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

Regional Hydro-power Resources: Status of Development and Barriers

Nepal

Nexant

September 2002

Regional Hydro-power Resources: Status of Development and Barriers
Nepal

For

United States Agency for International Development

Under

South Asia Regional Initiative for Energy

Prepared by
Nexant SARI/Energy

List Of Abbreviations

BPC	Butwal Power Company
CIWEC	Canadian International Water and Energy Consultants
DD	Detail Design
DOED	Department of Electricity Development
EPC	Environmental Protection Council
ETFC	Electricity Tariff Fixation Commission (ETFC)
FS	Feasibility Study
GLOF	Glacial Lake Outburst Flood
GWh	Gigawatt hours
HMG/N	His Majesty's Government of Nepal
INPS	Integrated Nepal Power System
IPP	Independent Power Producers
JICA	Japan International Cooperation Agency
kV	Kilo Volts
KWh	Kilowatt hour
LCGEP	Least Cost Generation Expansion Plan
MCM	Million cubic meters
MOWR	Ministry of Water Resources
MU	Million units (equivalent to GWh)
MW	Megawatt
NDC	National Development Council
NEA	Nepal Electricity Authority
NHA	Nepal Hydro-power Association
NPC	National Planning Commission
NWRDC	National Water Resources Development Council
PFS	Pre-feasibility Study
PROR	Peaking Run-of-River
PTC	Power Trading Corporation (India)
ROR	Run-of-River
SARI/Energy	South Asia Regional Initiative in Energy
SEB	State Electricity Board (India)
STO	Storage
USAID	United States Agency for International Development
WECS	Water and Energy Commission Secretariat

Contents

Executive Summary

Summary of the Document

- Nepal has a huge hydro-power potential of 83,000 MW, out of which 42,000 MW is considered to be economically feasible in the present condition. The present hydro-power capacity is about 500 MW. Only **18%** of the population has access to electricity. Even in the case of the most optimistic "high growth scenario", Nepal's domestic demand will reach to a level of 6,000 – 7,000 MW in the next 25 years.

- Hydro-power meets only about **1%** of the energy needs of the country. Fuel wood **(68%)**, agricultural wastes **(15%)**, animal dung **(8%)** and imported fossil fuel **(8%)** meet the bulk of the energy needs. Hydro-power is the major source of electricity (**86%** of the present capacity, the rest comes from thermal generation).

- The major policy objective of His Majesty's Government of Nepal is to develop the nation's vast hydro-power resource potential to serve the electricity needs of the people and to generate export revenue. The new "Hydro-power Development Policy, 2001" of Nepal provides the guidelines for hydro-power development in Nepal in line with this policy objective.

- This report presents the hydro-power potential, current utilization and future plan of hydro-power development in the country. The government policy on hydro-power and issues and barriers for the development of hydro-power in Nepal are discussed.

Principal Results

- Hydro-power development in Nepal can play a vital role in the overall development of Nepal. In addition, there is strong evidence that access to electricity has positive impacts on the poor, through improvements in children's education, better communications through radio and television, increase in rural production and improvement in health conditions of the rural people. The environmental benefits in terms of reduction in deforestation and pollution and the savings in terms of foreign exchange by the reduction in import of fossil fuel cannot be over emphasized.

- The domestic demand of Nepal is a very small fraction of the total potential and will remain so for the foreseeable future. Hydro-power potential of Nepal can thus be harnessed for mutual benefits of the countries in the region, particularly India and Bangladesh where there is demand for such power.

- The new "Hydro-power Development Policy" of Nepal encourages private investment in hydro-power sector. Procedures and arrangements have been made for granting licenses for study, production, transmission and distribution of hydro electricity. The Department of Electricity Development (DOED) under the Ministry of Water Resources (MOWR) has been given the promotional and study functions for hydro-power development including the task of issuing the licenses under a One Window Policy. Time bounds for processing of applications by DOED and the rates for royalty and other taxes have been explicitly stated in the new policy to promote and assist the private sector.

- The main issues in the hydro-power development have been identified as follows:

- Improving power system planning,
- Increasing access to electrification in rural areas,
- Raising the needed investments for hydro-power development,
- Institutional strengthening of agencies involved in the power sector,
- Promoting power exchange and export, and
- Reducing cost of hydro-power development.

- Given the huge hydro-power potential in Nepal as well as surplus of capacity and energy in terms of the temporal variations of demand and supply, a regional interconnection of transmission system would not only benefit Nepal but also countries in the region especially India and Bangladesh where there is deficit in supply. In addition, this interconnection will also enhance system reliability, improve security by diversity of supply and lead to a cost effective system operation. A more optimistic vision could also benefit other countries in South Asia through power trading in a regional power pool.

Next Steps

- Although Nepal has taken major initiatives in formulating a comprehensive hydro-power development policy, past experiences have shown that the implementation of such policies has seldom been lacking. All efforts must therefore be made to overcome the shortcomings and barriers to its implementation.

- Hydro-power production has to be cheap, reliable and environmentally and socially sustainable for it to meet the domestic as well as export markets. Concerted efforts have to be made in terms of study, project selection and implementation to make hydro-power development competitive and affordable.

- The concept of regional power pool and regional transmission system should be promoted.

- Lack of confidence has been one major barrier towards regional cooperation. The issue of sharing of water and its downstream benefits has hindered the implementation of a hydro-power project in Nepal for export to India and beyond. Identification and development of an "acceptable" project should be made first to build up "confidence and trust" in the region before embarking on more ambitious projects like Karnali (Chisapani) Multipurpose Project or the Koshi High Dam Project.

- Preparation of a regional project inventory for the mutual benefits of the region and a Regional Least Cost Generation Expansion Plan should be prepared to promote the "regional power pool" concept.

Nepal is a landlocked country in South Asia, situated between latitudes 26° 22' N and 30° 27'N and longitudes 80 ° 04' E and 88 ° 12' E, and bordered by China in the north and by India in the south, east and west (Map No. 1). Nepal has a land area of 147,181 km^2 and a present population of about 23.2 million. The country is predominantly mountainous, with the topography changing sharply from an elevation of 8,848 m from the top of the world's highest mountain, Sagarmatha to less than 100 m in the Terai within a short distance of 160 km to 270 km in the north-south direction. Nepal is known for its huge water resources potential. The surface water available in about 6,000 rivers and rivulets of the country is estimated to be about 224.7 billion m^3 per annum or equivalent to an average flow of 7,125 m^3/s. The high specific runoff and steep gradient of its rivers provide a large potential for hydro-power generation. The theoretical hydro-power potential of the country is estimated to be about 83,000 MW, out of which about 42,000 MW is said to be economically feasible in the present condition. The installed hydro-power capacity in 2001 was only 363 MW producing in an average about 2,000 GWh per annum. Two hydro-power projects that are in the phase of commissioning and hydro-power projects under construction will produce an additional 264 MW and average energy of 1,470 GWh per annum by the year 2005.

Hydro-power meets only about **1%** of the total energy needs of the country. Fuel wood **(68%)**, agricultural wastes **(15%)**, animal dung **(8%)** and imported fossil fuel **(8%)** meet the bulk of the energy needs. Hydro-power is the major source of electricity (**86%** of the present capacity) but only about **18%** of the population has access to electricity. A meager 55 KWh per capita of electric energy is consumed. The environmental benefits in terms of reduction in deforestation and pollution and the savings in terms of foreign exchange of the country by the reduction of import of fossil fuel strongly point to the need to harness the available hydro-power potential of the country.

Nepal is blessed with a huge hydro-power generation potential. A very small fraction of its potential is utilized to date. And even in the next twenty or thirty years, Nepal's electricity needs will be met by a small percentage of its potential. Hydro-power potential of Nepal can thus be harnessed for mutual benefits of the countries in the region, particularly India and Bangladesh where there is demand for such power.

Water is considered a prime natural resource for overall economic development of Nepal. The major policy objective of His Majesty's Government of Nepal (HMG/N) is to develop the nation's vast hydro-power resource potential to serve the electricity needs of the people and to generate export revenue. With this objective in mind, HMG/N has approved a new hydro-power development policy (2001). The new policy encourages private sector participation in the power sector, advocates a new institutional setup that separates regulatory and promotional functions, provides an explicit royalty structure and the rules for repatriation of equity returns for foreign investors, and sets a priority to developing hydro-power projects for rural electrification.

Section 2 Background and Justification

The Advisory meeting on Hydro-power Development and Rehabilitation of Hydro Plants in SARI region held in Sri Lanka has recommended a list of prioritized issues needing to be addressed in regional context. In order to address the issues raised in the workshop, particularly (i) Evaluation of unique economic and other benefits of a hydro-power project from a regional perspective and develop a pricing mechanism of hydro-power (ii) Develop a Regional Master Plan for exploitation of hydro-power resources and (iii) a Regional Least Cost Generation Expansion Plan, a comprehensive and authentic documentation of Regional Hydro-power Resources, the present status of its development, hydro-power development policies adopted and issues and barriers perceived by the partner countries in the development of hydro-power will be needed.

Section 3 Objective of the Report

The objective of the report is to provide a Comprehensive and Authentic Reference Document, comprising of the hydro-power potentialities with the parameters of all the identified projects, the present status of the utilization of hydro-power resources, the future hydro-power development plan, policies currently followed for the hydro-power development and the problems and issues as perceived in the partner countries.

This study is predominantly based on secondary data available from various sources relevant to the power sector and hydro-power development in Nepal. Table 4-1 presents the details of the references and resource database reviewed and used in the present study.

Table 4-1 References and Resource Database

S. N.	Country Code and Report Reference	Title	Author	Agency	Year	Status
1	4001	Water Resources Strategy, Nepal	Water and Energy Commission Secretariat (WECS)	WECS	January 2002	Published
2	4002	Corporate Development Plan FY2001/02-FY 2006/07, Final Report,	Nepal Electricity Authority (NEA)	NEA	December 2001	Internal
3	4003	Power System Master Plan for Nepal, Generation Expansion Plan, Final Report	Norconsult	Asian Development Bank (ADB) and NEA	August 1998	Internal
4	4004	Power System Master Plan for Nepal, Load Forecast, Final Report	Norconsult	ADB and NEA	December 1997	Internal
5	4005	Screening and Ranking Study Phase 1 Coarse Screening and Ranking Report, Volume 1-Main Report	Canadian International Water and Energy Consultants (CIWEC)	NEA, Medium Hydro-power Study Project	August 1996.	Internal
8	4008	The Nepal Hydro-power Database 2001	Nepal Hydro-power Association (NHA)	NHA	2001	Published
9	4009	Water Resources Act, 2049 (1992)	His Majesty's Government of Nepal (HMG/N)	HMG/N	December 1992	Published

Table 2-1 References and Resource Database (cont'd)

S. N.	Country Code and Report Reference	Title	Author	Agency	Year	Status
10	4010	Water Resources Regulation, 2050 (1993)	HMG/N	HMG/N	1993	Published
11	4011	Hydro-power Development Policy, 2049 (1992)	HMG/N	HMG/N	1992	Published
12	4012	Hydro-power Development Policy 2058 (2001)	HMG/N	HMG/N	October 2001	Published
13	4013	Electric Power Trade Agreement, 1997	HMG/N and Government of India.	HMG/N and Government of India.	1997	Published
14	4014	The Foreign Investment and Technology Transfer Act, 1992	HMG/N	HMG/N	November 1992 and January 1996 (Amendment)	Published
15	4015	Electricity Act, 2049 (1992)	HMG/N	HMG/N	December 1992	Published
16	4016	Electricity Regulation, 2050 (1993)	HMG/N	HMG/N	1993	Published
17	4017	Environment Protection Act, 2053 (1997)	HMG/N	HMG/N	1997	Published
19	4019	Industrial Enterprises Act, 1992	HMG/N	HMG/N	1992	Published
20	4020	Ninth Plan, 2054 – 2059 (1996/97 – 2002/03).	National Planning Commission (NPC).	HMG/N	1996	Published
21	4021	NEA Act, 2041 (1984)	HMG/N	HMG/N	1984	Published
22	4022	Water Resources Strategy Formulation Phase II Study, Annex 2 Macro Economic Framework	WRSF Consortium	WECS, HMG/N	December 2000	Internal

Table 4-1 References and Resource Database (cont'd)

S. N.	Country Code and Report Reference	Title	Author	Agency	Year	Status
23	4023	Water Resources Strategy Formulation Phase II Study, Annex 3 River Basin Planning Framework	WRSF Consortium	WECS, HMG/N	December 2000	Internal
24	4024	Water Resources Strategy Formulation Phase II Study, Annex 5 Hydro-power	WRSF Consortium	WECS, HMG/N	December 2000	Internal
25	4025	Nepal Proposed Power Sector Development Strategy (Report No. 21912-NEP).	Energy Sector Unit, South Asia Regional Office	World Bank	March 2001	Published
26	4026	NEA FY 2000/01, A Year in Review	NEA	NEA,	August 2001	Published
27	4027	Hydro-power Pricing in Nepalese Perspective	Vijaya Shankar Shrestha et al	First South Asia Water Forum, Kathmandu	26 – 28 February 2002	Published
28	4028	Model of Power Purchase Agreement between NEA and Independent Power Company	NEA	NEA	August 2001	Internal

There are more than 6000 rivers and rivulets in Nepal. The topography changes sharply from an elevation of 8,848 m to less than 100 m within a short distance of 160 km to 270 km in the north-south direction. The rivers mostly flow from north to the south direction passing through different physiographic regions. These regions that stretch west to east are the High Himalayas, High Mountains, Middle Mountains, Siwalik and the Terai. Depending on their sources, the rivers of Nepal can be classified into the following three types:

1. The major rivers originating from the Himalayas or the High Mountains,

2. The medium rivers originating from the Middle Mountains, and

3. The southern rivers originating from the Siwalik range or the Terai.

The major rivers are the Karnali, Gandaki (Narayani), Koshi and the Mahakali rivers along with their tributaries. These rivers have their sources in the snows and glaciers in the Himalayan region. These rivers have substantial flows even in the dry season and they provide reliable flows for irrigation, hydro-power, inland navigation etc. The medium rivers are the Kankai, Kamala, Bagmati, West Rapti and the Babai originating from the Mahabharata Ranges (Middle Mountains) below the snow line. These rivers are fed by groundwater including springs and do not dry up in the dry season. These rivers are good for irrigation and hydro-power. The seasonal variations in these rivers are however higher compared to the major rivers. The southern rivers originate in the Siwalik (Churia) range and the Terai and these rivers are normally dry in the lean season. Flash floods occur in the monsoon causing damages in these rivers. These rivers are not suitable for year round irrigation or hydro-power generation.

The high specific runoff and steep gradient of the rivers of Nepal provide a huge potential of hydro-power generation. The small tributaries in the hills and mountains have been used or have the potential to develop many micro and small hydro-power schemes to provide much needed electricity in the remote, isolated villages of the country where there is little hope of the national electric grid ever reaching. The major rivers and their tributaries, which are snow fed, have substantial flow even in the dry season and hence provide a favorable hydrological regime for the development of run-of-river type of hydro-power projects especially in the middle mountain region where the river gradients are high. Some major storage type hydro-electric projects with multi purpose benefits are also planned in these rivers, including the Koshi High Dam (4,000 MW), Karnali Multipurpose Project (10,800 MW) and the Pancheswar Project (6,000 MW). The medium rivers where the seasonal variations are high are mostly suitable for medium scale reservoir projects like the Kulekhani (92 MW), the only storage project at present, and other proposed projects such as the Kankai (60 MW), Bagmati (140 MW), Sharada (49 MW), Naumure (300 MW) etc.

The theoretical hydro-power potential of the country based on average flow available has been estimated to be 83,000 MW, out of which about 42,000 MW is estimated to be economically feasible under present condition (Table 5-1) About **85 %** of the potential is based on reservoir projects.

Table 5.1 : Hydro-power Potential (GW)

River Basin	Theoretical Potential		Economically Feasible	
	(GW)	(%)	(GW)	(%)
Koshi	22.35	27	10.86	26
Gandaki (Narayani)	20.65	25	5.27	13
Karnali and Mahakali	36.18	43	25.10	60
Others	4.11	5	0.88	2
Total	**83.29**	**100**	**42.13**	**100**

The theoretical hydro-power potential of the country based on average flow available has been estimated to be 83,000 MW, out of which about 42,000 MW is estimated to be economically feasible under present condition. About 85 % of the potential is based on reservoir projects. The reservoir projects will mostly also have other multi purpose benefits like irrigation, low flow augmentation, flood control and navigation.

Only about **1%** of the country's energy needs are met by hydro-electricity. Fuel wood **(68%)**, agricultural wastes **(15%)**, animal dung **(8%)** and imported fossil fuel **(8%)** are meeting the bulk of the energy needs of the country (Figure 6-1). About **18 %** of the population has access to electricity and electricity consumption of the country is a meager 55 kWh per capita.

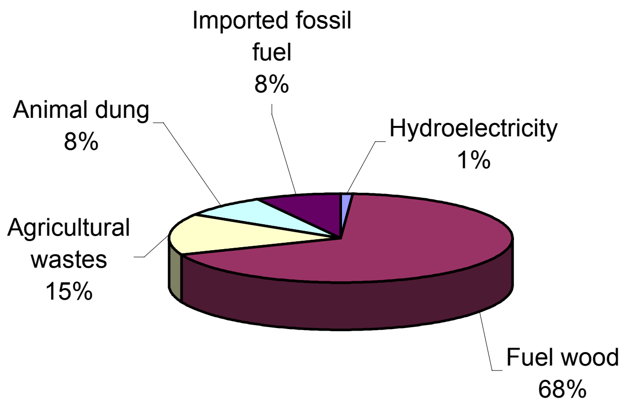

Figure 6-1: Current Energy Consumption

The first hydro-power plant of a 500 kW capacity was commissioned in 1911 at Pharphing. The current utilization of the hydro-power potential is 527 MW, including the two being commissioned this year, namely the Kali Gandaki A (144 MW) and Chileme (20 MW). In addition, thermal plants of 51.3 MW capacity and import (exchange) of upto 50MW from India is available to meet the power demand of the country. In the year 2001, 1,113 GWh of hydro-power generation **(87%)**, 27 GWh of thermal generation **(1%)** and 227 GWh of import from India **(12%)** were utilized. With 126 GWh of electricity exported to India, Nepal was a net importer of about 100 GWh of electricity in 2001. The majority of the hydro-power projects are owned by the national utility, the Nepal Electricity Authority (NEA), an undertaking of His Majesty's Government of Nepal. However, with the recent policies of the government to attract private investments in the hydro-power sector, some major projects have now been developed by the private sectors, namely the Butwal Power Company (BPC), Himal Power Ltd. and Bhote Koshi Power Company. These private power producers generated 113 MW of power and 501 GWh of energy in 2001, which is **27%** of the total generation in the country. Figure 6-2 presents the electricity generation by different sources in 2001.

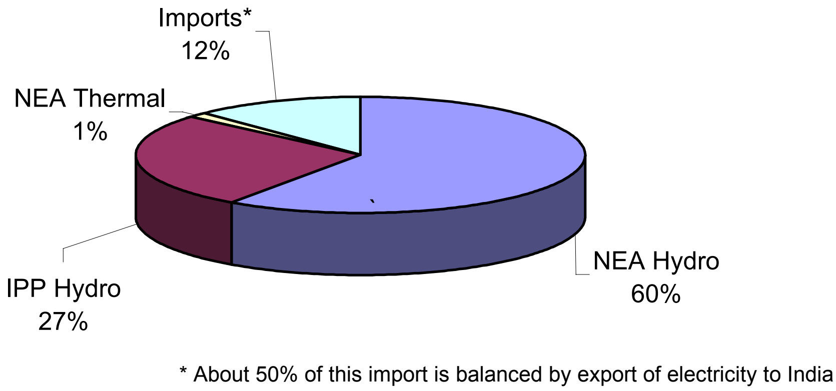

Figure 6-2: Electricity Generation in 2001

Hydro-power capacity was **86%** of the total installed capacity of the Integrated Nepal Power System (INPS) in 2001. With the two projects being commissioned in 2002, it will now be **90%** of the INPS. The rest are thermal plants using multi-fuels and diesel. There is only one reservoir project, which has seasonal peaking capability. All other hydro-electric projects are of the run-of-the-river (ROR) type, some of which have small pondage capacity providing daily peaking capability for few hours. These ROR projects with daily peaking capability are termed as peaking ROR (PROR). The load factor (ratio of average power demand and peak demand) in Nepal is quite low, about **52%.** The demand in the winter is higher than in the summer and the demand in the mornings and evenings are also higher as majority of the users are domestic users. There is a typical evening peak and low loads during night. About **20-30%** of the peak has durations of 4 hours or less. The monthly peak load variation is **88%** (mid August – mid September) and **100%** (mid December– mid January). The flows available in the rivers on the other hand are lower during the winter. This leads to some of the ROR projects (without pondage) not being able to generate to its full installed capacity during the dry season when the demand for electricity is more. Hence, a distinction between installed capacity and peaking capacity needs to be made in the case of hydro-power projects, particularly in the case of the pure ROR projects. Peaking capacity is the maximum capacity the power plant can generate in the driest period of the year. The list of current hydro-power projects in Nepal is presented in Table 6-1. Table 6-2 presents the current transmission lines in the country.

The power system of Nepal is a hydro-power-dominated system. With the commissioning of two new projects in 2002, hydro-power capacity will increase from 86% to 90% out of the total installed capacity from 2001 to 2002. Out of the total hydro-power capacity, 17% is from the only storage reservoir project, Kulekhani, and the rest (83%) is from run-of –river (ROR) type projects (39% pure ROR and 44% peaking ROR)

Nepal also has a power exchange agreement with the Government of India, which has recently been upgraded from 50 MW to 150 MW. The exchange is directed mainly to supplement power in case of power deficiencies and emergencies. The current exchange rate for a transmission voltage of 33 kV in 1996 price is equivalent to 1.67 Indian Rupees, with an annual escalation of **8.5%.** There is a rebate of **7.5%** for exchange at 133 kV and **7.5%** surcharge for exchange in 11 kV.

Table 6-1: Existing Hydro-power Projects

Project name	Owner	Year of Installation	Output			Reservoir		Type	Possible Renovation, Modernization and up-grading
			Installed Capacity (MW)	Peaking Capacity* (MW)	Annual Energy (MU)	Capacity (MCM)	Area (km^2)		
Trishuli	NEA	1967 (96)	24.5	19	292	-	-	ROR	Renovated in 1996
Devighat	NEA	1984 (96)	14.1	13		-	-	ROR	Renovated in 1997
Sun Koshi	NEA	1972	10.0	6	66	-	-	ROR	
Gandak	NEA	1979	15.0	10	53	-	-	ROR	
Marsyangdi	NEA	1989	69.0	69	519	3.9	na	PROR	
Andhi Khola	BPC	1991	5.1	4	38	-	-	ROR	
Jhimruk	BPC	1994	12.3	7	81	-	-	ROR	
Kulekhani I	NEA	1982	60.0	60	164	69.0	2.18	STO	
Kulekhani II	NEA	1986	32.0	32	96	-	-	STO	
Puwa Khola	NEA	1999	6.2	2	41	-	-	ROR	
Khimti Khola	Himal Power Ltd.	2000	60.0	23	353	-	-	ROR	
Bhote Koshi	Bhote Koshi Power Co.	2000	36.0	16	250	-	-	ROR	
Modi Khola	NEA	2000	14.0	6	87	-	-	ROR	
Chilime	Chilime Hydro-power Co.	2002	20.0	20	101	0.044	na	PROR	
Kali Gandaki A	NEA	2002	144.0	144	791			PROR	
Small Hydro	NEA	various	5.0	4	26	-	-	ROR	
		Total	527.6	455	3,109				

*The peaking capacity of run-of-river (ROR) projects without pondage is normally lower than the installed capacity because the flow available in the dry season is less than the design discharge and there is no peaking capability (pondage).

Table 6.2 : Transmission Line Length

S. No.	Type	Length (km)
1	132 kV Single Circuit	1,040
2	132 kV Double Circuit	367
3	66 kV Single Circuit	205
4	66 kV Double Circuit	162
5	66 & 132 kV Double Circuit	22
6	66 kV Four Circuit	3
7	33 kV Single Circuit	1,536

A total of 110 MW of capacity generating about 651 GWh of energy will be added in the next few years as shown in Table 7-1.

Table 7-1: Hydro-power Projects Under Construction

Project name	Owner	Planned Year of Installation	Output			Type
			Installed Capacity (MW)	Peaking Capacity* (MW)	Annual Energy (MU)	
Upper Modi	IPP	2003	14	8	90	ROR
Middle Marsyangdi	NEA	2004	70	70	398	PROR
Small Hydro	Private		26	18	166	ROR
		Total	110	96	651	

* The peaking capacity of run-of-river (ROR) projects without pondage is normally lower than the installed capacity because the flow available in the dry season is less than the design discharge and there is no peaking capability (pondage).

Section 8 Potential Upgrade of Existing Projects

As most of the existing projects were built in the recent past, potential for upgrading them is limited. Regular renovation and rehabilitation of these plants particularly in terms of maintenance and repair of civil and electro-mechanical components are carried out. Examples of which are the renovation works carried out in the Trishuli and Devighat projects in 1996. The renovations consisted mainly of civil works where the pondage capacity was restored in order to increase the peaking capacity in the dry season. There could however be some potential of upgrading of small hydro-power projects by upgrading the electro-mechanical equipment with low efficiency.

The present policy of the government is to make maximum utilization of the hydro-electricity potential in the country to meet the domestic demand in the country and to export hydro-electricity to the neighboring countries to increase its export revenue. The ninth 5-year plan for the period 1997-2002 envisaged to increase the share of hydro-electricity in the total energy consumptions from the present **1%** to about **3.5%** in the next 20 years. Similarly, His Majesty's Government of Nepal (HMG/N) has formulated favorable policies and supporting acts and regulations to attract private investment in the hydro-power sector both to meet the domestic demand and to export to neighboring countries. There have been projects planned and designed especially for export purposes. Licenses for their studies and implementation have already been issued. Hence, the future plan for hydro-power development essentially consists of two parts, one for domestic consumption and the other for export. Investments for their development will come both from the public/ government and private funds. The share of the private investment based on commercial loans will increase compared to the public sector investments, especially with the decline in multi-lateral and bi-lateral soft loans and grants that were available in the past.

Nepal Electricity Authority (NEA), an undertaking of the government, is involved in the generation, transmission and distribution of electricity in Nepal as per the NEA Act of 1984. NEA is the owner of the transmission and load dispatch center. All power presently generated by the private producers are purchased by NEA through power purchase agreements and sold to the consumers using the INPS grid, except for some small isolated power systems in the rural areas. Recent studies and government policies have suggested measures to restructure and privatize NEA in order to address the problems plaguing NEA like inefficiency, high system losses of NEA system, conflicts of interest in generation and sole ownership of the transmission system and also to mobilize private capital necessary for large projects of the future.

The future plan for hydro-power development will therefore depend on all the above factors, particularly the level of private investment that can be successfully attracted to develop projects for domestic consumption and for export, and the restructuring and unbundling of NEA into three components, the generation, transmission and distribution. The present methodology followed to select the projects to develop in the future is based on the "least cost generation expansion plan (LCGEP)". NEA normally undertakes LCGEP studies to decide on the sequence and schedule of projects to be developed. A load forecast for a period of 15-20 years is made on the basis of macro economic and other factors for the whole country. The median load forecast gives a rise of 391 MW peak load in 2000/01 to 1,373 MW in 2017, and an annual energy demand increase from 1879 GWh to 6,255 GWh, for the same period. Then a portfolio of candidate hydro-electric and thermal projects is considered to meet this demand in the least cost manner. The commissioning dates of the projects already committed or under construction are fixed in this future plan. These studies are updated regularly with the availability of more candidates and changes in the investment and economic scenarios. NEA updates such studies every few years and the last one was prepared in December 2000. The latest corporate plan of NEA (NEA, December 2001) has already made some changes in the last expansion plan due to changes in the load forecast and the investment scenario like the "signing of an joint venture agreement for the development of Upper Karnali by 2008/09", etc. The level of "uncertainty" in the formulation of such plans is evident from the fact that there is strong indication that the said joint venture agreement of NEA with the private developer is already broken since this corporate plan was prepared in December 2001. Table 9-1 presents the latest published generation expansion plan of NEA (NEA, December 2001). Table 9-2 presents the other candidate projects presently being considered in the expansion plan. Table 9-3 presents some of the larger projects where private developers have shown interest in development and/or which will be mainly suitable for export purposes.

The methodology followed to select the projects to develop in the future is based on the "least cost generation expansion plan (LCGEP)". NEA normally undertakes LCGEP studies to decide on the sequence and schedule of projects to be developed. A load forecast for a period of 15-20 years is made on the basis of macro economic and other factors for the whole country. Then a portfolio of candidate hydro-electric and thermal projects is considered to meet this demand in the least cost manner. The objective function of such a model is to minimize the total discounted cost which includes the capital costs, operation costs and the costs of any energy not served, which is many times higher than the most expensive thermal generation cost. These studies are updated regularly with the availability of more candidates and changes in the investment and economic scenarios. NEA updates such studies every few years and the last one was prepared in December 2001.

As explained above, the projects that are proposed by the private sector investment are automatically included as committed projects in the generation plan. The projects such as Indrawati, Dharam Khoal, Piluwa Khola, Chaku Khola, Syange, Pheme, Khudi, Mailungh, Upper Modi, Langtang and Sun Koshi were therefore treated as under construction projects as PPAs for them have already been signed. NEA is now undertaking an identification and feasibility assessment of storage projects of appropriate size to include in the expansion plan. Hence, these plans are flexible and may be amended as new data and investment scenarios change. A more complete compilation of the portfolio of hydro-power projects studied at different levels by different agencies used by NEA recently for project screening purposes is presented in Appendix A. Many of these projects are mutually exclusive as their project areas overlap. Their parameters like cost, energy, capacity etc are based on different criteria like units rates, load forecast etc adopted at the time of their study. Any attempt to compare these parameters has to be done with consideration of the level of study, the timing of study and the criteria used in the study. For example, the duration of hydrological time series used in estimating the energy generation, design flood etc may be different and may need some homogenization exercise before making any direct comparison.

From the economic point of view, the most promising thermal plant alternatives are combustion turbines, multi fuel plants and diesel generators operating at low plant factors in combination with hydro-power from ROR and PROR. NEA does not have experience with combustion turbines but only with diesel generators. Hence, small (20MW) multi fuel (diesel/ heavy fuel oil (HFO)) plants are considered to be the most realistic thermal alternative for use in generation planning (Norconsult, 1998). LCGEP studies have considered two least cost scenarios, one with hydro-power only and the other with a hydro-thermal mix. The hydro thermal mix gives a slightly less present value of the total cost but the hydro only expansion plan has been selected with the aim of being self sufficient as all fuels have to be imported. In the case of a high load forecast scenario and an increase of export capacity to a range of 200 MW, the all hydro scenario is also the cheaper option. The scenario with a storage project is also seen to be slightly more expensive mainly because the size of storage project considered is big for present level of load growth.

The present transmission system of the INPS consists of 33 kV, 66 kV and 132 kV transmission lines. And, the distribution of power is done through 11 kV and 400/230 V lines. New power transmission lines of 66 kV, 132 kV and 220 kV have been proposed to evacuate power from the new hydro-electric projects. These include the Bardhghat-Butwal 220 kV, Hetauda – Thankot 220 kV and Heatauda – Bardhghat 220 kV systems.

Table 9-1: Latest Generation Expansion Plan

Project name	Owner	Year of Commissioning	Output			Reservoir		Type	Status
			Capacity (MW)	Peaking (MW)	Annual Energy (MU)	Capacity (MCM)	Area (km^2)		
Indrawati	IPP	2002/03	7.5	3	37	-	-	ROR	PPA signed with NEA
Daram Khola	IPP	2002/03	5.0	na	na	-	-	ROR	PPA signed with NEA
Piluwa Khola	IPP	2002/03	3.0	na	na	-	-	ROR	PPA signed with NEA
Chaku Khola	IPP	2002/03	0.9	na	na	-	-	ROR	PPA signed with NEA
Pheme	IPP	2003/04	1.0	na	na	-	-	ROR	PPA signed with NEA
Upper Modi	IPP	2003/04	14.0	4	79	-	-	ROR	PPA signed with NEA
Khudi	IPP	2003/04	3.5	na	na	-	-	ROR	PPA signed with NEA
Mailung	IPP	2004/05	5.0	na	na	-	-	ROR	PPA signed with NEA
Middle Marsyangdi	NEA, under construction	2004/05	70.0	70	362	0.93	na	PROR	Under Construction
Langtang	IPP (Kantipur Hydro-power Pvt. Ltd)	2006/07	10.0	na	78	-	-	ROR	PPA signed with NEA
Chameliya	IPP	2006/07	30.0	30	195	0.62	na	PROR	Planned
Kulekhani-3	IPP	2006/07	42.0	42	50	-	-	ROR	Planned
Khimti-2	NEA joint venture	2006/07	27.0	27	157	0.175	na	PROR	NEA Joint Venture
Rahughat	IPP	2007/08	27.0	6	129	-	-	ROR	Private
Kabeli-A	IPP	2007/08	30.0	15	162	0.2	na	PROR	Private
Upper Karnali -A	NEA joint venture	2008/09	300.0	300	2133	4.8	na	PROR	Planned
		Total	575.9	497.0	3382				

Source: NEA, 2001

Table 9-2: Candidate Projects considered in the Expansion Plan

S. N.	Project name	Level of Study	Earliest Commissioning Date	Output	
				Capacity (MW)	Annual Energy (MU)
1	Kulekhani-3	DD	2005/06	42.0	50
2	Rahughat	FS	2006/07	27.0	165
3	Kabeli-A	FS	2006/07	30.0	164
4	Likhu-4	FS	2008/09	44.0	270
5	Thulo Dunga	PFS	2008/09	24.7	202
6	Chameliya	FS	2005/06	30.0	196
7	Upper Marsyngdi-3	FS	2006/07	70.0	409
8	Khimti-2	PFS	2006/07	27.0	157
9	Budhi Ganga	FS	2006/07	20.0	106
10	Tamur Mewa	FS	2007/08	101.0	489
11	Upper Modi A	FS	2007/08	42.0	285
12	Lower Modi	FS	2006/07	19.0	123
13	Upper Karnali-A	FS	2007/08	300.0	2,133
14	Dudh Koshi-1	FS	2009/10	300.0	1,702
15	Madi-1	FS	2007/08	10.0	73
16	Langtang	PFS	2005/06	10.0	78
17	Upper Tamakoshi (Rolwaling)	FS (Phase 1)	2007/08	250.0	1568
18	Andhi Khola (Storage)	FS	2007/08	176.0	547
19	Upper Seti Storag	FS	2009/10	122	558
20	Langtang Storage	PFS	2011/12	218	950
21	Madi Ishaneshwar Storage	PFS	2010/11	110	456
22	Kankai Storage	FS	2009/10	60	203
23	Upper MarSyangdi-2	Prelim.	2010/11	85	593
24	Upper Marsyangdi-3	Prelim.	2011/12	121	692

Source: NEA, 2001 and personal communication

Table 9-3: Projects under consideration by Private Sector

S. N.	Project name	Capacity (MW)	Type	Licensee for Feasibility Study
1	West Seti	750	STO	SMEC Development Pvt. Ltd
2	Likhu 4	50	ROR	Pacific Hydro Ltd., Australia
3	Rahughat	27	ROR	Pacific Hydro Ltd., Australia/ ICTC / BPC
4	Kabeli "A"	30	ROR	Sanima Hydro Power Pvt. Ltd.
5	Badigadh	20	ROR	Butwal Power Company (BPC)
6	Thulo Dhunga	25	ROR	Thulo Dhunga Hydro-power Co. Pvt. Ltd.
7	Upper Marsyangdi	121	PROR	VA Tech, Switzerland
8	Andhi Khola	180	STO	Trans HP Development, Nepal / Eur Orient, USA JV
9	Lower Arun	308	ROR	Braspower, Brazil
10	Upper Arun	335	PROR	EurOrient Investment, USA
11	Budhi Ganga	20	ROR	Birla Corporation, India
12	Tamur-Mewa	101	PROR	Combined Energy Companies Inc, USA
13	Dudh Koshi	300	STO	ASTQ Holdings Corporation, Canada
14	Budhi Gandaki	600	STO	SMEC, Australia and SMTQ Holding Canada
15	Kali Gandaki-2	660	STO	SMEC Development Pty. Ltd.
16	Upper Trishuli -2	300	PROR	Pacific Hydro Ltd., Australia

Source: NHA (2001)

Water is considered a prime natural resource for overall economic development of Nepal. The major policy objective of His Majesty's Government of Nepal (HMG/N) is to develop the nation's vast hydro-power resource potential to serve the electricity needs of the people, and to generate export revenue. With this objective in mind, HMG/N approved on 15 October, 2001 a new "Hydro-power Development Policy 2058 (2002 AD)". It attempts to make the hydro-power development procedures "simple, clear, investment friendly and transparent to hydro-power projects for domestic use as well as for export purposes". This new policy builds on experiences gained from the implementation of the earlier Hydro-power Development Policy 2049 (1992 AD), particularly in refining the policies and legal framework needs in line with the changing world market and its impact on technological developments, export of electricity, promotion of foreign investment and environmental conservation. It has also dealt on issues such as the concept of multipurpose projects, roles of public and private sectors, use of domestic and foreign capital markets and transparency in HMG/N procedures in relation to private sector participation.

Legal instruments in the forms of Acts and Regulations are required with the new Hydro-power Development Policy acting as the guiding principle. Water law in Nepal consists of customary rights and statutory laws. The National Code of 1910 BS (1853 AD) was the first statutory law in Nepal. It established the rights of the people on the usage of water as incident to ownership of land abutting the stream or river. A specific law, which first introduced the concept of water tax and licensing for water use in hydro-power generation, was the Canal, Electricity and Related Water Resources Act of 2024 BS (1967 AD). The umbrella legislation for hydro-power, irrigation, drinking water and other water use is the Water Resources Act and Regulation 2049 BS (1992). In addition, a separate Electricity Act and Regulation 2049 BS (1992 AD) specifies the legislation for the power sector. These acts and regulations will now have to be revised to make it commensurate with the new hydro-power development policy. There are other acts and regulations that are not specifically for the hydro-power sector but have a direct impact on hydro-power development and management. These include the Environment Protection Act and Regulations (1997 AD), Local Self Governance Act (1999 AD), Foreign Investment and Technology Transfer Act (1992 AD) and the Nepal Electricity Act (1984 AD).

10.1 Objectives

The objectives of the hydro-power policy are to achieve the following:

1. To utilize the existing water resource of the country and to produce electricity at a low cost.
2. To ensure dependable, reliable and quality electricity services within the country at a reasonable rate.
3. To tie-up electrification with the economic activities.
4. To extend rural electrification to support rural economic development.
5. To develop hydro-power as an exportable commodity.

10.2 Highlights of the New Policy

The policy provides guidelines and necessary institutional structure to develop the hydro-power resources both for domestic consumption and export purposes. Arrangements have been made to attract private sector investment in the hydro-power sector. The concept of integrated water resources development and the multi purpose development of water resources have been recognized. The role of hydro-power in rural electrification has also been considered.

Detailed procedures and arrangements have been made for granting licenses for survey/ study, production, transmission and distribution of hydro-electricity. No license is required to generate hydro-power up to 1 MW capacity but has to be registered with the District Water Resources Committee and the Department of Electricity Development (DOED) has to be informed. Licenses will be awarded by DOED. Time frame for application processing and the period of licenses have been explicitly stated in the policy. A license for hydro-power production will be provided for 35 years and 30 years form the date of production license received for domestic consumption and for export, respectively. In the case of storage projects, the license period can be extended for up to 5 years depending on the construction period. The royalty structure has been also set and formulae for the calculation of capacity and energy royalty have been set. The royalty rates have been based on the capacity of the project and are higher for export-oriented projects than for domestic uses for obvious reasons. It also makes arrangements to cover the investment risks and the rules for repatriation of equity returns for projects involving foreign investors.

A new institutional structure separating regulatory and promotional functions has been advocated. The present Electricity Tariff Fixation Commission (ETFC) will be developed into a regulatory body. The regulatory body shall be responsible for fixing the electricity tariff and wheeling tariff, monitoring and seting standards/criteria to ensure the quality of electricity supply and to protect the interests of the consumers. The promotional and study functions have been set for DOED and the Water and Energy Commission Secretariat (WECS). DOED will be the authority responsible for feasibility studies of hydro-power and multi purpose projects, issuing licenses through competitive bidding, encouraging private sector investment, and providing services under a One Window Policy to promote and assist the private sector in the implementation of projects. WECS shall be responsible for the identification of projects, conducting study of electricity demand forecast and power system planning and undertaking relevant research activities in the power sector. The existing institutions will also be unbundled to operate the generation, transmission and distribution systems separately. An autonomous public institution will operate the national grid. And, local bodies and private sector will be involved in the operation of distribution systems.

In order to promote and develop rural electrification, a rural electrification "fund" will be set up with some percentage of royalty received from hydro-power projects. The government shall provide **1%** of the royalty received to extend the rural electrification program to the villages directly affected by the project.

The policy covers the following topics/ provisions to develop hydro-power in the country to achieve the above stated objectives.

1. Environmental Provisions

2. Provision of Water Rights
3. Provision of Investment in Production, Transmission and Distribution
4. Special Investment Arrangement to Develop Infrastructure for Rural Electrification (rural Electrification Fund)
5. Project Handover Arrangements
6. Power Purchase Arrangements
7. Visa Arrangements
8. Maximum Utilization of Local Resources
9. Investment Risk Coverage (not to be nationalized during whole period of license, repatriation of foreign currency out of Nepal, as per Foreign Investment and Technology Transfer Act to foreign investors)
10. Domestic Electricity Market Arrangements
11. Electricity Export Arrangement
12. Licensing Arrangements
13. Royalty Arrangements
14. Tax and Custom Facilities Arrangements
15. Institutional Arrangements
16. Construction and Operation of Hydro-power Projects by the Government

10.3 Relevant Acts and Regulations

The Water Resources Act, 2049 (1992 AD) is an important legal instrument that gives absolute recognition to the state's ownership and control of water resources. The government is empowered to allocate water rights and resolve related issues, and to grant license and control usage. Although the Water Resources Act was meant to be an umbrella Act for water resources utilization, a separate act, the Electricity Act, 2049 (1992 AD) governs the generation, transmission and distribution of electricity. The act has introduced the licensing procedure for generation, transmission and distribution. DOED was established to process and grant the licenses. The act encourages private sector participation. The Electricity Tariff Fixation Commission (ETFC) was established as a regulatory body as per this act. This act will now have to be amended and updated to incorporate the guidelines of the new policy.

The Environmental Protection Act, 1997 and the Environment Protection Rules, 1997 provide the legal framework for the scoping exercise and requirements for initial environmental examination and environmental impact assessment of hydro-power projects based on their size and scope. The Local Self-Governance Act (LSGA) (1999) was enacted to promote "institutional development of local bodies capable of bearing responsibility by providing such responsibility and power at the local level as is necessary to formulate and carry out plans"

10.4 Institutional setup

A number of councils, commissions, ministries and line agencies are involved at the policy, planning and political decision-making. There are three levels of institutions with the functions related to policy and coordination, implementation and operational, and regulatory (Figure 10-1).

10.4.1 Coordination and Policy-Level Institutions

The National Development Council (NDC) is a high level policy and planning body chaired by the prime minister. It guides the National Planning Commission (NPC) in the formulation of development policy and periodic plans. The prime minister also chairs NPC. One Vice-chairman and five members form the commission. NPC is a planning body with jurisdiction over all ministries and public sector agencies for formulating annual plans and monitoring its implementation. Availability of financial resources and their allocation to different sectors in consultation with the sectoral ministries is made by NPC to formulate the annual budget. The National Water Resources Development Council (NWRDC) is a high level water resources policy and coordination institution also chaired by the Prime Minister. The membership of the council has representatives from political parties and from outside the government. Water and Energy Commission Secretariat (WECS) serves as its secretariat. The Water and Energy Commission (WEC) setup in 1976, and reconstituted in January 1999, is chaired by the Water Resources Minister and has the secretaries of related ministries and five members from outside the government as members. WEC is a national water planning unit to promote multipurpose water resources and energy projects. WECS serves as its secretariat also. The Environment Protection Council (EPC) is also chaired by the PM. EPC provides policy guidelines and advice to the government to coordinate the activities related to the management and protection of the environment. The line ministry overlooking the hydro-power and the power sector is the Ministry of Water Resources (MOWR). MOWR is responsible for the formulation of policy, plans and programs related to water and energy sector. It is the authority to grant license for generation, transmission and distribution of electricity.

10.4.2 Implementation – Level Institutions

The Department of Electricity Development (DOED) assists MOWR to conduct studies of hydro-power and multipurpose projects and the processing of licenses to develop hydro-power projects. The new hydro-power policy has also assigned the department the role of encouraging private investment in the power sector and providing a "one window" policy to assist the private sector. The Electricity Tariff Fixation Commission (ETFC), under the Electricity Act, 1992 and the new policy, has been established to fix the tariff of electricity and to function as a regulatory agency to ensure the quality of electricity supply and to protect the interests of the consumers.

10.4.3 Operational – Level Institutions

Nepal Electricity Authority (NEA) is an integrated public utility with the mandate for power generation, transmission and distribution and for power exchange with India. NEA owns the national transmission and load dispatch center and all major private power producers sell the generated power to NEA through power purchase agreements. The institutional weakness of NEA has lead to low operational efficiency of the power system. There is a growing conflict of interest of NEA with the private developers, some of which are joint venture partners of NEA, as NEA is the single buyer of private power and also the single largest seller. The new hydro-power policy has therefore advocated the need to unbundle the three components of NEA, the generation, transmission and distribution as separate bodies.

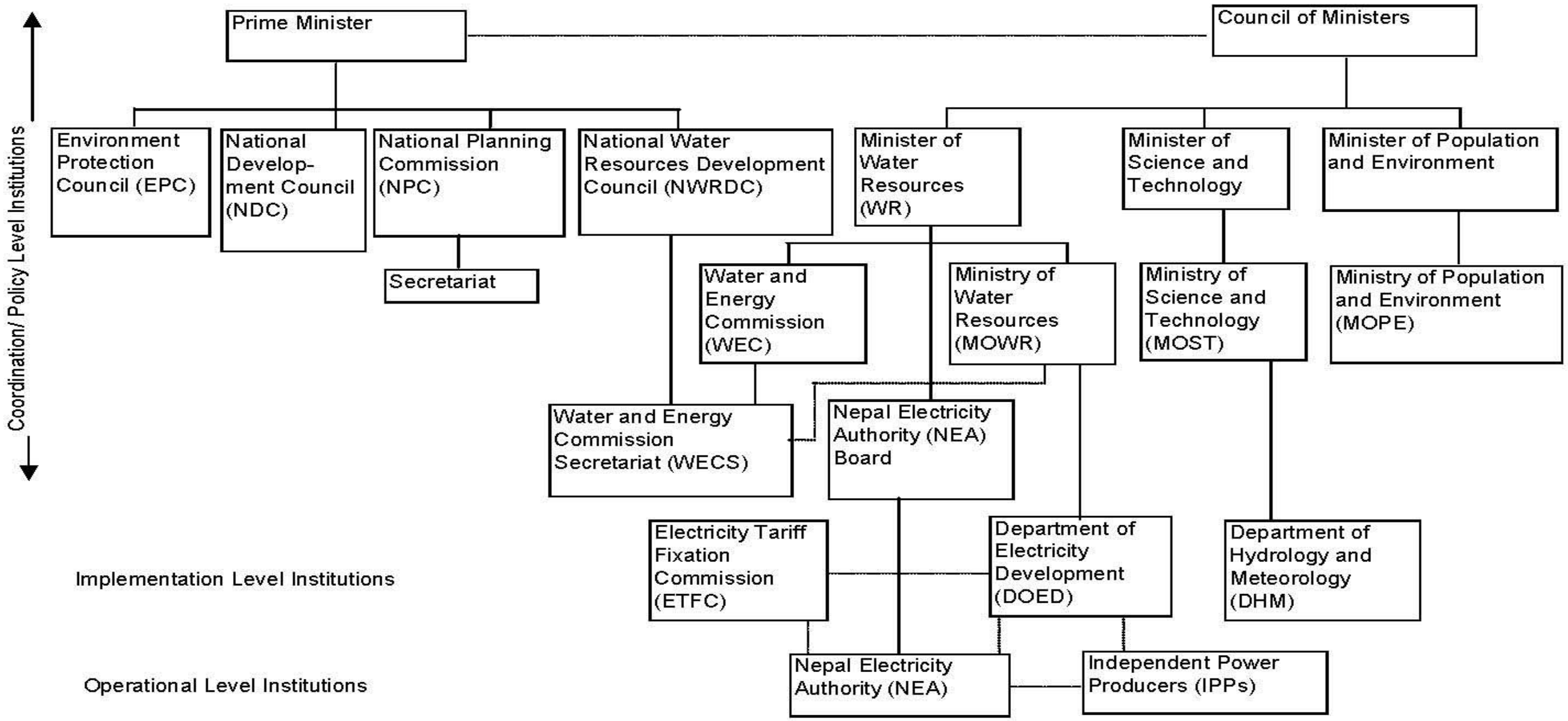

Figure 10-1: Instututional Setup for Power Sector

Despite the focus of all past development plans and policies on the objective of harnessing the vast hydro-power potential for the overall economic development of the country, the present level of hydro-power development in Nepal is a dismal percentage of the total potential. A situation review of the power sector in general and hydro-power in particular show that:

- Only about **1%** of the total energy needs is met by hydro-power, the bulk coming from fuel wood, agricultural wastes, animal dung and fossil fuel.
- Less than **1%** of the economical hydro-power potential is developed to date.
- Only about **18%** of the population has access to electricity and about 55 kWh per capita of electricity is consumed in the country, the lowest rate of consumption in South Asia.
- The present consumption of electricity is concentrated in the urban areas and the majority of rural areas, where majority of the population reside **(88%)** and agro-based industries, irrigation and cottage industries are based, is not connected with electricity supply.
- System losses in the power system are high as **25 %**, which include both technical and non-technical losses like pilferage.
- Due to the high variation of peak load and base load and the natural variations of the flows in the river, which often do not match, there is a deficit in the peaking capacity in the dry season and a surplus of energy in the wet season, which is mostly spilled.
- The present tariff rate is one of the most expensive in South Asia and is beyond the affordability of the majority of the people.
- Hydro-power projects are capital intensive and the investment requirement for the expansion of the power sector for domestic demand alone over the next ten years is estimated to be US$ 1.8 billion (World Bank, 2001). With the declining trend of availability of scarce public resources and soft loans and grants from multilateral and bilateral agencies, such financial resources will have to be mobilized through the private sector.
- In the current institutional framework, there is no clear separation of policy, regulation, and operational functions in the power sector. This has been a major impediment to the involvement of private investors in the power sector (World Bank, 2001).
- Nepal Electricity Authority (NEA) has been functioning as an integrated publicly owned utility responsible for generation, transmission and distribution of electricity in the country. NEA is the main buyer of all power produced by the private power developers as it is also the sole owner of the transmission and load dispatch system. There is thus growing conflicts of interest of NEA and the private producers.
- The vast hydro-power resource of the country can no way be fully utilized domestically even in the long term. There is a strong possibility of export of power to neighboring countries where there is a high demand. Such export can bring in much needed revenue for the country.
- The environmental and social concerns of hydro-power projects especially the storage projects is well recognized and hence there is a need to pay special attention in mitigating the environmental impacts of hydro-power development.

- Hydro-power development has to be based on the principles of Integrated Water Resources Development and Management and hence its relationships and tradeoff with other multiple-purpose uses of water resources have to be considered.
- The rivers of Nepal have an international dimension and can be a medium of international cooperation for the mutual benefit of the region. The development of storage reservoirs for hydro-power and other uses will have substantial downstream benefits to India and even Bangladesh in terms of both low flow augmentation and flood control.

11.1 Issues

There have been several recent studies on the identification of the key issues and problems in the power sector. The prominent ones are the "Water Resources Strategy of Nepal" (WECS, 2002 and WRSF Consortium, 2000) and the "Nepal- Proposed Power Sector Development Strategy" (World Bank, 2001). Based on the review and analysis of these study reports and other relevant documents and data, the key issues in development of the hydro-power resources of the country are as follows:

11.1.1 Improving Power System Planning

The Integrated Nepal Power System (INPS) is the national grid owned and operated by NEA supplying electric power in Nepal. In addition, the isolated power centers in rural areas are supplied from dedicated micro and small hydro-power projects. The load factor (the ratio of peak to average energy) is quite low, about **52 %**, because of the predominance of domestic consumptions and low demand of base load industrial consumption. There was a power deficit in the peak period, during evening hours in the winter season, and a surplus of energy in the monsoon season in the last few years due to a mis-match of demand and generation capacity of the power system. The recent commissioning of some private power projects like Khimti and Bhote Koshi and the more recent addition of Kali Gandaki this year has increased the capacity to avoid this power shortage in the peak hours for a few years. There is however still a surplus amount of energy in the wet season which is normally spilled. The major reason for this situation is an unsuitable mix of projects in the system. The hydro-power capacity has increased from **86%** to **90%** out of the total power capacity from 2001 to 2002, the rest being thermal capacity. Out of the total hydro-power capacity, **83%** is of the run-of-river type (**39%** pure ROR and 44% ROR with pondage). An optimal mix of ROR and storage projects along with a small percentage of thermal plants would be optimal to avoid situations of power deficits in the peak season and surpluses in the low season.

The power system expansion plan is normally decided using a Least Cost Generation Expansion Plan (LCGEP) study. A demand forecast is made for a period of 15 – 20 years based on various macro economic and power system forecasts. Project sequencing and scheduling exercise is then undertaken by finding the least cost way of meeting this demand over the 20 years. A portfolio of candidate projects consisting of run-of-river and storage hydro-power projects and thermal plants is considered. Given the load and hydrological characteristics, a need of a suitable storage project in the system is considered to be suitable. The operation of hydro-power-dominated systems is quite different than a thermal dominated system and hence the power system planning models and tools have to be appropriately selected. Past LCGEP studies have been carried out using tools more suitable for thermal systems that does not recognize fully the operational and other characteristics of hydro-power dominated systems. In the present context of private sector developing new projects, the selection of these projects to be developed has to be in line of the LCGEP studies. The current licensing and awarding procedure of projects does not take care of this. The projects are normally selected in isolation without consideration of its role and position in the power configuration and the power demand pattern. For example, the optimization of the installed capacity of a hydro-power project depends on the system configuration and the load pattern and can not be carried out on an individual project basis as is the practice especially for the projects selected for development by the private sector. A case in point, is the low firm capacity of the two recent privately developed projects leading to reduced peaking capacity (about one third of the installed capacity) in the dry season and surplus energy generation on the monsoon period. This can be an important consideration in the optimization of the installed capacity of the project especially when the power purchase agreements are based on "pay or take" basis.

The other factor needing improvement is the high system losses of about **25 %** of the total power generated in the course of transmission and distribution. The losses include both technical and non-technical losses. About **52%** of the total losses is considered to pilferage which could be drastically reduced with proper legislative and political will to punish the guilty. Several loss reduction programs are in place and should be given high priority. The recent efforts on passing a legislation to punish consumers involved in pilferage is a note worthy effort towards this direction.

Some of the options that could be implemented to improve the power system planning are as follows:

- Selection of an optimal generation mix
- Introduction of storage projects to increase the firm capacity of the system
- Optimization of the installed capacity of the projects based on a "systems concept" rather than on an isolated project optimization basis
- Interconnection with India to take advantage of coordinated operation of hydro-power dominated and thermal dominated systems
- Implementation of demand side management to improve the load factor and also to reduce the high system losses
- Use of appropriate planning tools suitable for hydro dominated systems for investment planning studies

11.1.2 Increasing access to Electrification in Rural Areas

Access to electricity and to commercial energy sources in general in the rural areas is very low (about **5%**) even compared to the national average **(16%)**. Yet a majority of the people **(88%)** resides in the rural areas and most agro-based industries, irrigation and cottage industries are based in these areas. The rural population thus consumes traditional fuels, mainly fuelwood, agricultural wastes and animal dung to meet their energy needs. The environmental degradation through deforestation and the health concerns of the rural people due to the use of these fuels is alarming. There are also strong empirical evidences to show strong linkages between access to electricity and poverty reduction in the rural areas. A major reason for this lack of access of electricity can be said to be because of the difficult terrain and spread of isolated rural villages all across the country but there could still be much done to improve rural access to electricity.

Options for increasing access to electricity to rural areas could be the following:

- Grid based rural electrification

- Mini and small hydro based local grid
- Use of other renewable sources like solar, wind and biogas

The overriding criteria for increasing access of electricity to rural areas have to be its affordability and sustainability. The cost of the supply of rural electricity is obviously high due to low demand and difficult terrain. On the other hand the affordability of such households are very low. Subsidies could be one option but the many distortions they bring and their chances of being mis-used or diverted from the needy can be counter productive. Hence, proper institutional and other mechanisms have to be in place to make it affordable and sustainable in the long run.

11.1.3 Raising the needed Investments for Hydro-power Development

Hydro-power development is very capital intensive. An estimate of investment requirements over the next fifteen years, to meet a GDP growth rate of **6.5%**, is around 4 billion US$ at present price level (WRSF Consortium, 2000). In the past, as much as **80%** of all investment requirements came from multilateral and bilateral donor assistance. Out of the remaining **20%**, NEA covered about **75%** and the rest was covered by government funds. The availability of concessional resources from the donors are now declining, and the scarce public funds are more essential for the social sectors like health, education, sanitation etc. Hence, the investment requirements of the power sector have to come from the private sector.

It has therefore been the policy of HMG/N to attract the private sector to invest in the power sector. Policy and legal provisions have been made with the aim of making hydro-power development and operation procedures standard, timely and transparent. The recent Hydro-power Development Policy (2001) has provided guidelines for the facilitation, assistance and incentives to be provided to the private sector and also ensured a one-window policy of attracting the private sector. The Department of Electricity Development (DOED) (formerly Electricity Development Center), under the Ministry of Water Resources, was established to develop and regulate the hydro-power sector and to attract the private sector.

The problems facing Nepal are due to institutional factors (World Bank, 2001). The overlap in the roles and responsibilities of public sector institutions, and the conflicts of interest and inefficiencies of NEA etc are some of the reasons for the failure of attracting investment in the power sector.

A review of the policy, acts and regulations has to be made given the changing market scenario and the need to attract huge investments in the power sector. The issues of sharing the risks involved in hydro-power development, tariff setting, project licensing and approval procedure and other incentives to be provided should be made timely and transparent.

11.1.4 Institutional Strengthening of Agencies involved in Power Sector

There are currently five main public institutions involved in policy formulation in the hydro-power sector, viz., Ministry of Water Resources (MOWR), Nepal Electricity Authority (NEA), Department of Electricity Development (DOED), Water and Energy Commission Secretariat (WECS) and the Electricity Tariff Fixation Committee (ETFC). There is a need to clearly separate the policy, regulatory and operational functions of these organizations so that there is no overlap in their work.

The institutional strengthening also should be geared towards development of multi purpose projects that can have benefits of cost sharing and optimum utilization of the available water resources potential. The Water Resources Strategy Study (WECS, 2002) has recognized the need to consider 'river basins' as fundamental planning units for integrated water resources planning and management. The trade-off, complementarity and conflicts between water use sectors and regions can be addressed by the river basin approach.

Nepal Electricity Authority (NEA) has been functioning as an integrated public utility. NEA has the mandate to generate, transmit and distribute electricity in the whole country. NEA owns the national transmission system and the load dispatch system. All power produced by the independent power producers (IPPs) connected to the national grid is purchased by NEA and sold to the consumers through NEA's transmission and distribution system. NEA is characterized by weak operational efficiency, insufficient credit worthiness to allow access to private capital markets, and growing conflicts of interest with existing and new IPPs (World Bank, 2001). Hence, power sector unbundling and its privatization particularly of the distribution system may be a viable option for restructuring the power sector. There are various options that have been proposed for possible restructuring and reforming NEA (see World Bank, 2001, WECS, 2002).

11.1.5 Promoting Power Exchange and Export

The huge hydro-power potential of Nepal can be of benefit of both Nepal and neighboring countries. HMG/N's policy has thus been to encourage export of power to neighboring countries particularly India, where there is demand for such power. The success of development of hydro-power for export however depends on the developments in the Indian Market over which Nepal has no control. One major constraint for export of power to India is the financial situation of the State Electricity Boards (SEBs) of north Indian states bordering Nepal. However, recent developments in India such as the creation of Power Trading Corporation (PTC) and the restructuring of the state electricity boards can lead to a favorable condition for the export of hydro-power of Nepal. The cost of hydro-power has to be cheap and competitive for such export to take place. The identification of some projects in the large and medium scale specifically for export is geared towards attracting the private sector to develop these projects for export. A case in point is the West Seti Storage Project (750 MW) with considerable peaking capacity that is being negotiated with concerned Indian authorities by a private developer. There has been news reported that some positive development has been made towards a power purchase agreement of power to be exported to India.

Apart from the direct revenue benefits of export of power to India, the benefits of interconnection of hydro dominated Nepali power system and thermal dominated Indian systems in terms improvement of system reliability, security due to diversity of supply and cost effective generation benefiting the consumers is quite evident. The present exchange agreement of 50 MW between Nepal and India is being upgraded to 150 MW to encourage both export as well as coordinated operational benefits. The concept of "Regional Power Pool" and the "South Asian Transmission Grid" would be in line with this objective.

One issue that will have to be considered is the down stream benefits that would be accrued by the development of storage type of projects in Nepal. The increase on dry season regulated flow and decrease in flood discharge can have substantial benefits to downstream countries.

11.1.6 Reducing Cost of Hydro-power Development

The cost of hydro-power development is high because of the following reasons (WECS, 2002):

- Heavy reliance on bilateral and multilateral financing;
- Extensive employment of international contractors and consultants;
- Fragile unstable geology of hydro-power sites;
- Small economy of scale; and
- Limited manufacturing capability related to hydro-power plant construction.

The bilateral and multilateral financing that are available are mostly attached with some sort of 'tied' conditions which can make the unit rates expensive than the ones based on global competitive basis. As most technology and raw materials are also imported, the costs have been relatively high. In addition, the remoteness of the country and difficult terrain conditions, lack of infrastructure like access roads, fragile geology and hydrological variability, isolated load centers and need for long transmission lines all compound to higher costs. Cost of any infrastructure is also related to risks involved. These risks may be of technical nature like geology, hydrology etc and non-technical like financial risks, market risks, credit worthiness of the utilities and the country, foreign exchange risks etc. The snow-covered mountains of Nepal are the sources of base flow in the rivers, but they also bring risks such as the risk of Glacial Lake Outburst Floods (GLOFs) in some of the rivers. The high sediment laden rivers also require provisions for their sediment control and exclusion from entering the turbines. Measures to address these natural risks add to the cost of the project. Nepal has a lot to be done in terms of reducing the other non-technical risks so that the investors are willing to take up projects in competitive terms. There have been efforts to reduce these risks, which have been rightly included in the new hydro-power policy like the provision of investment risk coverage, pre defined royalty and other tax arrangements, rules for repatriation of equity on foreign investment etc.

11.2 Barriers

The issues discussed in the preceding sections have pointed out to some of the barriers and challenges facing the hydro-power sector in Nepal. These may be enumerated as follows:

- Lack of internal resources to finance the huge investment needs of the power sector
- Lack of proper infrastructure facilities like access roads and transmission network
- Lack of local capability such as trained man power, raw materials and electro-mechanical equipment manufacturing facilities leading to import of all such items
- Conditions of difficult terrain and isolated load centers
- Fragile geological conditions and hydrological variability including sparse hydro-meteorological network and short duration data
- High cost of hydro-power production and transmission leading to high tariff beyond the affordability limits of the majority of the population
- High risks in terms of market risks, currency depreciation, production risks and foreign exchange risks
- Export market beyond the control of Nepal
- Weak institutional capability and over lap of policy, regulatory and operation functions of existing institutions to attract private capital and to promote power trade

- Stringent environmental criteria to be followed while implementing hydro-power projects and the rise of the role of 'environmental activists' in decision making
- Geo-political situation restricting the market for export of electricity to third country or to more financially sound State Electricity Boards within India
- Lack of zeal in regional cooperation in the countries of the region and weak political will to enhance regional cooperation in hydro-power sector
- Tie-up of hydro-power projects with other water resources uses including riparian rights and downstream benefits

- Hydro-power development can plan an important role in the overall economic development of Nepal. The vast hydro-power potential cannot only bring prosperity to the country but can also be a means of regional cooperation for mutual benefits of South Asia. The present and future utilization of hydro-power in the country will only be a small fraction of the total potential. Hence, Nepal can also earn much needed revenue from export of power to India and the region.

- Hydro-power projects are capital intensive and the investment requirement for the expansion of the power sector for domestic demand alone over the next ten years is estimated to be US$ 1.8 billion (World Bank, 2001). With the declining trend of availability of scarce public resources and soft loans and grants from multilateral and bilateral agencies, such financial resources will have to be mobilized through the private sector.

- The new "Hydro-power Development Policy" of Nepal encourages private investment in hydro-power sector. Procedures and arrangements have been made for granting licenses for study, production, transmission and distribution of hydro-electricity. The Department of Electricity Development (DOED) under the Ministry of Water Resources (MOWR) has been given the promotional and study functions for hydro-power development including the task of issuing the licenses under a One Window Policy. Time bounds for processing of applications by DOED, the rates for royalty and other taxes and the rules for repatriation of equity on foreign investments have been explicitly stated in the new policy to promote and assist the private sector.

- Given the huge hydro-power potential in Nepal as well as surplus of capacity and energy in terms of the temporal variations of demand and supply, a regional interconnection of transmission system would not only benefit Nepal but also countries in the region especially India and Bangladesh where there is deficit in supply. In addition, this interconnection will also enhance system reliability, improve security by diversity of supply and lead to a cost effective system operation. A more optimistic vision could also benefit other countries in South Asia through power trading in a "regional power pool".

- The rivers of Nepal have an international dimension and can be a medium of international cooperation for the mutual benefit of the region. The development of storage reservoirs for hydro-power and other uses will have substantial downstream benefits to India and even Bangladesh in terms of both low flow augmentation and flood control. Lack of confidence has been one major barrier towards regional cooperation. The issue of sharing of water and its downstream benefits has hindered the implementation of a hydro-power project in Nepal for export to India and beyond. Identification and development of an "acceptable" project should be made first to build up "confidence and trust" in the region before embarking on more ambitious projects like Karnali (Chisapani) Multipurpose Project or the Koshi High Dam Project.

- Preparation of a regional project inventory for the mutual benefits of the region and a Regional Least Cost Generation Expansion Plan should be prepared to promote the "regional power pool" concept.

S. N	Code No	Project Name	Type	Installed Capacity (MW)	Annual Energy (MU)	Discharge (m^3/s)	Gross Head (m)	Tunnel Length (km)	Cost (m US $)	Base Yr. of Cost Estimate	Trans. Length (km)	Access Road (km)	Level of Study	District	Remarks
Koshi Basin															
1	DD-1	Dudh Koshi No.1	PROR	228.00	978.00	300.00	96.60	2.60	449.00	1983	75	45	Rec	Okhaldhunga	Priority scheme in MP
2	DD-2	Dudh Koshi No.2	ROR	87.00	690.00	50.00	222.50	9.50	166.00	1985	95	60	Rec	Solukhumbu	Road Updated from MP
3	DD-3	Dudh Koshi No.3	ROR	48.00	381.00	45.00	137.20	5.80	129.00	1985	100	68	Rec	Solukhumbu	"
4	DD-4	Dudh Koshi No.4	ROR	46.00	367.00	32.00	182.90	5.80	123.00	1985	105	72	Rec	Solukhumbu	"
5	DD-5	Dudh Koshi No.5	ROR	73.00	580.00	30.00	304.00	7.50	140.00	1985	115	80	Rec	Solukhumbu	"
6	DD-6	Dudh Koshi No.6	ROR	36.00	286.00	36.70	152.40	5.80	119.00	1985	120	87	Rec	Solukhumbu	"
7	DD-7	Dudh Koshi No.7	ROR	89.00	704.00	29.00	380.90	5.30	146.00	1985	125	93	Rec	Solukhumbu	"
8	DD-8	Dudh Koshi No.8	ROR	93.00	740.00	26.00	442.00	3.80	140.00	1985	130	100	Rec	Solukhumbu	"
9	DD-9	Dudh Koshi No.9	ROR	63.00	501.00	26.00	304.80	6.60	141.00	1985	140	105	Rec	Solukhumbu	"
10	DD-10	Dudh Koshi No.10	ROR	49.00	388.00	25.00	243.80	3.90	124.00	1985	145	113	Rec	Solukhumbu	Inside Sagarmatha National Park
11	ID-1	Indrawati 1	ROR	58.00	249.00	110.00	71.50	6.50	161.00	1985	25	6	Rec	Sindhupalchowk	Not Feasible due to Meamchi River water diversion for water sup
12	ID-2	Indrawati 2	ROR	33.00	234.00	23.00	186.00	12.60	74.00	1985	35	13	Rec	Sindhupalchowk	Licensed (Less than 10 MW)
13	ID-3	Indrawati 3	ROR	25.00	172.00	12.00	259.00	7.90	42.00	1985	45	25	Rec	Sindhupalchowk	Licensed (Less than 10 MW)
14	TM-3	Tamur 3	PROR	186.00	812.00	310.00	74.00	5.20	194.00	1983	95	8	Rec	Tapjing/Panchthar	
15	TM-4	Tamur 4	ROR	51.00	356.00	67.00	97.50	6.40	122.00	1985	105	8	Rec	Taplejung	
16	TM-5	Tamur 5	ROR	70.00	489.00	55.00	161.50	6.00	129.00	1985	110	12	Rec	Taplejung	
17	TM-6	Tamur 6	ROR	76.00	535.00	53.00	182.90	7.40	127.00	1985	115	15	Rec	Taplejung	
18	TM-7	Tamur 7	ROR	101.00	705.00	52.00	244.00	6.30	138.00	1983	120	30	Rec	Taplejung	
19	TM-8	Tamur 8	ROR	59.00		22.00	332.00	5.50			125	35	DS	Taplejung	Private Proposal
20	BH-0	Bhote Koshi	ROR	48.00	358.90	23.00	281.00	9.07	85.94	1987	15	1	PFS	Sindhupalchowk	NEA PFS Study (mutually exclusive with LBH-1 & BH-4)
21	BH2-3	Bhote Koshi 2-3	ROR	34.73	253.34	33.02	136.00	3.00	60.25		18	1	PFS	Sindhupalchowk	Same as UBH-1
22	UBH-1	Upper Bhote Koshi1	ROR	36.00	244.00	32.00	135.00	3.50	68.84	1994	18	1	FS	Sindhupalchowk	Licensed
23	BH-4	Bhote Koshi 4	ROR	41.00	320.00	22.70	238.00	7.30			15	1	Rec	Sindhupalchowk	NEA Rec. (Mutually Exclusive to LBH-1 & BH-4
24	BH-5	Bhote Koshi 5	ROR	26.50	212.76	25.20	143.00	6.70			55	1	Rec	Sindhupalchowk	NEA Rec.
25	LBH-1	Lower Bhote Koshi	ROR	80.00	466.00	32.00	300.00	10.30	119.00	1995	65	1	Rec	Sindhupalchowk	NEA Rec.
26	LK-1	Likhu 1	ROR	21.00	145.00	23.00	118.00	7.90	84.00	1985	53	38	Rec	Ramechp/okhal	
27	LK-2	Likhu 2	ROR	17.00	118.00	21.00	107.00	7.60	81.00	1985	66	26	Rec	Ramechp/okhal	
28	LK-3	Likhu 3	ROR	31.00	213.00	19.00	204.20	7.70	88.00	1985	75	23	Rec	Ramechp/okhal	
29	LK-4	Likhu 4	ROR	18.00	134.00	13.00	186.40	4.20	51.50	1994	80	30	Rec	Ramechp/okhal	EDC Rec
30	BL-1	Balephi-1	ROR	15.81	116.99	10.98	206.00	8.30	44.06			10	DS	Sindhupalchowk	BL-1 & BL-2 Mutually Exclusive

Project Inventory (cont'd)

S. N	Code No	Project Name	Type	Installed Capacity (MW)	Annual Energy (MU)	Discharge (m^3/s)	Gross Head (m)	Tunnel Length (km)	Cost (m US $)	Base Yr. of Cost Estimate	Trans. Length (km)	Access Road (km)	Level of Study	District	Remarks
Koshi Basin (cont'd)															
31	BL-2	Balephi-2		10.54	77.97	10.98	138.00	5.70	31.56			10	DS	Sindhupalchowk	BL-1 & BL-2 Mutually Exclusive
32	BL-0	Balephi	ROR	18.00	150.00	12.24	187.00	7.00	106.00	1994	52	15	Rec	Sindhupalchowk	EDC Rec (Mutually Exclusive to BL-1 & BL-2)
33	KB-A	Kable-A	ROR	11.00	88.97	17.00	93.00	4.90		1985	90	5	Rec	Panchthar	NEA Rec
34	KB-1	Kabeli -1	ROR	15.00	109.00	12.00	274.30	10.40	71.00	1985	90	10	Rec	Panchthar	
35	KB-2	Kabeli -2	ROR	15.00	105.00	7.00	366.00	10.00	68.00	1985	95	20	Rec	Taplejung	
36	KB-3	Kabeli -3	ROR	12.00	81.00	4.00	74.00	5.50	56.00	1985	110	25	Rec	Taplejung	
37	SU-4	Sun Koshi-4	ROR	26.00	181.00	53.00	74.00	12.70	117.00	1985	42	10	Rec	Sindhupalchowk	
38	MO-1	Moulun	ROR	13.00	92.00	9.00	185.00	9.30	79.00	1985	78	27	Rec	Okaldhuga	
39	KH-2	Khimti-2	ROR	22.00	154.00	9.00	305.00	3.90	33	1985	100	15	Rec	Dolkha/Ramchp	
40	TA-2	Tama Koshi -2	ROR	196.00	1013.00	150.00	176.00	9.90	245	1983	75	1	Rec	Dolkha	
41	TA-3	Tama Koshi -3	PROR	123.00	603.00	150.00	107.00	7.00	206	1983	78	6	Rec	Dolkha	Licensed
42	TA-4	Tama Koshi -4	ROR	126.00	624.00	140.00	119.00	8.10	263	1983	90	15	Rec	Dolkha	
43	TA-5	Tama Koshi -5	ROR	102.00	615.00	60.00	214.00	7.30	114	1983	95	30	Rec	Dolkha	
44	TA-6	Tama Koshi -6	ROR	113.00	686.00	58.00	244.00	6.30	113	1983	100	36	Rec	Dolkha	
45	RS-1	Roshi Khola	ROR	16.00	97.00	13.00	159.00	8.10	42	1985	50	28	Rec	Dolkha	
46	RS-2	Roshi Khola	ROR	13.00	76.00	11.00	150.00	6.20	43	1985	38	20	Rec	Dolkha	
47	RS-3	Roshi Khola	ROR	12.00	73.00	7.00	229.00	8.40	44	1985	22	10	Rec	Dolkha	
48	RS-4	Roshi Khola	ROR	10.00	61.00	5.00	259.00	6.00	31	1985	17	6	Rec	Kavre	
49	SN-0	Sankhuwa Khola	ROR	13.00	90.00	17.00	100.00	2.80			120	80	Rec	Sankhuwasabha	NEA Rec 1996, May)
50	MW-0	Mewa Khola	ROR	15.00	100.00	12.00	160.00	3.50			120	12	Rec	Taplejung	NEA Rec 1996, May)
51	SB-0	Simbuwa Khola	ROR	37.00		7.00	651.00	4.20			120	40	DS	Taplejung	Private Proposal
52	GH-0	Ghunsa Khola	ROR	11.00		20.00	70.00	5.50			125	45	DS	Taplejung	Private Proposal
53	SBGH-0	Simbua & Ghunsa Khola		143.00		27.00	651.00	9.70			125	45	DS	Taplejung	Private Proposal
54	TD-0	Thulo Dhunga		24.70	200.00	4.85	610.00	5.30			100		PFS	Solukhumbu	Pre Feasibility Study ITECO

Project Inventory (cont'd)

S. N	Code No	Project Name	Type	Installed Capacity (MW)	Annual Energy (MU)	Discharge (m^3/s)	Gross Head (m)	Tunnel Length (km)	Cost (m US $)	Base Yr. of Cost Estimate	Trans. Length (km)	Access Road (km)	Level of Study	District	Remarks
Gandaki Basin															
1	UT-0	Upper Trishuli Syb to Bet	ROR	178.40	1523.00	33.65	772.00	25.30		1977	53	9	Rec	Rasuwa/ Nuwkot	NEA Rec
2	UT-1	Upper Trishuli Syb to Hal	ROR	55.00	481.40	33.65	244.00	8.70		1992	50	6	Rec	Rasuwa	
3	UT-2	Upper Trishuli Haku to G	ROR	65.00	555.00	34.55	274.00	8.20		1992	45	20	Rec	Rasuwa	
4	UT-3	Upper Trisuli Gogne to B	ROR	62.60	534.60	35.90	254.00	10.00		1992	40	13	Rec	Nuwakot	
5	TG-3	Tris-Ganga (Mugling)	ROR	90.00		710.00	185.00	1.00	177	1977	18	1	Rec	Gorkha	24 km Highway submerged
6	LT-0	Lower Trishuli	ROR	15.90	62.20	81.00	27.00	7.00			25	7	Rec	Nuwakot	Canal 7 km
7	UKG-0	Upper Kaligandaki	ROR	68.00	556.70	19.12	518.00	9.60		1992	60	48	Rec	Myagdi/Mustang	
8	UKG-1	Up Kali (Dhump to Kabre	ROR	104.00	856.40	18.51	823.00	9.50			70	60	Rec	Mustang	Inside Acap
9	UKG-2	Kali Ga to Near Butwal		150.00		430.00	198.00	25.20	233	1977		24	Rec	Palpa	Mutually Exclusive with Kali Gandaki 'A' & KG-2
10	UBG-1	Up Bu Gan Lukuwa to Se	ROR	72.67	264.20	28.60	259.00	6.00			77	75	Rec	Gorkha	NEA Rec Gandaki Basin
11	UBG-2	Up bu Gan Lukuwa to Ya	ROR	104.70	899.00	28.60	533.00	11.70			75	75	Rec	Gorkha/Dhading	NEA Rec Gandaki Basin
12	UBG-3	Up Bu Yaru to Namrung	ROR	24.30	209.00	31.08	114.00	9.50			66	68	Rec	Gorkha	NEA Rec Gandaki Basin
13	S-1	Seti River	ROR	15.00			65.00	5.40			30	10	Rec	Tanahun	S-1 and SK-1 are mutually exclusive
14	SK-1	Seti River 1	ROR	11.10	94.30	12.36	131.00	10.80			30	18	Rec	Tanahun	NEA Rec long tunnel option
15	SK-2	Seti River 2		29.00	42.40	24.29	30.00	6.30			30	18	Rec	Tanahun	Dropped (5 MW in NEA Rec short tunnel option)
16	MD-0	Modi Khola		14.00	91.02	25.00	72.50	1.90	30.9		32	1	DD	Parbat	Licenced(Under Construction by NEA)
17	UMO-1	Upper Modi		14.00	83.70	17.00	111.00	3.35	30.27	1994		7	Fes	Kaski	Licensed
18	UM-1	Up Mar Thonju to Randi	ROR	85.00							60	35	Rec	Lamjung	UM-1& UM-2 Multually Exclusive
19	UM-2	Up Mar Thonju to Chhiju	ROR	95.00							60	35	Rec	Lamjung	
20	UMS-1	Upper Marsyandi	ROR	50.00			315.00	5.00			60	40	Rec	Lamjung/Manang	Mutually Exclusive with UM-1 & UM-2(Inside ACAP),NEA Rec
21	UMS-2	Upper Marsyandi	ROR	62.00			310.00	5.00			58	35	Rec	Lamjung/Manang	Mutually Exclusive with UM-1 & UM-2 NEA Rec
22	UMS-3	Upper Marsyandi	ROR	49.00		28.00	210.00	6.00			57	26	Rec	Lamjung	Mutually Exclusive with UM-1 & UM-2 NEA Rec
23	UMS-4	Upper Marsyandi	ROR	45.00		30.00	180.00	6.00			55	17	Rec	Lamjung	NEA Rec
24	UM-0	Upper Marsyandi		43.00	342.00	42.00	131.00	4.80			44	15	Rec	Lamjung	Licensed
25	MM-0	Middle Marsyandi		42.00	254.60	78.00	65.50	3.30	109.4	1994	45		FS	Lamjung	Licensed
26	MS-0	Marsyandi to Seti		0.00							10	3	Rec		Not feasible due to Marsyandi Project
27	MT-0	Marsyandi to Trisuli		36.00							65	75	Rec		Not feasible due to Marsyandi Project
28	SG-0	Sapta Gandaki		225.00	1609.00	617.00	46.00	0.30	354	1982	5	3	FS	Chitwan	Detail Feasibility Study (JICA)
29	RH-0	Rahughar Khola	ROR	18.00	133.00	10.00	235.00	6.50			60	25	Rec	Myagdi	NEA Rec (1996,May)
30	MA-0	Madi Khola	ROR	16.00	112.00	12.00	170.00	3.50			18	20	Rec	Kaski	NEA Rec (1996,May)
31	JM-0	Jhumsa Khola		15.00		3.50	520.00	3.50			15	20	DS	Rupandehi	Private Proposal(not feasible due to small catchment)
32	CL-0	Chilime River		20.00	137.00	7.50	351.00	3.40	27.5	1996	38	5	DD	Rasuwa	Licensed
33	KL-3	Kulekhani-III		14.00	40.82	15.00	114.30	4.40	24.84	1996	1	1	FS	Makanpur	Licensed
34	KG-2	Kali Gandaki-2	STO	576.00	3240.00		135.00						PFS	Tanahun	

Project Inventory (cont'd)

S. N	Code No	Project Name	Type	Installed Capacity (MW)	Annual Energy (MU)	Discharge (m^3/s)	Gross Head (m)	Tunnel Length (km)	Cost (m US $)	Base Yr. of Cost Estimate	Trans. Length (km)	Access Road (km)	Level of Study	District	Remarks
Karnali & Mahakali Basin															
1	BR-1	Bheri River, Bheri-Babai	PROP	82.90	595.00	58.20	180.00	9.00	184.4	1993	42	15	Rec	Surkhet	No.1 in JICA MP-1993, EDC
2	BR-6	Bheri River,	ROR	49.10	329.00	22.70	273.00	7.20	154	1993	150	120	DS	Dolpa	
3	BR-7	Bheri River,	ROR	29.20	196.00	5.10	730.00	6.60	138.5	1993	160	120	DS	Dolpa	
4	BR-8	Bheri River,	ROR	30.00	201.00	12.40	305.00	4.40	190	1993	145	120	DS	Dolpa	
5	SR-3	Seti River	PROP	75.20	497.00	39.60	240.00	8.60	166	1993	120	65	Rec	Bajhahg	Priority Scheme in JICA MP
6	SR-7	Seti River	ROR	52.40	347.00	14.70	451.00	6.80	152.6	1993	150	80	DS	Bajhahg	
7	MKR-1	Mugu Karnali	ROR	90.50	634.00	52.90	216.00	5.20	282.8	1993	188	155	DS	Mugu	
8	MKR-2	Mugu Karnali	ROR	55.60	390.00	46.80	150.00	4.30	272	1993	190	160	DS	Mugu	
9	MKR-3	Mugu Karnali	ROR	124.00	872.00	27.10	580.00	6.80	331	1993	210	200	DS	Mugu	
10	KR-2	Karnali River	PROP	275.00	2107.00	120.70	288.00	2.90	666	1993	90	70	DS	Kalikot	
11	KR-3	Karnali River, Lakharpata	ROR	289.00	2215.00	196.60	186.00	6.20	515	1993	20	15	DS	Surkhet	Mutually Exclusive to KRIA
12	KR-4	Karnali River	PROP	87.50	613.00	134.90	82.00	3.70	332.5	1993	150	150	DS	Humla/Mugu	
13	KR-7	Karnali River	PROP	243.00	1703.00	295.20	103.00	0.60	325	1993	40	35	DS	Achham	
14	KR-1A	Upper Karnali	ROR	240.00	1665.00	195.20	141.00	2.30	365	1989	95	20	PFS	Dailekh/Achham	
15	HKR-1	Humla Karnali	ROR	178.60	1251.00	69.90	323.00	11.40	412	1993	220	170	DS	Humla	
16	HKR-2	Humla Karnali	ROR	77.70	545.00	65.50	150.00	4.30	354.6	1993	230	185	DS	Humla	
17	HKR-3	Humla Karnali	ROR	71.60	502.00	51.40	176.00	4.60	360.6	1993	235	205	DS	Humla	
18	HKR-4	Humla Karnali	ROR	111.00	778.00	47.40	296.00	6.40	416	1993	235	210	DS	Humla	
19	TR-1	Tila River	ROR	182.00	1276.00	57.80	398.00	7.80	340	1993	85	52	DS	Kalikot	
20	TR-2	Tila River	ROR	185.30	1299.00	46.80	500.00	6.60	314.8	1993	100	75	DS	Kalikot	
21	TR-3	Tila River	ROR	104.00	734.00	52.70	251.00	3.60	290	1993	80	70	DS	Kalikot	
22	TR-4	Tila River	ROR	10.50	73.00	7.20	185.00	5.80	64.6	1993	150	140	DS	Jumla	
23	BG-0	Budha Ganga	ROR	12.90	86.00	18.20	90.00	4.50	98.8	1993	120	35	DS	Bajura	
24	BG-1	Budha Ganga-1	ROR	33.45	216.00	32.10	135.00	9.00			75	28	Rec	Achham	NEA Rec (Mutually Exclusive to BG-2)
25	BG-2	Budha Ganga-2	ROR	14.90	97.80	33.10	60.00	3.50			75	28	Rec	Achham	NEA Rec
26	BG-3	Budha Ganga-3		12.40	97.10	8.30	224.00	8.30	39.34		75	30	DS	Bajura	
27	BG-4	Budha Ganga-4	ROR	35.00	183.00	30.00	110.00	6.50			75	30	Rec	Achham	NEA Rec(1996,May)
28	SA-0	Sani Bheri	ROR	18.20	119.90	11.34	183.00	6.00			105	75	DS	Rukum	Desk study (NEA)
29	P-1	Poliparni		41.00	358.00	19.66	273.00	6.50	72	1993		90	DS	kalikot	To be Replaced by TR-1
30	R-1	Rammi		19.00	166.00	17.12	153.00	6.50	54			90	DS	kalikot	To be Replaced by TR-2
31	J-1	Jubithan		16.00	144.00	16.40	153.00	12.00	69			96	DS	kalikot	To be Replaced by TR-3
32	CR-0	Chameliya River		20.10	134.00	21.70	117.00	4.30	68	1993		10	DS	Darchula	Same as CR-2 (License)
33	CR-2	Chameliya River		30.00	162.00	36.60	104.00	4.20	62.4	1995	127	20	FS	Darchula	Licensed (Feasibility Study by SAARC Fund)

Project Inventory (cont'd)

S. N	Code No	Project Name	Type	Installed Capacity (MW)	Annual Energy (MU)	Discharge (m^3/s)	Gross Head (m)	Tunnel Length (km)	Cost (m US $)	Base Yr. of Cost Estimate	Trans. Length (km)	Access Road (km)	Level of Study	District	Remarks
Other Storage Projects															
1	ST/AK-1	Andhi Khola-1	STO	156.00	676.00	29.00	410.00	3.20	390	1995	50	10	Rec	Syangia	Field Study by NEA
2	ST/AK-0	Up Gang to Barigad	STO	270.00		16.00	1315.00	12.60	355	1977	95	60	Rec		Inside Dhorpatan Humting Reserve Area
3	ST/LT-0	Langtang Khola	STO	175.00		9.00	1585.00	12.15	325	1977	60	15	Rec	Rasuwa	Inside Langtang National Park
4	ST/S-2	Seti River-2	STO	160.00		200.00	63.00	0.56	157	1977	10	8	Rec	Tanahun	Inside Regulated flow from Seti No.1 storage scheme(320MW)
5	ST/LR-1	Lohore Khola	STO	58.00	236.00	72.00	115.00	3.80	118	1993	75	5	Rec	Dailekh	
6	ST/S	Sarada Stroage	STO	49.00	222.20	12.80	258.30		39		40	32	Rec	Salyan	Field Study by EDC
7	ST/US	Upper Sharada	STO	35.00		15.00	180.00	3.20				4	DS	Salyan	Multipropose Project(Desk Study by planning commission)
8	ST/MS	Middle Sharada	STO	10.00		20.00	100.00	9.20				4	DS	Salyan	Multipropose Project(Desk Study by planning commission)
9	ST/ML	Mai-Loop	STO	13.00	57.00	7.80	185.00	0.30	20.2		35	15	Rec	Ilam	Study underway by NEA, Seme as MKL-1
10	ST/ML-1	Mai-Loop	STO	45.00	238.00	51.00	109.00	0.00					Rec	Ilam	NEA Rec(1996, May),ML-1 & ML-2 Mutually Exclusive
11	ST/ML-2	Mai-Loop	STO	72.00	364.00	82.00	109.00	0.00					Rec	Ilam	NEA Rec(1996, May),ML-1 & ML-2 Mutually Exclusive
12	ST/MD-1	Madi Diversion	STO	50.00		60.00	105.00	5.90			10	0	DS	Pyuthan	Multipropose Project(Desk Study by planning commission)
13	ST/NM(LB)	Naumure Multi P/Project(Left Bank)	STO	306.00	979.00	114.00	317.00	0.12			50	3	PFS	Arkhi/Pyuthan	Multipropose Project
14	ST/NM(RB	Naumure Multi P/Project(Right Bank)	STO	160.00	431.00	104.00	181.00	0.62			50	3	PFS	Arkhi/Pyuthan	Multipropose Project
15	SD-0	Sunkoshi Diversion to Kamala River	STO	61.40	511.00	72.00	102.00	16.60	228.2	1985			DS	Udaypur	Multipurpose Project(SD-0 & ST/KD interrlated to each other)
16	ST/KD-0	Kamla Dam Project	STO	32.00	121.00	120.00	32.00	0.00	90	1985			DS	Udaypur	Multipurpose Project(SD-0 & ST/KD interrlated to each other)
17	ST/KN	Kankai Multipurpose Project	STO	60.00		121.00	59.00	0.43	158	1978	15	3	FS	Jhapa. Ilam	Multipurpose Project
18	ST/BGT	Bagmati Multipurpose Project	STO	140.00				0.30	366	1986	62	1	FS	Sarlahi/Rautahat	Multipurpose Project
19	BG	Budhi Gandaki	STO	600.00	2495.00	430.00	185n	0.28	774	1983	65	2	PFS	Dhading-Gorkha	

Source: CIWEC (1996), NEA and NHA Database (2001)

Abbreviations

DS - Desk Study Only

Rec - Reconnaissance carried out either during Master Plan Study on Priority schemes or subsequently by NEA- title or no field investigation.

PFS - Prefeasibility study - Field investigation usually limited to Test pits, Seismic survey and Topographical mapping. Although in some cases Drilling carried out.

FS - Feasibility study- Comprehensive field investigation carried out including Topo mapping Seismic surveys and Drilling at all major structures

DD - Detail Design, MP- Master Plan, JICA- Japan International Cooperation Agency.

Note:

1. Annual Energy, Installed capacity, Tunnel Length, Cost, Head and Discharge are Extracted from available reports.
2. Access Road length is calculated by increaseing the aerial distance by 50% from nearest Road Head.
3. Transmission Line Length is calcilated the aerial distance by 20% from the nearest 132 kv Sustation.

Regional Map

Power Development Map of Nepal