamakoshi power plant has been commissioned in 2015 as planned. This establishes a 220kV double busbar substation at Dhalkebar. This can easily be expanded to accommodate the link to Muzaffarpur which will be transferred from the 132kV substation where it is assumed to be connected on completion of option 1C-1 or 1C-2. IRG have considered 2 options for this transmission link as follows:

- 2C-1: Expansion of option 1C-1
- 2C-2: Expansion of option 1C-2

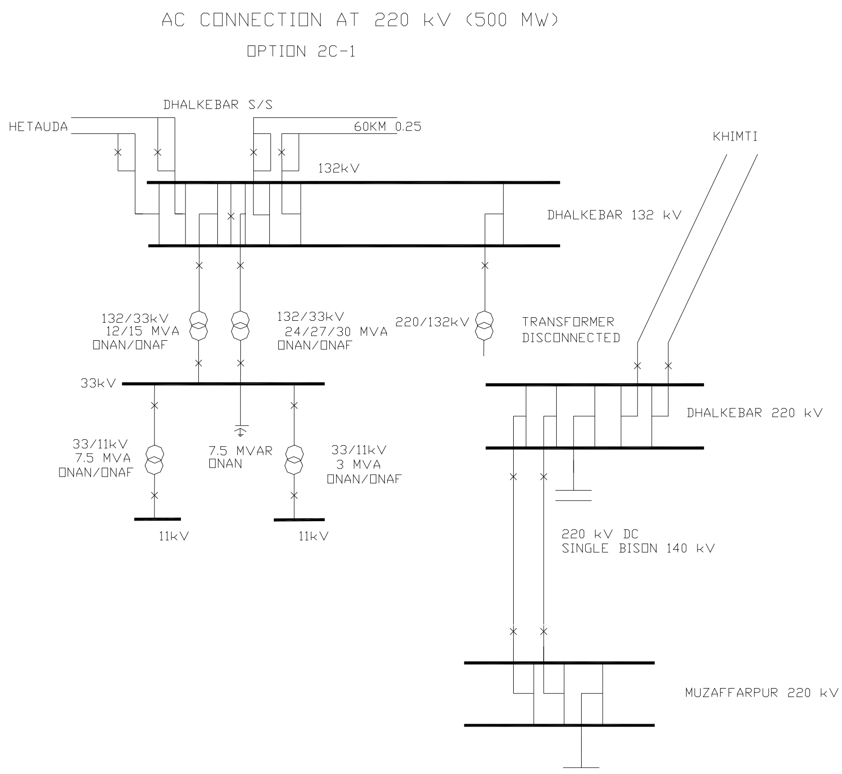
Option 1C-1 established a 132kV link from Dhalkebar – Sitamari. The expansion works to establish this link at 220kV to Muzaffarpur are described below:

NEED Diagram

- 2 x 220kV Double busbar line switchbays at Dhalkebar
- 1 x 220kV Double busbar capacitor bay
- Capacitor 10MVAr
- 220kV Double circuit, double bison conductor extension to Sitamari - Muzaffarpur(61km), string second circuit Dhalkebar - Sitamari (82km)
- 2 x 220kV Double busbar line switchbays at Muzaffarpur
- 1 x 220kV Double busbar capacitor bay
- Capacitor 520MVAr

[5] In Report on Transmission Planning Studies 2005, published by System Planning Department, NEA.

The second option (2C-2) is to expand the inter-connector to Muzaffarpur established in option 1C-2. This disconnects the 220/132kV transformer at Dhalkebar which becomes redundant and could potentially be used elsewhere on the INPS as it will be only a few years old. The construction works necessary are described below:



- 2 x 220kV Double busbar line switchbays at Dhalkebar
- 1 x 220kV Double busbar capacitor bay at Dhalkebar
- Capacitor 10MVAr
- 220kV Double circuit, double bison conductor extension to Sitamari - Muzaffarpur(61km)
- 1 x 220kV Double busbar line switchbays at Muzaffarpur
- Additional Capacitor 240MVAr

If Upper Tamakoshi is not commissioned as planned this inter-connector may be expanded in a similar manner but the link would have to establish the 220kV substation at Dhalkebar which would involve additional cost. IRG have assessed the additional costs and included those in the table of cost estimates below

2.3.3 Cost Estimates

Option	Description	Cost
2C-1	Stage 2 - 500MW Transfer (Upper Tamakoshi connected)	$32.3M
2C-2	Stage 2 – 500MW Transfer (Upper Tamakoshi connected)	$18.6M
2C-3	As 2C-1, 500MW Transfer (Upper Tamakoshi not-connected)	$41.4M
2C-4	As 2C-1 500MW Transfer (Upper Tamakoshi not-connected)	$27.8M

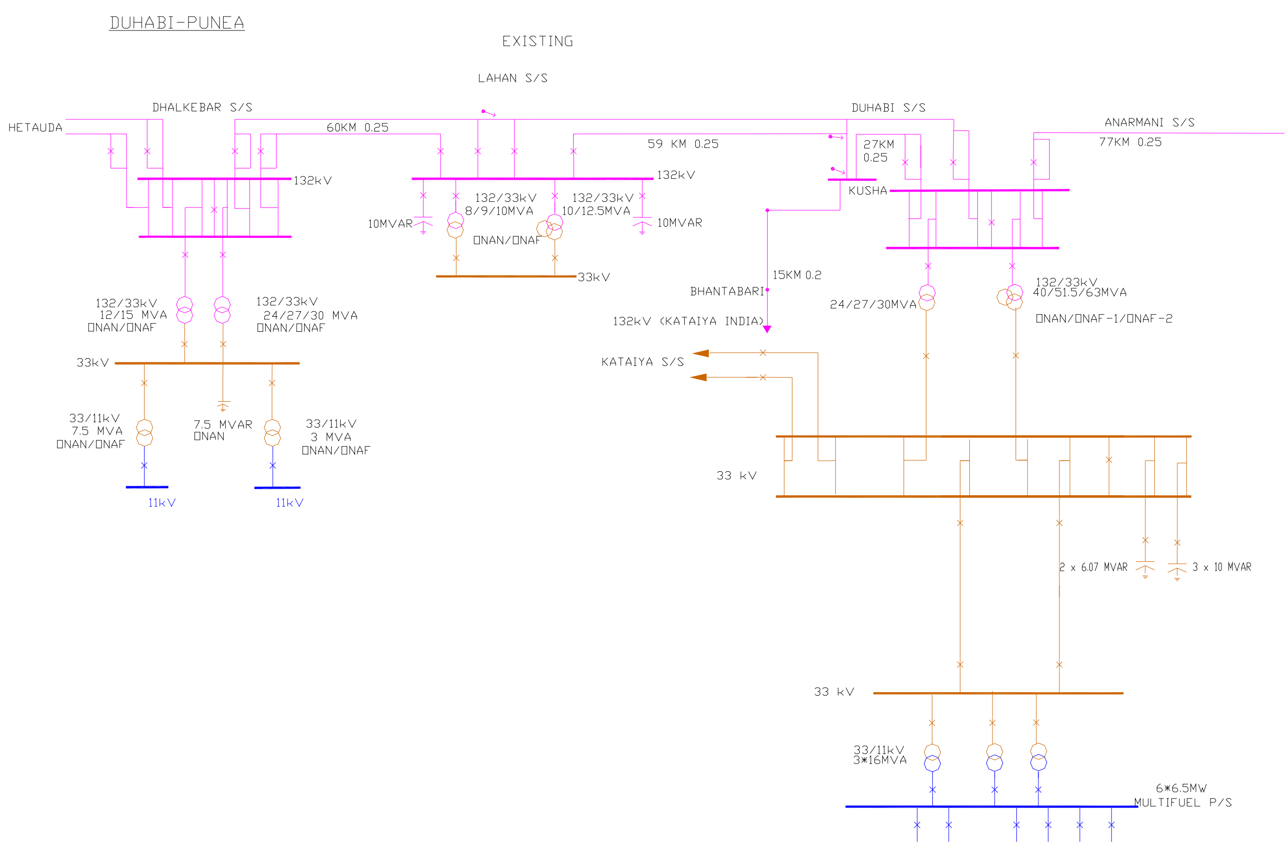
These cost estimates assume that an AC connection can be made. If it is determined that a DC connection is necessary then it will be necessary to add $125M to the cost estimates.

2.4 Option 2D: 220kV Duhabi–Purnea

If large generating plants are built in eastern Nepal, this option is preferable for exporting power to India; it will also be attractive in the short term to import power from India (as electricity in India's eastern region is cheaper than in other regions). There is a 220kV substation in operation in Purnea; and another 400kV PGC substation is expected to be commissioned in Purnea in 2006.

2.4.1 System Studies

The analysis carried out by the IRG team indicates that this system is not capable of transferring up to 500MW from Duhabi – Purnea without significant reinforcement of the INPS. The INPS in the region is shown diagrammatically in figure JJJ below:



In particular the following existing overhead lines would have to be uprated:

- Dhalke – Lahan (double circuit)
- Lahan – Duhabi (double circuit)
- Khimti – Lamosangu (single circuit)

2.4.2 Construction Details

This option necessitates construction of a 220kV line from Duhabi to Purnea, involving:

- 2 x 132kV double busbar transformer bays at Duhabi
- 2 x 220/132kV 500MVA transformers at Duhabi
- 2 x 220kV double busbar transformer bays at Duhabi
- 2 x 220kV double busbar line switchbays
- 1 x 220kV double busbar capacitor switchbay
- 270MVAr capacitor at Duhabi
- 220 kV double circuit line between Duhabi and Purnea (100km)
- 2 x 220kV double busbar line bays at Purnea
- 1 x 220kV double busbar capacitor switchbay at Purnea
- 300MVAr capacitor at Purnea

Load Flow Diagram

Appendix G

Environmental Analysis of transmission routes

APPENDIX G

Preliminary Environmental Assessment

1. Introduction

A preliminary environmental assessment of the proposed 220 kVDhalkebar – Muzaffarpur and Butwal – Gorakhpur transmission line corridors was conducted to identify if any major environmental or social issues would preclude the transmission lines to be constructed. The assessment was performed based on a review of topographical maps of the area, relevant literature, field survey results, and discussions with the survey team. Based on experience, the right of way (RoW) of the transmission line was taken as 30 meters (15 meters on each side of the center line). For each tower, the foundation area was assumed as 12.5 m x 12.5 m.

2. Dhalkebar – Muzaffarpur Route

The proposed transmission line starts from Dhalkebar substation of Dhanusha district of Nepal and ends at Kafen Muzaffarpur of Muzaffarpur district, India. The total length of the transmission line is 138.77 km. Out of this length, 42.81 km is in Nepal (Dhalkebar to Indo-Nepal border) and 95.51 km is in India (Indo-Nepal border to Muzaffarpur).

2.1 Baseline Conditions

2.1.1 Natural Environment

The alignment passes through the flat plains of Terai. Its maximum elevation is about 182 m above mean sea level at Dhalkebar while its minimum elevation is about 61 m at the Indo-Nepal Border.

The primary land uses along the alignment are cultivation, settlements, forestry, fruit gardening, road, river and rivulets etc. About 90% of the alignment passes through cultivated land (Table G.1). Natural forest is not found in the right of way of the proposed alignment. Private forest (trees planted in farm lands) and fruit garden (mango, litchi, etc.) fall along 6% of the total length of the transmission line. Roads, rivers, railways and others account for the remaining alignment.

220 kV and 132 kV transmission lines, 33 kV lines and distribution lines are found within the RoW. Telecommunication tower located in major cities, namely Janakpur, Jaleshwar and Muzaffarpur, are far off from the proposed transmission line alignment. In Nepal, the distance of the transmission line from the road head ranges from about 400 m to 2.5 km. Except at crossings, this distance varies between 200 m to 3 km on the Indian side. The alignment passes at a distance of about 4 km from the Janakpur airport. Landslides and slide prone areas are not found along the alignment. In most stretches of the alignment, the soil is clay. Clay mixed with sand is found near rivers and rivulets.

Table G.1 Land use pattern along Dhalkebar – Muzaffarpur alignment

Land Use	Line Length (m)		Total (m)	%
	Nepal	India		
Cultivated Land	36,144	89,088	125,232	90.24
Private forest	1,042	1,885	2,927	2.11
Fruit garden	3,220	2,105	5,325	3.84
Grass land	500	300	800	0.58
River, rivulets	701	525	1,226	0.88
Road	277	327	604	0.44
Pond, Canal	815	515	1,330	0.96
Railway	10	75	85	0.06
Others	110	1,131	1,241	0.89
Total	**42,819**	**95,951**	**13,8770**	**100.00**

2.1.2 Social Environment

The alignment passes through Dhanusha and Mahottari districts of Nepal and Sitamadhi and Muzaffarpur districts of India. It passes through 13 village development committees (VDCs) and 2 municipalities of Nepal and 26 panchayats of India. In most of these areas, the settlement is dense. Detail of VDCs, municipalities, panchayats and settlements found along the alignment are presented in Table G.2.

A Central Reserve Police (CRP) camp and an intermediate college are located along the alignment in India. Mahendra Highway, Banepa-Bardibash Highway, Sitamadhi-Muzaffarpur, Muzaffarpur- Mother, Muzaffarpur-Peoria and Muzaffarpur-Chakra Highways are present in the project area.

2.2 Impacts

2.2.1 Positive Impacts

The alignment is selected with due consideration to environmental damage. As it lies within 0.2-2.5 km of main highways and close to feeder roads, the alignment will minimize material transportation cost. Resettlement along the alignment will not be necessary as houses will not be affected. The alignment does not cross settlements.

The transmission line will have the following positive impacts:

- It will result in an increase in employment opportunities.
- Changes in local economy will result from increase in trade and business.
- Local skills, especially in driving, tower erection, stringing line, etc., will develop.
- Revenue will be generated from power export to India.
- The line will reduce transmission losses and provide reliable power.

Table G.2 VDCs, municipalities, panchayats and settlements along the Dhalkebar – Muzaffarpur alignment

Country	Districts	VDCs, Municipalities & Panchayats	Settlements
Nepal	Dhanusha	Begadabar	Jamunibash, Shivanagar
		Naktajheel	Anandpur
		Sakhua	Mahendranagar Bazar, Manglapur Haririya
		Ramariya Bhawadi	Ramespur
		Sapahi	Aslewa, Banigama
		Sunarjore	Sohani, Adrewa
		Janakpur Municipality	Ranibazar, Datta tole, Pidari
		Basbitti	Basbitti
	Mahottari	Saharwa	Saharwa, Hardiya
		Ratauli	Ratauli
		Pipra	Pipra, Parsa
		Mahottari	Mahottari
		Parkauli Phulari	Phulari
		Jaleshwor Municipality	Ratwadi
		Nainahi	Dahabauli, Surahiya, Malbara
India	Sitamadhi	Khandi Bhitta	Bhitta mode
		Hanumannagar	Hanumannagar
		Surshand	Gopalpur, Pupadi
		Banauli	Chandpatti
		Raj Banauli	Banauli, Padampura
		Raghwa	Bikha, Kabda
		Kumbha	Parsa
		Karbanna	Sundahi, Koriyahai
		Bathnaha	Rupali, Chaudhari tole
	Muzaffarpur	Bishunpura	Bajitpur Bichala tole
		Lagma	Lagma, Pakdiya tole
		Gadha	Dhanukhi, Patelnagar
		Dhanukhi	Sambhu Nagar
		Modsand	Modsand
		Raina Bishauni	Belsand, Rumi, Saiyadpur
		Rumi Saiyadpur	Kashiya, Kataujha
		Manpur	Ratnaul, Nayabishanpur tole
		Mahesh Pharakpur	Koahi, Tariyani
		Olipur	Kodlahiya, Dharmapur
		Jhapaha	Gaunjmeenapur, Jamlabad
		Bhikhanpur	Rasalpur
		Kolhuwadadar	Koluhwa
		Sadatpur	Damodarpur, Sirkahi
		Subhankarpur	Jagarnath patahi, Parmanand tole
		Khabda	Khabda
		Kafen	Kafen

2.2.2 Adverse Impacts

2.2.2.1 Natural Environment

Land Use

The total land use affected by the project is 416.31 ha. This consists of 375.7 ha of cultivated land, 8.71 ha of private forest, 15.98 ha of fruit garden and 15.86 ha of other areas which include rivers, roads, canals, ponds, etc (Table G.3). In terms of land use changes, the transmission line will not have significant impacts on rivers, roads and other lands. In cultivated areas, the land use pattern of the area occupied by the tower pad will be completely changed. Land use changes will be significant in private forest and fruit garden areas.

Table G.3 Land use affected by the project

Land Use Category	Affected Land Use (ha)		
	Nepal	**India**	**Total (ha)**
Cultivated Land	108.43	267.26	375.70
Private forest	3.13	5.66	8.78
Fruit garden	9.66	6.32	15.98
Grass land	1.50	0.90	2.40
River, rivulets	2.10	1.58	3.68
Roads	0.83	0.98	1.81
Ponds, canals	2.45	1.55	3.99
Railways	0.03	0.23	0.26
Others	0.33	3.39	3.72
Total	**128.46**	**287.85**	**416.31**

Crossings of Infrastructures

The alignment crosses high voltage transmission lines (220 kV and 132 kV), sub-transmission and distribution lines, telephone lines, road and railway several times. The crossings with high voltage line and other infrastructures may have interference and safety impacts.

Impact on Drainage Pattern

A total of 462 towers, which include 417 tangent, 10 small angle tower, 8 medium angle tower and 27 large angle towers, will be erected from Dhalkebar to Muzaffarpur. According to available information, 70% of the alignment area is submerged during monsoon. The erection of such a large number of towers will pose further problems with regards to drainage pattern of the area.

Impact on Water Quality

The proposed transmission line crosses river, rivulets, ponds and canals several times. Details of crossings on the Nepalese and Indian sides are given in Table G.4.

Table G.4 Water bodies found along the alignment

S.No.	Water Bodies	Number of Crossings		
		Nepal	India	Total
1	River	2	9	11
2	Rivulets	4	2	6
3	Canal	18	1	19
4	Pond	6	7	13

Construction work near the water bodies may affect the water quality. For construction activities, water will be used from the nearby rivers, rivulets etc. Improper disposal of spoil, solid wastes, such as cement slurry, other construction materials and human wastes from the work force, may deteriorate the water quality of the water bodies.

Loss of Trees

The implementation of the proposed project will not affect natural forests in Nepal and India. The project will affect 8.78 ha of private forests and 15.98 ha of fruit gardens. Mango, Litchi, Sisso and Teak are the main plant species affected by the project.

Avian Hazards

The presence of the conductors (wires) may affect birds during the operation of 220 kV transmission line. In particular, birds may not be able to detect and avoid the earth wires, which are located at the highest point on the towers and are thin, and they may suffer injury and death from collisions with these wires. This type of impact is expected to be high in low visibility conditions, especially in bad weather and night time. Some species like raptors and fruit bats are likely to be affected more due to line collision.

2.2.3 Socio-economic Environment

Land Acquisition

The project will erect 462 different types of towers in 138.77 km. Out of these, 417 towers will be erected in cultivated land. The placement of 1 tower will require an area of 12.5 m x 12.5 (0.0154 ha). As such, a total of 6.43 ha of land will be permanently acquired by the project for the placement of tower in cultivated land. Approximately 112 metric tons of food grain will be lost annually due to land acquisition.

Farming Hindrance and Impact on Standing Crop

Towers constructed in cultivated area, especially those erected in the middle of land parcels, will pose hindrance during plowing of the agricultural fields. The fields may be cultivated by using human labor; however, this will increase the cost of production.

Since 90% of the alignment passes through cultivated land, the impact on standing crop is considered significant during the construction phase. Normally, the winter crop will be affected as construction will be curtailed, or even closed down completely, during the monsoon.

Reduction of Land Value

About 416 ha of the land along the alignment fall within the RoW. Due to safety reasons, houses will not be allowed to be constructed within the RoW. As the land will not be available for construction, the value of this land, especially in urban areas, will be reduced.

Impact on Aesthetic

As the proposed transmission passes mostly through cultivated lands, it will not affect the visual beauty of the area. The alignment passes more than a kilometer from the welcome gate constructed at the Indo-Nepal border; hence no significant impact is expected with respect to the aesthetic importance of the gate.

2.3 Mitigation Measures

The following mitigation measures are proposed to minimize the impacts of the project:

- Unnecessary acquisition of land shall be minimized, and land use shall be reclaimed.
- Due care shall be taken to protect water bodies.
- Appropriate safety shall be applied at crossings.
- Compensation shall be paid for the acquisition of land, standing crops, fruit plants and other private trees at the prevailing market rate.
- Private lands falling within the RoW shall be compensated for.
- To the extent possible, towers shall not be placed in the center of fields.
- Enhancement programs shall be implemented in the project area.

3. Butwal – Gorakhpur Route

The proposed transmission line starts from Butwal substation in Rupandehi district of Nepal and ends at Sahajanwa substation of Gorakhpur district, India. The total length of the transmission line is 122.14 km. Out of this length, 25.51 km lies in Nepal (Butwal –Sunauli) and 96.63 km lies in India (Sunauli to Gorakhpur).

3.1 Baseline Conditions

3.1.1 Natural Environment

The alignment passes through the flat plains of the Terai. Its maximum elevation is about 154 m above mean sea level at Butwal while its minimum elevation is about 38 m.

The main land uses in the project area are cultivation, settlements, forestry, fruit gardening, road, river and rivulets etc. About 92% of the alignment passes through cultivated land (Table G.5) whereas 5.3% of it passes through forest areas, which include national and private plantations.

Table G.5 Land use pattern along the Butwal – Gorakhpur alignment

Land Use	Line Length (m)		Total (m)	%
	Nepal	India		
Cultivated Land	19401.5	92302	111703.5	91.45
Forest Land	4530	640	5170	4.23
Private forest	135	825	960	0.79
Fruit garden	65	860	925	0.76
Shrub and grass land	340	0	340	0.28
River, rivulets, canal	91.5	380	471.5	0.39
Road	100	650	750	0.61
Pond, Lake	50	930	980	0.80
Railway	0	45	45	0.04
Others	800	0	800	0.65
Total	**25513**	**96632**	**122145**	**100.00**

Transmission lines of 400 kV, 220 kV and 132 kV capacities, 33 kV lines and distribution lines lie along the transmission line alignment. Telecommunication tower are located within 2 km of the proposed alignment. The alignment lies about 6 km from the Bhairawa airport and 20 km from the Gorakhpur air force base. In Nepal, the distance of the line from the road head ranges from 1.5 km to 6 km. On the Indian side, this distance varies from 2 km to 8 km.

Landslides and slide prone areas are not found along the alignment. The soil is plastic clay in most of the stretch of the alignment. Clays mixed with silt are present near rivers and rivulets.

The transmission line does not pass through any national park, wildlife reserve, buffer zone and conservation area. It passes through 4.53 km of forest near Butwal and 0.64 km near Anandnagar. Sal, which is protected under the Forest Act by the Government of Nepal, is the main forest type along the alignment.

The forests along the alignment in Nepal and India are national forests. Besides these forests, the line also passes through mango gardens and private forests of sisso at a few locations. Saruwa Lake, Khumar Lake and Likhiya Lake are the main wetlands found close to alignment. These lakes provide important habitat for many fishes and birds.

3.1.2 Social Environment

The alignment covers three districts of Nepal and India. It passes through 7 VDCs and 1 municipality of Nepal and 4 blocks and more than 6 panchayats of India. VDCs, blocks and settlements found along the alignment are listed in Table G.6. The panchayats include Sahajnawa, Chamdaha, Rampur Kathaliya, Harpur, Serauliya and Rajapur. Dense settlements are present along most parts of the route.

Table G.6 VDCs, blocks and settlements along the Butwal – Gorakhpur alignment

Country	VDC/Municipality & Block	Settlements
Nepal	Butwal Municipality	Butwal bazaar
	Karahiya VDC	Ganeshnagar, Gaighat, Bihuti,
	Makrahar VDC	Kwari, Pradeepnagar, Makrahar
	Gangwaliya VDC	Bidure, Darshantole, Badera
	Madhwaliya VDC	Baruwaliya, Darkhosuwa,
	Hatiprasatikar VDC	Nayamil, Nawadiha, Balapur tole
	Basantpur VDC	Sano Madhuwa, Thulo Madhuwa
	Bagaha VDC	Bagha, Bargadi
India	Pharenda Block	Mahawa tole, Parsa Mahant, Dehawa, Ledahawa, Sidhwari khas,
	Campiarjung Block	Thakur Nagar, Gopalpur, Bishambhpur, Pratapur, Dharampur
	Ratnapur Block	Urdichoke, Gopanpur, Siwan, Barawabhoj, Lohasi, Simalipur
	Koudia Block	Dihawa, Gadpatiya Gadela, Koudiya, Chariya, Sherpur, Aminpur, Bhandara, Tajdiha, Khadiya, Gahashara

Chakiya primary school, lower secondary school of Chakiya, Thakur Nagar primary school and Jamura Khurd primary school are located close to transmission line alignment. The locations of these schools and their approximate distances from the alignment are presented in Table G.7.

Table G.7 Schools near Butwal – Gorakhpur alignment

S.N.	Name of School	Location	Approx. distance from alignment (m)
1	Chakiya primary School	Chakiya Village	12
2	Lower Secondary School	Chakiya village	40
3	Thakur Nagar Primary School	Thakurnagar Village	50
4	Jamurakhurd Primary School	Jamurakhurd village	100

Kalika temple of Thakurnagar and Janaki temple are religious places located close to the alignment. Of these, the former is located approximately 18 m from the route while the latter is about 60 m from it.

3.2 Impacts

3.2.1 Positive Impacts

The alignment is selected with due consideration to environmental damages. As it lies within 2 to 8 km of main highways and close to feeder roads, the alignment will minimize material transportation cost. Resettlement along the alignment will not be necessary as houses will not be affected. The alignment does not cross settlements.

The positive impacts of the transmission line will be similar to those listed in Section 2.2.1.

3.2.2 Adverse Impacts

3.2.2.1 Natural Environment

Land Use

The usage of 366.4 ha of land will be affected by the project. This land includes 335.1 ha of cultivated land, 19.4 ha of forest land, 2.8 ha of fruit gardens and 2.5 ha of other areas which include river, road, canal, pond etc (Table G.8). The impact on rivers, roads and other lands is not considered significant in terms of land use changes. In cultivated areas, the land use pattern of the area occupied by the tower pads (about 5.78 ha) will be completely changed. Land use changes will be significant in forest areas.

Table G.8 Land use affected by the Butwal – Gorakhpur alignment

Land Use Category	Affected Land Use (ha)		
	Nepal	India	Total (ha)
Cultivated Land	58.20	276.91	335.11
Forest Land	13.59	1.92	15.51
Private forest	0.41	2.48	2.88
Fruit garden	0.20	2.58	2.78
Shrub and grassland	1.02	0.00	1.02
River, rivulets, canal	0.27	1.14	1.41
Road	0.30	1.95	2.25
Pond, lake	0.15	2.79	2.94
Railway	0.00	0.14	0.14
Others	2.40	0.00	2.40
Total	**76.54**	**289.90**	**366.44**

Crossings of Infrastructures

The transmission line crosses high voltage transmission lines (400 kV, 220 kV and 132 kV), sub-transmission and distribution lines, telephone lines, road and railway several times. The crossings of high voltage lines may have interference impact.

Impact on Drainage Pattern

A total of 415 towers, which include 365 tangent, 16 small angle, 18 medium angle and 16 large angle towers, will be erected from Butwal to Gorakhpur. According to available information, about 60% alignment area on Nepalese side and 80% alignment area on Indian side is submerged during monsoon. The erection of a large number of towers will aggravate the problems with regards to drainage pattern of the area.

Impact on Water Quality

The proposed transmission line crosses river, rivulets, ponds, canal and wetlands several times. The details of crossings on the Nepalese and Indian sides are given in Table G.9.

Table G.9 Water bodies found along the Butwal – Gorakhpur alignment

S.N.	Water Bodies	Number of Crossings		
		Nepal	India	Total
1	River	4	3	7
2	Rivulets	1	3	4
3	Canal	24	4	28
4	Pond	1	2	3
5	Wetland	0	3	3

Construction work near the water bodies may disturb water quality. For the construction activities, water will be used from the nearby rivers, rivulets etc. Improper disposal of spoil, solid wastes, such as cement slurry, other construction materials and human wastes from the work force, may deteriorate the water quality of the water bodies.

Loss of Vegetation/Forest

The implementation of the proposed project will fell 15.5 ha of national forest, including 13.6 ha in Nepal and 1.9 ha in India. Sal is the major tree (95%) affected by the transmission line. The project will affect approximately 8,000 timber class trees and 5,000 pole size trees in Nepal and approximately 2,000 pole size trees in India.

Besides government forests, the project will also affect private forests of sal, mango gardens and sisso and teak trees planted in farmlands. Approximately 250 mango trees, 300 sisso trees, 100 teak teas, and 6 pole size plants of sal would be affected by the project.

Loss of Habitat

The removal of vegetation will reduce the available habitat for the birds and mammals. This is considered an adverse impact on the wildlife of the area.

Impact on Wet Land

The transmission line crosses Saruwa, Khumar and Likhiya Lakes. These lakes provide important habitats for many birds, fish and aquatic plants. Construction activities in these areas may disturb the normal feeding and movement of birds, fishes and other animals. The labor force may also involve in hunting and poaching of birds, illegal fishing etc. This will affect the population of the water-loving birds.

Avian Hazards

The operation of 220 kV transmission line may affect bird flights. The principal problem will arise from the earth wires, which being at the highest point and being thin, are hard for birds to detect and avoid. Birds, which do not see the wire or which notice them too late, may suffer injury and death from collisions. This type of impact is expected to be high in low visibility conditions, especially in bad weather and at night time. Some species like raptors and fruit bats are likely to be affected more due to line collision.

3.2.2.2 Socio-economic Impacts

Land Acquisition

The project will erect 415 different types of towers in 122.14 km. Out of these, 375 towers will be erected in cultivated land. As the placement of 1 tower will require an area of 12.5 m x 12.5 (0.0154 ha), a total of 5.78 ha of cultivable land will be permanently acquired by the project for the placement of tower. As such, approximately 100 metric tons of food grain will be lost annually.

Acquisition of House and Other Structures

The project will acquire 4 houses at different localities along the transmission line. Besides this, 1 cow shed, compound of brick industry and 1 cremation site will also be affected by the project.

Impact on Schools

The project will directly affect the Chakiya primary school which is within the RoW of the transmission line alignment. Two other schools are located very close to, but not within the RoW of, the alignment. Since these schools do not have compound walls, construction-related impacts of the transmission line on the schools are considered to be significant.

Impact on Temple

The project will not directly affect any temple. The Kalika temple lies within 18 m of the alignment. Construction works may cause disturbance to the worshippers at this temple.

Farming Hindrance and Impact on Standing Crop

As the placement of one tower will occupy 0.015 ha of land, towers constructed in cultivated area, especially in the middle of land parcels, will pose hindrance to plowing the agro-fields. The field may be cultivated using human labor; however, this will increase the cost of agricultural production.

Since 91.5 % of the alignment passes through cultivated land, the impact of the line on the standing crop is considered significant during construction phase. Normally, the winter crop will be affected because the construction will be curtailed, or even closed down completely, during the monsoon.

Reduction of Land Value

About 366.44 ha of land fall within the RoW of the transmission line. As this land will not be available for construction of houses, its value, especially at Nautanwa, Bargadaha, Mohaniya Belaw road, Mahuwa Tole, Gorakhpur road, Brijmangaunj road, and Sidhwaria will be reduced.

Impact on Aesthetic

As the proposed transmission line mostly passes through cultivated land, the visual beauty of the area will not be affected. The alignment passes more than a kilometer from the Indo-Nepal border gate and 15 km from the famous religious temple of

Gorakhnath at Gorakhpur. Hence, no significant impact is expected with respect to aesthetic importance.

3.3 Mitigation Measures

Mitigation measures to minimize the impacts of the project shall be similar to those listed in Section 2.3. In addition, the following measures will be adopted to address the other adverse impacts of the project:

- Replacement plantation at the rate of 1: 25 shall be implemented.
- Construction materials of old houses shall be allowed to the respective owners for the construction of new houses.
- Construction of new school building for Chakiya School and compound walls for the other two schools shall be provided for.

4. Conclusions and Recommendations

The preliminary assessment shows that the Dhalkebar - Muzaffarpur and the Butwal - Gorakhpur transmission line alignments would not likely result in any major environmental effects. Land-acquisition is not considered difficult. Anticipated environmental impacts may be easily minimized or mitigated without serious cost implications to the project. The transmission line corridors are, therefore, considered environmentally benign and feasible. An Environmental Impact Assessment for the selected route will be required prior to construction of the line.

It is recommended that early in the preparation of project EIA, refinement of the alignment and land acquisition activities be studied in greater detail to minimize land disturbance and environmental effects and to lower project costs. It is further recommended that a public involvement program be initiated at the beginning of the EIA process to ensure adequate and timely representation of the affected communities in the decision-making process.

Appendix H

Presentation made at the POWERing Nepal- Connecting Markets seminar November 3, 2006

Nepal-India Transmission Link

G. Krish Krishnan
Chief of Party
International Resources Group

USAID
FROM THE AMERICAN PEOPLE

IRG

Integrated Nepali Power System (INPS)

- Developed over the years in line with perceived generation requirements
- Significant difference in planned generating needs (878 MW by 2017) and actual to date (61 MW – Marsyangdi)
- Significant difference between planned TL development (9 corridors) and actual realized to date (1- Marsyangdi)

FROM THE AMERICAN PEOPLE

INPS NEEDS

- Long-term TL plan done without one-to-one corresponding generation projects
- Better power flow within INPS system
- Good grid connections to develop fully small and medium size projects
- Potential spill energy usage

The Study: Fundamentals

- Export of hydropower IS essential for Nepal’s growth
- India interested in importing hydropower on Availability Based Tariff (ABT)
- Nepal and India CAN discuss and resolve issues of “other” benefits and cost of hydro development (e.g. irrigation, flood control, resettlement of people) independent of power price
- Both countries will gain from improved efficiency and judicious joint development of energy resources
- Power trade will contribute to more effective management of energy security issues

USAID FROM THE AMERICAN PEOPLE

IRG

The Study: Fundamentals (cont'd)

- NEA is mandated primarily to meet domestic demand
- NEA has no impetus to export except as swaps at its systems extremities
- Indian Electricity Act of 2003 has opened unprecedented opportunity
- Both Governments have worked on cross-border power transactions for several decades, unfortunately without much success

USAID FROM THE AMERICAN PEOPLE

IRG

The Study: Fundamentals (cont'd)

- Planned NEA TL system expansion with a 24/7 TL inter-connection between India and Nepal will
  - Provide improved economics of existing plants
  - Accelerate better development of river basins and smaller plants (20-100 MW) for domestic use and export
  - Facilitate commercial transaction on the basis of an ABT
- 350 GWh ($12M) available annually now during certain times in NEA INPS that can be used in India; significant shortage exists at other times
- With planned generation expansion NEA system will have 2,000 GWh ($80M) energy for export by 2014)

The Challenge

- NEA, PTC, PGC have studied alternative TL inter-connections and found them not viable at currently projected export levels
- Nepal experiences significant power shortage during certain other times (evening peaks) and needs to import power on a short-term basis
- At crude oil at $60/bbl, solar, wind energy etc technologies will become attractive in 5-10 years

How to make it work?

Experience indicates

- Build and it will get used – self-generated traffic because of availability
- Future TL corridors become major development issues
- Hydropower plants have more benefits than generally planned or foreseen
- Historically demand has outstripped planned capacity and energy

How to make it work? (cont'd)

Take long-term strategic view

- Commercial power trade on ABT basis
- Sub-optimal development of smaller plants in Nepal if TL system is not designed for long-term development scenario

Status Quo is NOT an option

Opportunities

- Time lag between INPS evening peak and Indian peak
- Possible extended use of mid-level thermal plants in India to supply Nepal’s peak
- India is importing rising volumes of electricity from Bhutan and soon from Bangladesh and possibly hydroelectric power from Tibet/China and Central Asia
- India is looking at importing pipeline gas from Burma, Bangladesh, Iran; LNG from Qatar – the GON Must Establish **Nepal's NICHE NOW!!!**
- Private sector/PPP has the incentive to build and operate 24/7 TL inter-connection

INPS –TLs and cross-border TLs Existing and proposed lines

Nepal-India TL Inter-connections

132/220 kV inter-connections

- Existing
- Mahedranagar – Tanakpur 132 kV: import
- Bardghat via Gandak –Ramnagar – Muzaffarpur: 132 kV
- Duhabi – Kataiya - Purnea: 132kV

TL inter-connections studied

- Butwal - Anandnagar - Gorakpur 132/220 kV
- Dhalkebar - Sitamarhi - Muzaffarpur 220 kV
- Duhabi - Purnea 132/220 kV
- Anarmani - Siliguri 132/220 kV

Approach to Solution

- Private development and PPP in Nepal/India will assist both governments in accelerating cross-border power trade – industrialists and entrepreneurs have better success in trade
- Time is of the essence; with power shortages growing in India *and Nepal* putting constraints on economic development, now is the moment to get concrete actions done quickly

Analyses

Simulated NEA system using PSS/E software

With NEA's planned generation to 2017

- With NEA's planned TL strengthening inside Nepal
- Connection to PGC grid in India

Concentrated export demand at alternative locations points

- 100 MW export by 2010 (350 GWh)
- 500 MW export by 2015 (2,100 GWh)

Analyses (cont'd)

Modeled several alternatives

- Butwal - Anandnagar - Gorakpur
- Dhalkebar – Sitamarhi - Muzaffarpur
- Duhabi - Kataiya

Estimated cost of TL strengthening required to meet export demand

Preferred Corridor

Dhalkebar-Muzaffarpur

- Phase 1: 220 kV double Bison; string single circuit; charged at 220 kV
- Phase 2: Expand to 220 kV double circuit
- Potential capacity to 800 MW

Key Results

- 220 kV Dhalkebar – Muzaffarpur interconnection
  - Exports only at estimated levels (100 MW in 2010; 500 MW+ in 2015)
  - Viable even in asynchronous mode as well (HVDC cost $20k/MW)
  - Average export price of $0.04/kWh; energy purchase price $0.015-0.03/kWh
  - Wheeling charges $0.005/kWh for transactions each way

- 132/220 kV Butwal-Gorakpur and 220 kV Duhabi-Purnea lines also are viable

USAID FROM THE AMERICAN PEOPLE

IRG

Key Results (cont'd)

If Nepal imports 100 MW for 4 hours per day for the next 5 years and

- Average import price is similar to avg. export price
- Wheeling charges are $0.005/kWh for transactions each way
- Margin between purchase and sale price to NEA for imports is $0.005/kWh

Economics of the TL improves by 10-15%

The Numbers

Synchronous interconnection

	Dhalkebar-Muzaffarpur	Butwal-Gorakpur
Cost M$	52.4	55.6
B/C	2.1	2.0
IRR (npv)	25.7%	25.1%

The Numbers

Asynchronous interconnection

	Dhalkebar-Muzaffarpur	Butwal-Gorakpur
Cost M$	152.4	160.6
B/C	1.4	1.3
IRR (npv)	8.9%	8.1%
Cost M$	132.4	140.6
(w/donor assistance)		
B/C	1.5	1.4
IRR (npv)	12.9%	12.0%

USAID FROM THE AMERICAN PEOPLE IRG

NEA's OBSERVATIONS ON THE STUDY

- Alternative synchronous/ asynchronous connection needs detailed additional system study
- Delayed implementation of NEA's generation and TL plans may reduce export quantum
- Judicious pricing for export and import is a necessity
- Need for firm commitments from both countries

TL interconnections would offer effective and efficient development of hydro in Nepal and thermal in India (with possible Carbon credits)

Recommendations

In the next 5-6 months: with donor funding,

- Confirm through further system study, asynchronous or synchronous connection
- Develop and obtain approvals from Nepal and India for proforma third party energy sales contracts
- Establish grid code conformity for transactions in both countries
- Get regulatory requirements in place in Nepal for power trading; wheeling through NEA TL system; third party sales; approval in India for wheeling Nepal's power through Indian grid (for short term)

Recommendations (cont'd)

In the next 12 months, with donor assistance

- Prepare contract documents for a BOOT type development in consultation with PTC, PGC, NEA, DOED, and private sector (Reliance, Tatas, BPC)
- NEA, DOED, and GON prepare/confirm plans for generation and TL strengthening of INPS
- NEA, DOED, and GON conduct focused discussions with donor community, IFIs, and IPPs for timely development to fund generation and TL projects including DM under
  - NEA ownership;
  - Private ownership; and/or
  - PPP arrangement

USAID FROM THE AMERICAN PEOPLE

IRG

Recommendations (cont'd)

Now. With some donor assistance, Form Champion teams comprising IPPAN, IPPAI, AMCHAM, CII, FNCCI, and other interested organizations

- To legislate Electricity Act and the NERC Act in Nepal;
- To amend Indian EA for cross-border wheeling (shot term)
- Assist potential developers on both sides to meet regulatory, legal, and administrative requirements
- Facilitate development of PPPs, match making among developers, investment communities, financial institutions, consultants, equipment manufacturers, software/hardware developers, and contractors

USAID FROM THE AMERICAN PEOPLE

IRG

Appendix I

Details of Financial Analysis