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SOUTH ASIA REGIONAL INITIATIVE FOR ENERGY INTEGRATION (SARI/EI)

Working Paper:

Impact of Cross-Border Electricity Trade on Bhutan (Country Series)

September, 2016

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List of Abbreviations

ABT	Availability Based Tariff
ARIMA	Autoregressive Integrated Moving Average
BEA	Bhutan Electricity Authority
BHP	Basochhu Hydro Power Plant
BPC	Bhutan Power Corporation Limited
BTN	Bhutanese Ngultrum
CAGR	Compound Annual Growth Rate
CBET	Cross-Border Electricity Trade
CDM	Clean Development Mechanism
CEA	Central Electricity Authority of India
CERC	Central Electricity Regulatory Commission
CHP	Chhukha Hydro Power Plant
DGPC	Druk Green Power Corporation Limited
DHI	Druk Holdings and Investments
DHMS	Department of Hydro-Met Services
DHPC	Dagachhu Hydro Power Corporation
DHPS	Department of Hydropower & Power Systems
DOT	Department of Trade
DPR	Detailed Project Report
DRE	Department of Renewable Energy
ERLDC	Eastern Region Load Dispatch Centre, India
FYP	Five Year Plan
GDP	Gross Domestic Product
GNI	Gross National Income
GoI	Government of India
GW	Gigawatt
HDI	Human Development Index
IRADe	Integrated Research and Action for Development
JV	Joint Venture
KHP	Kurichhu Hydro Power Plant
MHPA	Mangdechhu Hydroelectric Project Authority
MU	Million Units
NLDC	National Load Dispatch Centre, India

NTGMP	National Transmission Grid Master Plan
OA	Open Access
PCEC	Per Capita Electricity Consumption
PHPA-I	Punatsangchhu-I Hydroelectric Project Authority
PHPA-II	Punatsangchhu-II Hydroelectric Project Authority
PLF	Plant Load Factor
POC	Point of Connection
PPP	Public-Private Partnership
RE	Renewable Energy
RGoB	Royal Government of Bhutan
RoR	Run of River
SARI/EI	South Asian Regional Initiative for Energy Integration
STOA	Short Term Open Access
THP	Tala Hydro Power Plant
THPA	Tala Hydroelectric Project Authority
TPCL	Tata Power Company Limited
TPTCL	Tata Power Trading Corporation Limited
USAID	United States Agency for International Development

Acknowledgments

The preparation of this Working Paper on “Impact of Cross-Border Electricity Trade on Bhutan” for the SARI/Energy Integration Program would not have been possible without the valuable contribution of the multiple stakeholders.

We would like to express our sincere thanks to Mr. Colin Dreizin, Director, Clean Energy and Environment Office, USAID/India and Ms. Monali Zeya Hazra, Regional Energy Manager and Clean Energy Specialist, USAID/India for their valuable inputs and suggestions not to mention their wholehearted support for this activity. We would also like to thank Mr. Padu S. Padmanaban, Strategic Energy, Water and Environment Expert for his contribution to this concept.

Our sincere thanks are to Dr. Jyoti Parikh, Chairman IRADe without whose valuable guidance this report would never have seen the light of day. We hope this document will clarify the various issues pertaining to the commercial aspects of Cross-Border Power Trade and will be a milestone in the path of promoting a South Asian Power Market.

We would like to thank Dr. Pradeep Dadhich who in his initial capacity as Project Director for Analytical Studies conceptualized and initiated the same. We would also like to thank Mr. V.K. Kharbanda, Project Director for smooth functioning and providing the initial thrust to this paper. Last but not the least, we would like to express our sincere thanks to the Bhutan Task Force members, Mr. Karma P. Dorji, Mr. Karma Tshewang, Mr. Karma Tshering, Ms. Tshering Yangki and prominent dignitaries from Department of Hydropower & Power Systems, Ministry of Economic Affairs, Bhutan for their inputs and suggestions.

Preface:

We are happy to present this Working paper "Impact of Cross Border Electricity Trade (CBET) on Bhutan" carried out under the South Asian Regional Initiative for Energy Integration (SARI/EI) project of USAID. It was felt that success story of Bhutan-India trade can help to bring wider consensus among power sector experts, economists, financers and policy makers. CBET has transformed Bhutan economy and reach at another level altogether in less than two decade. During preparation of the working paper had discussions with various government institutions such as Bhutan Power Corporation (BPC), Druk Green Power Corporation (DGPC) and electricity planners.

In this paper, an analysis was done of the demand and supply of electricity for future upto 2050 with basic excel based modelling tool. Based on the plans, an estimate was made of the surplus power available for export in the future. Simple analysis through ARIMA technique indicated that Bhutan has the potential to export 52 BU and 89 BU in the years 2030 and 2050 respectively.

From the analysis undertaken in this paper, it was evident that sales of power through CBET would have a huge impact on the overall economy of Bhutan. However, for the development of CBET and successful implementation of the hydro projects, various aspects to mitigate financial risks especially to encourage private sector participation, need to be addressed at the earliest. For examples, issues such as open access, under injection/over draw, power scheduling and dispatch, developer's risk and financing requirements among others have to be taken up between the two governments to bring about policy harmonization to facilitate the smooth transfer of bulk power in the range of several GW across the border.

The project goal is to advance regional energy integration, thus increasing CBET in the region. It has three key task forces working towards to achieve the overall objective. Task Force (TF) -1 deals with issues related to the policy, legal, and regulatory aspects of Cross Border Electricity Trade. The TF-2 identifies import-export points for technically and economically feasible cross-border interconnections over the next 20 to 30 years. TF-3 focuses on establishment of South Asian Regional Electricity market including a Regional Power Exchange. The TF-3 activities explore market-driven, commercial practices in the trading of power, including long-term contractual instruments and medium/short-term trading exchanges. It covers matters relating to guarantee mechanisms, tariffs, wheeling changes, attribution of transmission losses, transmission pricing and other commercial issues etc.

To enlarge engagement beyond power sector experts, IRADe has also initiated a macro-economic study of electricity trade with the primary purpose to build consensus for cross border electricity trade by quantifying the benefits of cross border electricity trade. IRADe has already completed India- Nepal macroeconomic modelling exercise and India- Bangladesh is already underway. We intend to complete the Bangladesh–India exercise and link it to the Nepal–India exercise. This may transform the economies of the two countries and make a case for regional integration among BBIN (Bangladesh, Bhutan, India and Nepal). The link can be extended to the Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation (BIMSTEC) involving countries along the Bay of Bengal.

We are grateful to the USAID for supporting this working paper series. I am grateful to our Bhutan and USAID colleagues who assisted our work. I thank the IRADe team that worked diligently, enthusiastically and relentlessly worked and completed the same.

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Executive Summary

South Asia is a region of developing economies. A large section of population in the region lives below the poverty line. Governments of the South Asian region have adopted multi-pronged strategies to uplift the economic conditions of the common people. In this context, the governments have realized that energy is one of the key factors for the socio-economic development of the region. The South Asian nations lag far behind their developed counterparts in terms of access to clean, reliable and affordable energy especially electricity. The South Asian region's energy endowment is limited and dispersed across the region, with large unexploited hydro-electric potential in some parts and increasing dependence on fossil fuel in other parts. Bhutan is one such nation in the South Asian region which has large untapped hydro-electric potential.

Bhutan is endowed with technoeconomic hydropotential of 24 GW, however only approximately six per cent of it has been tapped so far. The five hydropower plants (Chukha, Kurichhu, Tala and Basochhu-I & II and Dagachhu) account for 99 per cent of the current total installed power generation capacity in Bhutan. After the commissioning of Chukha Hydroelectric Power Plant in 1986, Bhutan started exporting power to India.

Presently, Bhutan is exporting power to India through Cross-Border Electricity Trading (CBET) interconnections. The electrical interconnections between India and Bhutan with its diverse generation mix and unique demand characteristics are bringing economic and environmental benefits to the respective countries as well as to the region as a whole. Bhutan's power generation is primarily based on hydropower, which is cyclic in nature due to the monsoon variation. Further, Bhutan also imports power from India during the lean/dry season of hydro base generation thus reducing its power deficit. The quantum of power exported by Bhutan to India is very high as compared to its power import during the lean season. Power export provides a large and stable source of revenue for Bhutan and also helps in mitigating GHG emissions in India as it replaces fossil based power with hydro power.

Bhutan's revenue from power exports to India contributes a significant share to the total GDP. In the past, a huge surge in GDP was observed with the commissioning of the export oriented Tala Hydroelectric Power Plant supplying power to India. The Royal Government of Bhutan (RGoB) in consultation with the Central Electricity Authority (CEA) has prepared the National Transmission Grid Master Plan (NTGMP) under which the RGoB plans to establish total hydro capacity of 11,814 MW and 26,534 MW by 2020 and 2030 respectively. This huge planned capacity addition of hydropower under the NTGMP, has immense potential to increase revenues from power export.

The establishing of CBET oriented projects would also help in the development of other sectors such as construction, transportation, manufacturing etc. Over the last decade, the power sector has been one of the key sectors that helped Bhutan in sustaining GDP growth rates of around eight per cent.

In this paper, which is the first among the series for Bhutan, an analysis was done of the demand and supply of electricity up to 2050. Based on the plans, an estimate was made of the surplus power available for export in the future. The analysis indicated that Bhutan has the potential to export 80 BU and 116 BU in the years 2030 and 2050 respectively. Further, as per initial analysis, the per capita earnings from electricity export is expected to increase to BTN 3,84,062 in 2035 from BTN 13,276 in 2012. In subsequent papers the impact of power exports on Bhutan's economy will be studied and the results will be presented.

From the analysis undertaken in this paper, it was evident that sales of power through CBET would have a huge impact on the overall economy of Bhutan. However, for the development of CBET and successful implementation of the hydro projects, various aspects to mitigate financial risks especially to encourage private sector participation, need to be addressed at the earliest. Issues such as open access, under injection/over draw, power scheduling and dispatch, developer's risk and financing requirements among others have to be taken up between the two governments to bring about policy harmonization to facilitate the smooth transfer of bulk power in the range of several GW across the border. A key point that emerged from the assessment undertaken in this paper was that **Bhutan should avoid delays to maximize the benefits from the planned hydro projects**.

1 Introduction

The Kingdom of Bhutan is a small landlocked country located to the eastern side of the Himalayas at 27º28.0'N and 89º38.5'E in South Asia. Flanked by giant neighbors – China to the north and north-west and India to the south, south-west and east – Bhutan is a small country in terms of its population as well as geographical size. Bhutan shares a 470 kilometers long border with Tibet (China's Xizang Autonomous Region) in the north and north-west, 605 kilometers with the Indian state of Sikkim in the west, West Bengal in the southwest, Assam in the south and southeast, and Arunachal Pradesh in the east. Most of the population lives in the central highlands, and almost two-thirds are classified as rural inhabitants. The terrain is mostly mountainous, with alpine peaks in the north and some sub-tropical foothills in the south.

The Bhutanese community is predominantly agrarian with 69 per cent[1] of the country's population living in the rural areas. However, more people have been moving into urban areas. Between 1985 and 2005, Bhutan's urban population grew from 13.1 per cent to 30.9 per cent of the country's population.

Table 1.1 shows key socio-economic indicators of Bhutan for the year 2012.

Table 1.1: Bhutan's key socio-economic indicators for year 2012

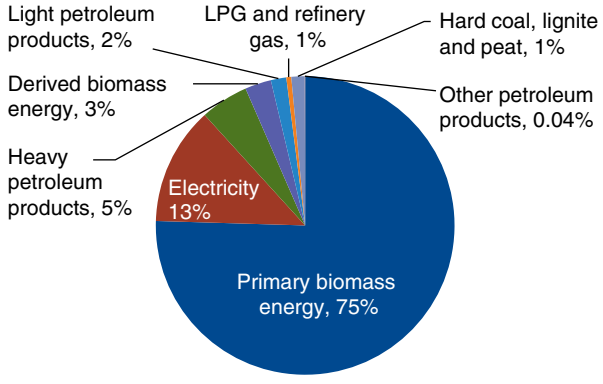
Key Indicators	
Geographical area (in square kilometer)	38,394
Population (as on 1 July 2012) projected population (as of 2015)_Statistical year book of Bhutan 2015, NSB	7,57,042
Urban population (% of total population)	34%
Population density (person per square kilometer)	19.7 (NSB 2015)
GDP by industrial origin at current market prices (in million BTN)	99,455
GDP growth rate at constant price of year 2000 (between 2003-2012)	8.2%
GDP- Structure of output (in %)	
Agriculture Industry Services	18.1% 41.9% 40%
Per capita GDP (at current market prices in BTN)	1,38,002
Per capita GNI (at current market prices in BTN)	1,31,243
Per capita GDP (at constant price of year 2000 in BTN)	71,592
Per capita electricity consumption (in kWh)	2,572

Source: ADB; World Bank

[1] Population and Housing Census of Bhutan, 2005

Bhutan's total energy requirement in the year 2010 was 58,639 Terajoules[2] and biomass alone provided about 75 per cent of the total energy requirement. Figure 1.1 highlights the share of various energy sources in Bhutan's total energy requirement. The key reason for the high share of biomass is its easy availability as about 70 per cent[3] of Bhutan's land is covered by forest and a majority of the population lives in rural areas. All the primary and derived biomass energy is consumed by the household and other consumers segment.

Figure 1.1: Total energy requirement in year 2010 (in percentage)

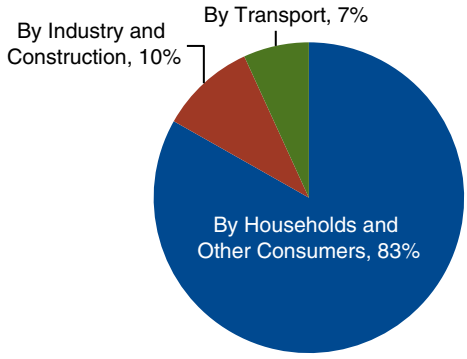


Total Energy Requirement = 58,639 Terajoules

Source: Energy Balances and Electricity Profiles 2010, United Nations Statistics Division

The household and other consumer segment is the largest energy consumer in Bhutan which is also highlighted in Figure 1.2. The major source for energy in the household and other segment is the primary and derived biomass energy that itself accounts for 97 per cent in the total household and other segment, followed by electricity that accounts for around two percent and rest by other sources of energy.

Figure 1.2: Sector-wise final energy consumption in year 2010 (in percentage)



Total Energy Consumption = 56,258 Terajoules

Source: Energy Balances and Electricity Profiles 2010, United Nations Statistics Division

Electricity is the second most widely used energy source in Bhutan, whose share is expected to increase in the future with the development of its huge untapped hydroelectric potential. Bhutan is endowed with a techno-economic hydroelectric potential of 24 GW and presently only six to seven per cent of it is being tapped. Electricity today has become the most favorable element for the nation's economic growth and hydropower in particular as it contributes about 45 per cent of the national revenue and constitutes about 17.3 per cent (NSB 2015) of the country's GDP. Over the years, there has been a significant increase in the share of electricity exports and consumption by the industry and construction sectors.[4]

Bhutan is the only country in the South Asian region, which has a large amount of surplus power and the highest per capita electricity consumption of 2,572 kWh[5] in 2012. Power exports contribute a significant share (10-20% in the last 10 years) in GDP and (30-50% in the last 5 years) to export earnings.

Table 1.2: Bhutan's power generation, import, export and internal demand trend

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014
Net Production (in MU)	3,337	6,401	7,135	6,898	7,305	7,046	6,811	7,531	7,147
Imports	34	11	7	17	20	20	56	108	187
Exports	2,027	4,533	5,922	5,405	5,579	5,273	4,896	5,558	5,044
Energy Requirement (in MU)	738	973	1152	1442	1655	1714	1,854	1,924	2,085

[2] Energy Balances and Electricity Profiles 2010, United Nations Statistics Division
[3] Statistical Year Book of Bhutan 2013
[4] Energy Balances and Electricity Profiles 2010, United Nations Statistics Division
[5] World Bank Data Source, 2013

Objective and Scope of the Study

The objective of the study is to assess the impact of CBET on Bhutan's economy. The key results of the study will help to establish whether CBET is creating a positive or negative impact on the economy. This paper provides a brief coverage on the historical evolution of the power sector, electricity demand-supply situation, export and import of electricity, seasonal variation in power generation, revenue generation from electricity trade, the investment required and impact on the economy.

Under this study, only Bhutan's economic gain is examined, however environmental benefits, energy security and the cost of under supply of electricity to the Indian economy has not been calculated. The true picture of benefits would be assessed only after considering all these dimensions, which would be discussed in the forthcoming working papers.

2 Bhutan's Power Sector

Overview

Bhutan has abundant hydro resources and it possesses techno economic viable hydropower potential of 23,700 MW. Its current installed power generation capacity is 1,614 MW which is only six per cent of its techno economic feasible hydropower potential. Table 2.1 highlights the present hydropower generating stations and their transmission interconnection voltage. Out of these five hydropower generating stations, Basochhu-I and Basochhu-II are generating power to meet Bhutan's domestic demand and the rest (Chukha, Kurichhu, Tala and Dagachhu) are exporting power to India after meeting the domestic demand.

Table 2.1: Existing hydroelectric generating stations

Name of Plant	Installed Capacity (Unit * Unit Size) MW	Transmission Voltage (KV)
Chhukha (CHP)	(4*84) 336	220 KV, 66KV
Basochhu-I (BHP)	(2*12) 24	66 KV
Basochhu-II (BHP)	(2*20) 40	220 KV, 66KV
Kurichhu (KHP)	(4*15) 60	132 KV
Tala (THP)	(6*170) 1020	400 KV
Dagachhu	(2*63) 126	220 KV
Mini/Micro	8 (17 no)	6.6 KV/415 V
Total	**1614**	

The current transmission line length is more than 1,000 kilometers, and their line voltages and lengths are mentioned in Table 2.2.

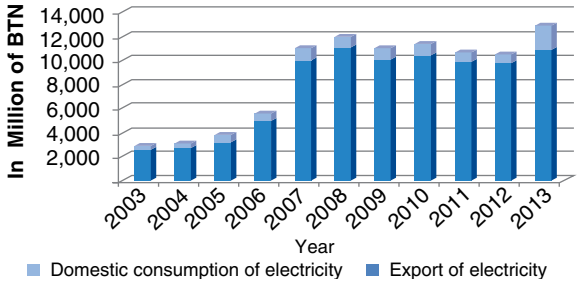
Table 2.2: Existing power transmission lines in Bhutan

Line Voltage	Line Length (Ckt Km)
400 KV	74.14
220 KV	326.62
132 KV	344.54
66 KV	352.32
Total	**1097.62**

Source: Power data book 2014

In 2014 Bhutan exported 5,044.33 MU to India and also imported 187.37 MU of electricity from India during the same year primarily to meet its power demand during the dry season. Electricity export is further expected to increase as per Bhutan's power expansion plan. Figure 2.1 clearly depicts that the revenue generated from the export of electricity is much higher than the domestic sales revenue.

Figure 2.1: Hydropower plant electricity sale (2003-2013 in millions of BTN)*



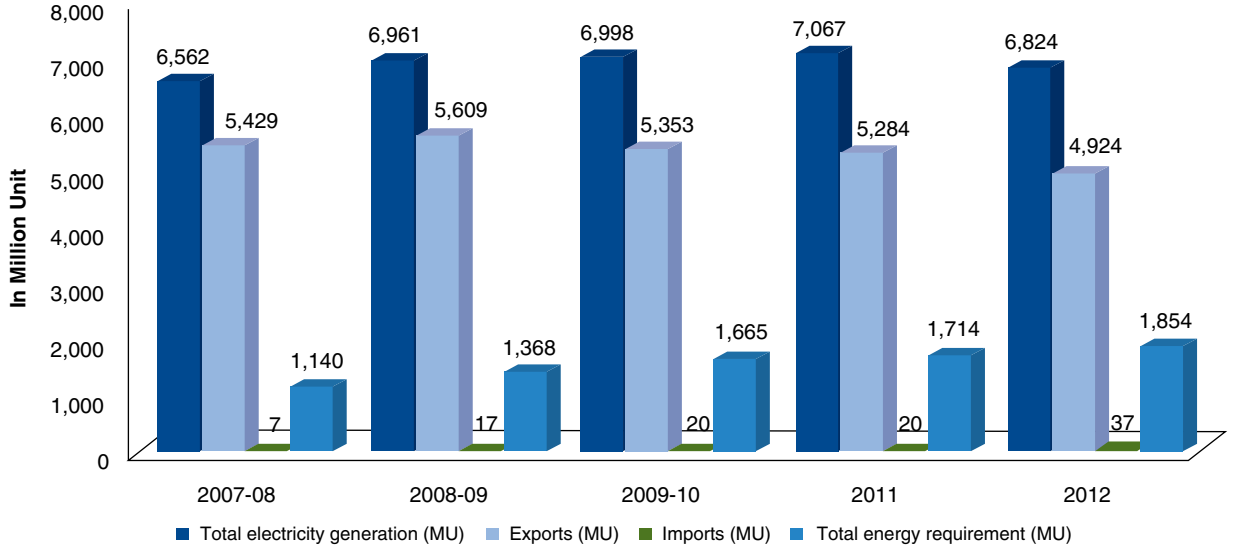
Source: Bhutan Statistical Year Book 2012-13

*(1) *Power tariff for export to India: BTN 2.25 per unit for CHP (revised from BTN 2 per unit from Jan. 2014); BTN 1.98 per unit for KHP (revised from BTN 1.75 per unit from Jan. 2008) & BTN 1.98 per unit for THP.*

(2) *Power tariff for domestic sales: BTN 0.13 per unit for royalty energy (15% of total to government; revised from BTN 0.3 per unit from August 2010) and BTN 1.20 for the rest (industrial use mainly from KHP). BHP sales are to CHP at BTN 1.2 per unit. Domestic sales are exclusive of demand charges.*

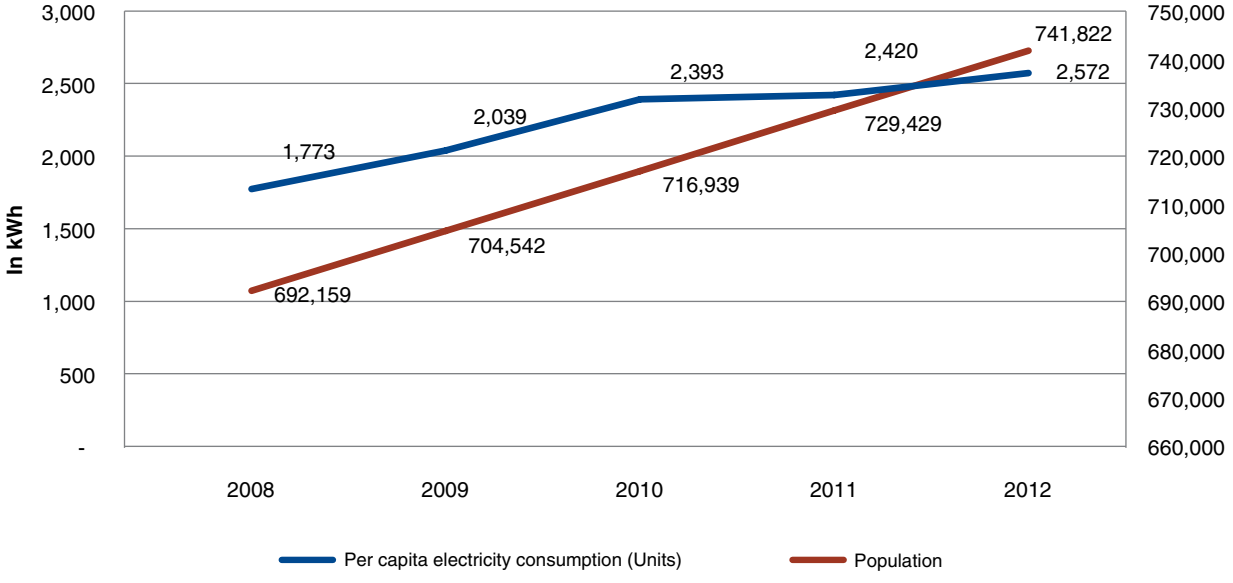
(3) *Export sales reflected here are net of any payments for the import of power from India in each month.*

Figure 2.2: Total electricity generation, export, import and total electricity requirement of Bhutan from 2008-2012



Source: Statistical Yearbook of Bhutan, 2013

Figure 2.3: Per capita electricity consumption and population trend (from 2008-2012)



Source: World Bank Data Source, 2013

Bhutan's power imports are gradually increasing as shown in Figure 2.2 due to an increase in the per capita electricity consumption (from 1,773 MU in 2008 to 2,572 MU in 2012) and population increment (shown in Figure 2.3), while there was no change in the installed power capacity from 2007 until the 126 MW Dagachhu HEP was commissioned in 2015. The import pattern needs to be studied with the inclusion of the energy generated from Dagachhu.

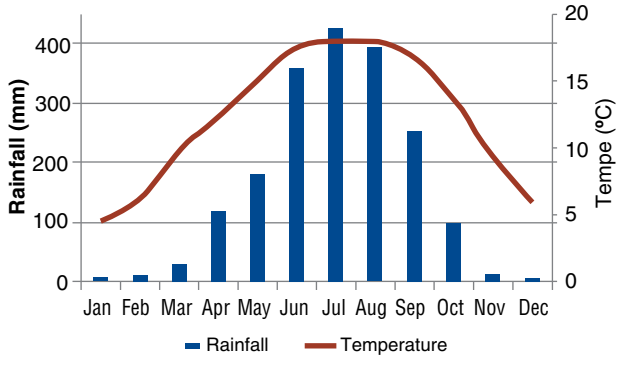
Cyclic Variation in Bhutan's Power Generation

Bhutan's power generation is majorly dependent on the Run of River (RoR) type hydropower plants. The monthly variation in Bhutan's **rainfall has a direct impact on its power generation due to the change in water flow**. Bhutan imports power from India during the dry season (November to March: due to low rainfall resulting in less hydro power generation), however the amount of power imported is much lower than the power exported (refer Figure 2.2 and Figure 2.4).

Figure 2.4 **shows the average monthly rainfall and temperature pattern for the year** 1999-2000 and the monthly power generation variation and domestic electricity sale are depicted in the figures below. Figure 2.5 gives an indication of the monthly variation in power generation and Figure

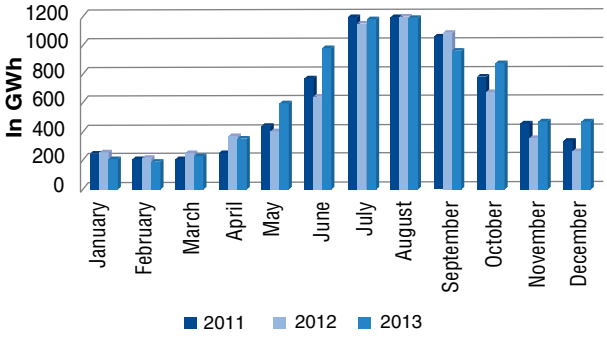
2.6 indicates the monthly variation of exported power. The rainfall in the 1st and 4th quarters of every year is very low; therefore there is a corresponding decrease in power generation from hydropower plants resulting in lower revenues from very low power exports. During the same period, power generation is predominantly used for meeting domestic demand and additionally, power is also imported to meet domestic demand. However during the 2nd and 3rd quarters, there is surplus power available which is exported to India.

Figure 2.4: Average monthly rainfall and temperature, 1999-2009



Source: The Hydro-Electrical Power Sector in Bhutan: An Economic Assessment, 2013

Figure 2.5: Monthly electricity generation variation in last three years (GWh)



Source: Druk Green Power Corporation annual reports

Figure 2.6: Monthly variation in power exports from major hydropower plants

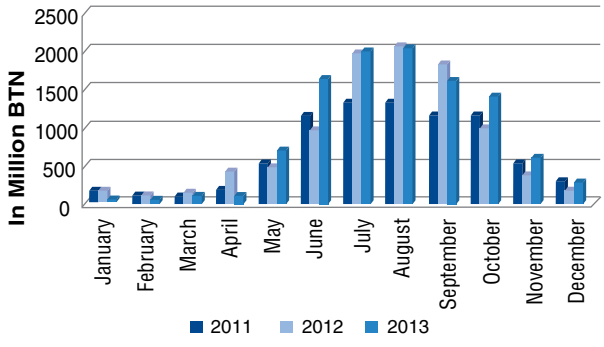
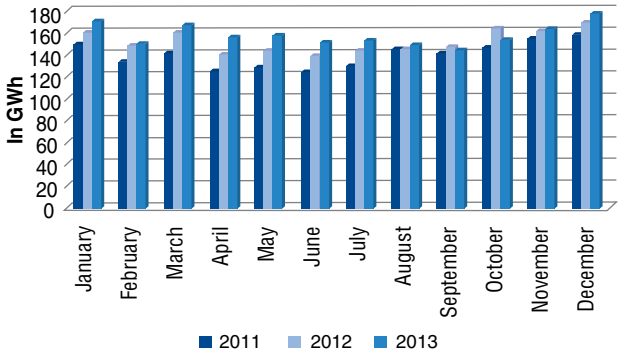


Figure 2.7: Monthly electricity domestic supply variation in last three years (GWh)

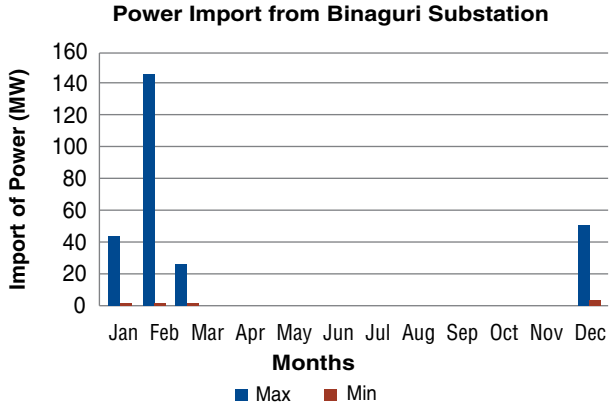


Source: Druk Green Power Corporation annual report

Power Import: Monthly Maximum and Minimum Power Import

Bhutan's power imports (maximum and minimum) from substations in India (Binaguri, Birapara, Salakoti and Rangia) in 2013 are given below.

Power import from substations is also cyclic due to the mismatch in demand and supply. The maximum import of power was 146 MW from Binaguri substation in the month of February 2013 due to a shutdown of all the units of the Tala Hydropower Plant. Therefore, power was imported via the 400 kV Binaguri–Malbase line to feed loads that were connected to Malbase substation.



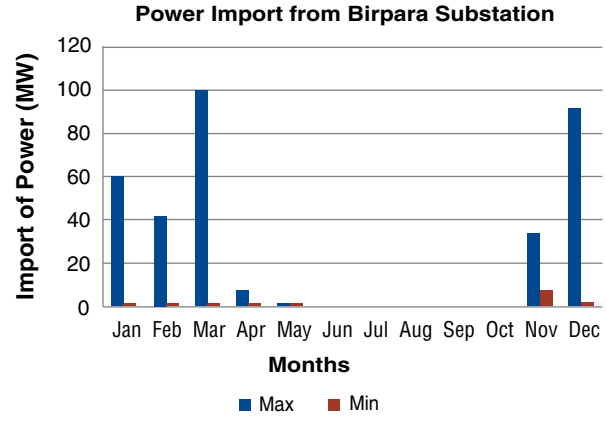
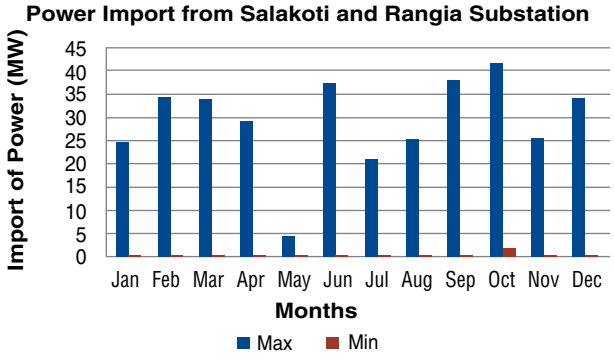


Figure 2.8: Power import: Maximum and minimum power import from substations



Source: NLDC, 2013

Regulatory Structure

1. **Bhutan Electricity Act (EA)-2001:** It includes the formation of the Bhutan Electricity Authority (BEA) and its activities; licenses for all the power related activities and its processes, private participation in the sector, power to acquire land and water, contingency provisions, social obligation, technical requirement and safety. The objectives of the Act include, but are not limited to the following:
   - To promote a safe and reliable supply of electricity throughout the country.
   - To enhance revenue generation through the export of electricity.
   - To develop the socio-economic welfare of the people.
   - To promote economic self-reliance of the country through the development of a financially viable and reliable electricity industry.
   - To promote the development of renewable energy resources.
   - To take environmental considerations into account when developing the electricity supply industry; and
   - To promote efficiency in management and service delivery.

2. **Bhutan Tariff Determination Regulation-2007 (Updated as of August 2013) (BEA, 2007):** The purpose of this regulation is to provide for the determination of electricity prices in accordance with the Electricity Act of Bhutan, 2001. All distribution, supply, transmission, generation and system operation licensees shall comply with the provisions in this regulation. All electricity tariffs for sale of electricity shall comply with the terms of this regulation, except for import/ export of electricity to other countries and sales of electricity under Power Purchase Agreements, which shall be governed by the license terms of the Licensee.

3. **Bhutan Sustainable Hydropower Development Policy-2008 (Department of Hydropower and Power System, 2008):** The policy captures most of the aspects related to hydropower development such as the institutional structure of the hydropower sector, project solicitation process, project investment options and issues, fiscal incentives, dispute resolution mechanisms, CDM benefits, off take of electricity, transmission and load dispatch, regulatory aspects, environmental requirements, social consideration, exclusions, amendments and definition etc. The key objectives of the policy are:
   - Mobilize funds and attract investment for accelerated hydropower development.
   - Enhance the revenue contribution to the Royal Government.
   - Contribute to socio-economic development.
   - Ensure domestic electricity supply security and reliability.
   - Ensure that hydro power development is in accordance with the sustainable development policy of the Royal Government, keeping in view the country's fragile mountain ecosystem.
   - Contribute towards the development of clean energy to mitigate problems related to global warming and climate change.

4. **Alternative Renewable Energy Policy-2013 (Ministry of Economic Affairs, 2013):** This policy aims to provide the necessary direction for the promotion and development of Renewable Energy (RE) that not only contributes in meeting the current requirement but also shapes the future energy security options for the nations. The Bhutan Sustainable Hydro Development Policy-2008 and the Economic Development

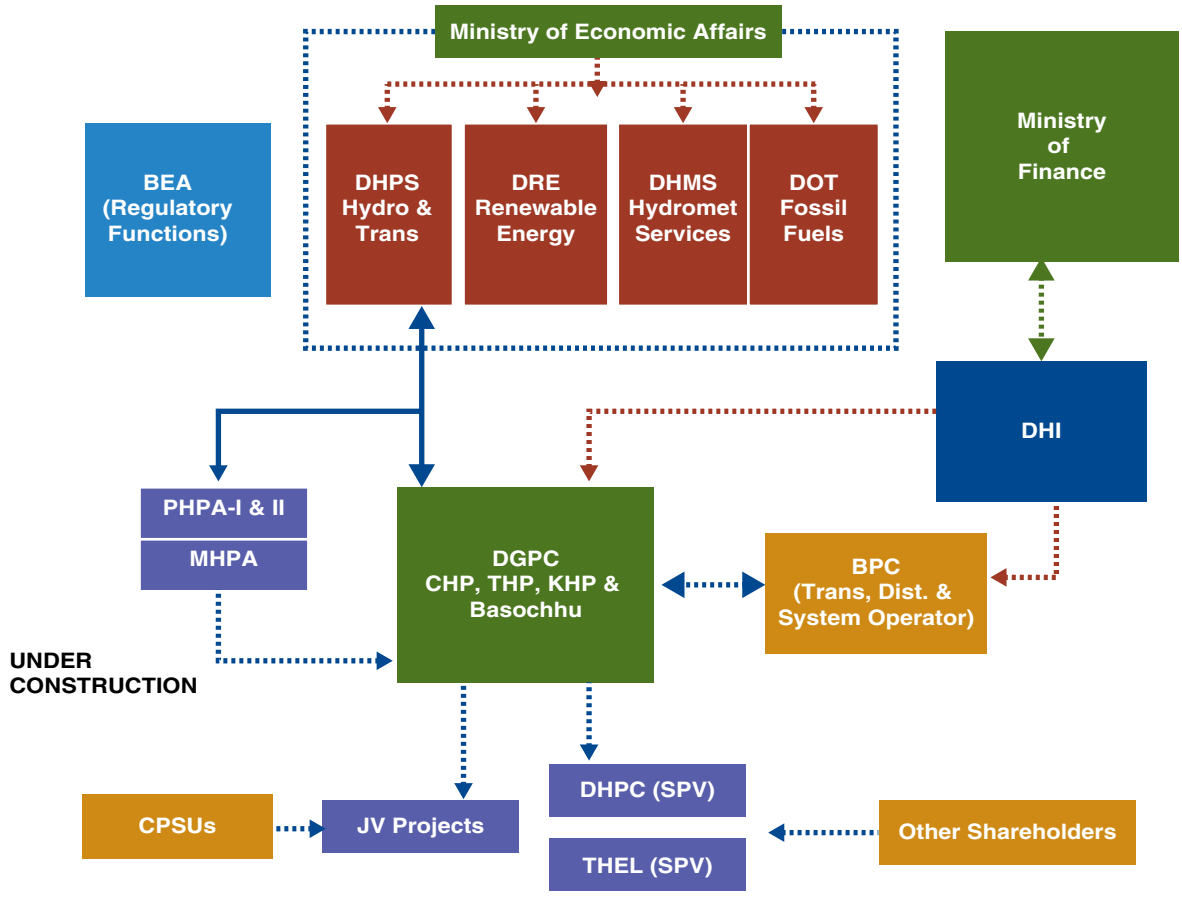
Policy 2008 recognize the need for an alternative renewable energy policy for the promotion of RE resources in order to ensure national energy security. The policy strives to ensure adequate provision and extensive use of modern energy services in rural areas, which have been largely dependent on firewood and kerosene for cooking, heating and lighting. In the urban areas, the policy shall strive to optimize and conserve the usage of grid-based power through the promotion of dispersed energy generation options. Large hydro projects (more than 5 MW) are not under the purview of this policy.

Institutional Structure

1. **Department of Hydropower and Power Systems** under the Ministry of Economic Affairs is responsible for policy making and planning all aspects of the energy and power sector in Bhutan.
2. **Bhutan Power Corporation** (BPC) is a government owned utility which is responsible for transmission and distribution of electricity in Bhutan.
3. **Bhutan Electricity Authority** (BEA) is an autonomous regulatory body and licensing authority for generation, transmission and distribution of electricity. The Government of Bhutan issued a sustainable hydro policy in 2008, for encouraging private sector participation in hydro power development and export of electricity for revenue generation.
4. **Druk Green Power Corporation (DGPC)** is responsible for managing all power plants which are wholly owned by the RGoB. The Bhutan Electricity Authority has issued licenses to DGPC for generation and transmission (export lines) of electricity.

Transmission: The Bhutan Power Corporation owns and operates the transmission and distribution of power sector in the country under license from BEA. The Bhutan Power Corporation is responsible for domestic power supply, and Druk Green Power Company (DGPC) is responsible for operating the export-oriented hydropower projects.

Figure 2.9: Bhutan's power sector's institutional structure



Future Demand-Supply Situation: Power Plan

As per the RGoB's National Transmission Grid Master Plan (NTGMP), it is expected that by 2020, a power generation capacity of 10,334 MW would be installed primarily for export. However, various projects have already been delayed by three to six years at different stages of implementation.

Bhutan is exporting 70-85% of its total electricity generation. By 2018-19, with the commissioning of new projects this share is expected to increase to 90%.

As per the government's plan, it is expected that after 2017, Bhutan would be self-sufficient in meeting its domestic electricity demand during the dry season and its power exports would double and a high surge in the economy is expected due to power trade. Bhutan has already developed its transmission grid master plan considering the future generation plants and power export. All these projects are expected to be completed between 2014-2025. Table 2.3 below depicts the upcoming plants, implementation mode and total investment requirements. The gestation period for hydro power projects is high compared to other power projects, hence the expected investment would be required over the next 5-10 years till the project's commissioning date. For calculating the investment requirement, transmission costs have been taken directly from the NTGMP plan while the generation costs are calculated as per the below assumptions.

Table 2.3: Bhutan's future power development plan and expected cost in Nu

S.No.	Projects	River Basin/ Location	IC (MW)	Project Cost (Nu. million)	Associated Transmission Cost (Nu. million)	Commis-sion Date	Mode of Opera-tion	Remarks
1	Punatsangch-hu-I	Punatsangch-hu/ Wangdi-phodrang	1,200	93,960.85	under imple-mentation	Dec-19	IG	Under construc-tion
2	Punatsangch-hu-II	Punatsangch-hu/ Wangdi-phodrang	1,020	74,890.00	4442.00	Jun-18	IG	Under construc-tion
3	Mangdechhu	Mangdechhu/ Trongsa	720	40,755.80	5299.90	May-18	IG	Under construc-tion
4	Amochhu	Amochhu/ Chukha	540	37,383.70	1051.00		IG	Dropped from implementation
5	Sankosh	Punatsangch-hu/ Lhamoiz-ingkha	2,560	140,951.56	2969.50	2022	IG	Implementation under discus-sion
6	Kuri-Gongri	Drangmechhu/ Mongar	2,640	146,799.51	8099.00	2027	IG	DPR and its implementation under discus-sion
7	Kholongchhu	Drangmechhu/ Trashiyangtse	600	31,436.39	8858.25	2020	JV	Under construc-tion since Sept 2015
8	Bunakha	Wangchhu/ Chukha	180	24,926.42	895.00	2021	JV	Under discus-sion between the JV partners
9	Wangchhu	Wangchhu/ Chukha	570	40,027.56	538.00	2021	JV	Under discus-sion between the JV partners
10	Chamkharch-hu-I	Mangdechhu/ Zhemgang	770	47,760.22	6372.30	2025	JV	Under discus-sion between the JV partners
11	Nikachhu	Mangdechhu/ Trongsa	118	11,964.59	1026.75	Mar-19	PPP	Under construc-tion

Electricity Demand by 2050

Future electricity demand projections are essential for ensuring energy security. The projections help in planning to meet the demand and in assessing the risks associated with energy availability over the period. For ensuring future growth, it is essential to prepare a road map for electricity requirements and resources to fulfill the growing demand for energy.

The various methodologies used to project electricity demand are listed below.

- Econometric model
- Time series
- Time trend (CAGR)
- End use
- Partial end use

Every model requires some inputs or assumptions to make reliable predictions, and the accuracy of the model's output depends upon the availability and accuracy of input data.

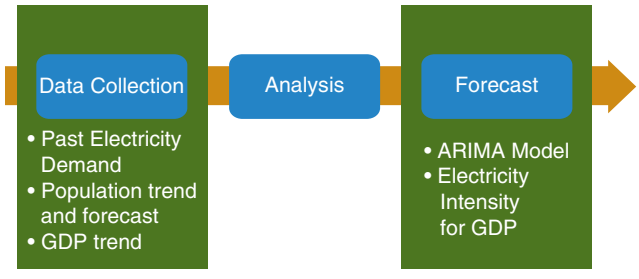
- The econometric method ascertains electricity demand by considering the influence of independent variables such as population, employment, income, weather, appliance ownership, and market prices. Econometric models are estimated equations that relate electricity demand to external factors such as those listed above.
- The time series method used to forecast the demand for electrical energy is based on the patterns and trends found in input data. In using the time series method, the researcher extrapolates statistical data to calculate loads based upon historical data for the load being forecasted.
- Time trend, or the compound annual growth rate (CAGR) method, determines electricity demand by simulating the growth rate of GDP and the elasticity between the GDP and electricity.
- In the end-use method, the electricity demand of each sector is projected by determining the energy intensity of each sector, and the overall demand is assessed by the summation of demand from all the sectors.
- The partial end-use method is the combination of the end-use method and one of the above-mentioned methods.

After evaluation of various demand forecasting techniques such as time series method, trend method, elasticity and energy intensity method, two methods were selected i.e. ARIMA technique and electricity intensity method. The two techniques were selected based on comparison of per capita electricity consumption obtained from models.

Methodology - Electricity Demand Forecast

For assessment of electricity demand in this paper two models were considered based on the Autoregressive Integrated Moving Average (ARIMA) technique and Electricity Intensity of GDP. Figure 2.10 highlights the methodology for forecasting electricity demand for Bhutan.

Figure 2.10: Methodology for forecasting electricity demand



Data for developing the time series was sourced from Ministry and Government bodies' reports of Bhutan, United Nations Population Prospects and United Nations Statistics Database.

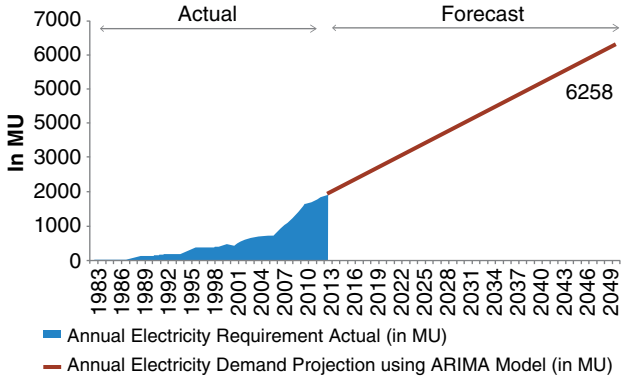
Bhutan's Electricity Demand Projections up to 2050

Time series data of Bhutan's electricity requirement for the past 30 years (1983-2012), population and GDP (at constant price of 2005) were analyzed. Bhutan's population numbers for the past and future were considered as per the UN World Population Prospects 2012 wherein Bhutan's population in 2010 was 7.2 lakhs which is expected to rise to 9.8 lakhs by 2050.

ARIMA Projection

ARIMA lag 2 (1,2,0) using R technique was used for projecting Bhutan's electricity demand up to 2050 using the past 30 years' (1983-2012) time series data of Bhutan's electricity requirement. The projection from the model is shown in Figure 2.11.

Figure 2.11: Electricity demand projection up to 2050 using ARIMA model



Bhutan's annual electricity requirement in 2012 was 1,853 MU[6] and in the past 10 years (from 2003 to 2012) the annual electricity demand increased at a CAGR of 11 per cent. Based on the ARIMA lag 2 (1,2,0) model output the expected annual electricity demand of Bhutan in 2050 would be 6,258 MU.

Projections using Electricity Intensity of GDP

To project the electricity demand based on electricity intensity for GDP the following assumptions were made:

- In the past, it was observed that the GDP (constant price of 2005) has grown with a CAGR of 8.2 per cent[7] during the period 2003 to 2012 and the following growth rates have been assumed for projecting the future GDP:
  - Growth rate of eight per cent between 2013 to 2025
  - Growth rate of seven per cent between 2026 to 2035
  - Growth rate of six per cent between 2036 to 2050
- Over the past 10 years (2003-12), the average electricity intensity for GDP was 0.02389 kWh and the same value has been used for projecting the future electricity demand (past electricity intensity value has been used due to limited data availability and lack of clarity on future scenario).

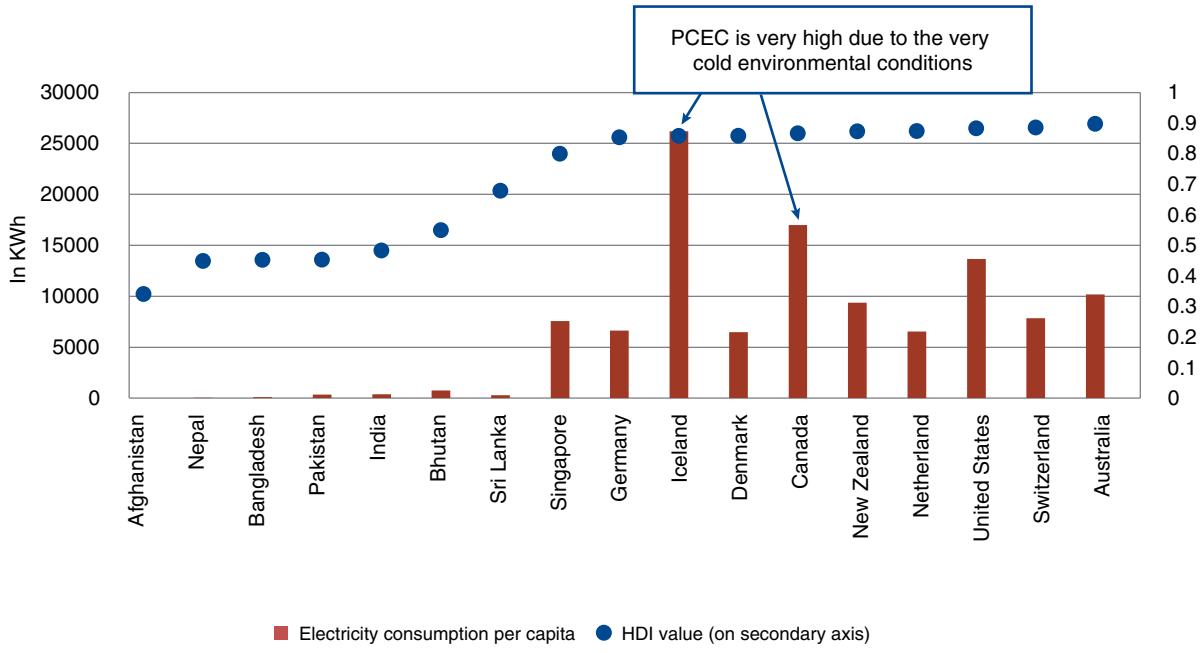
Based on the above assumption and using electricity intensity for GDP, Bhutan's electricity demand in 2050 will be 19,765 MU.

For the time being, academic demand projections have been made considering the limited data availability. However, we expect the present demand projections may further increase or decrease with more data availability. The present projection gives per capita electricity consumption (PCEC) of around 6,386 kWh (based on ARIMA lag 2 model) to 20,169 kWh (based on electricity intensity for GDP) for year 2050. The PCEC based on electricity intensity for GDP is quite high as compared to the present electricity consumption of key developed nations/economies. Figure 2.12 and Figure 2.13 highlight the Human Development Index (HDI) vs. PCEC of selected countries for year 2000 to 2010 respectively. The PCEC for developed nations does not exceed the level of 10,000-15,000 kWh, except for a few countries such as Iceland, Canada etc. These exceptional countries have very high PCEC values due to their cold/hot environmental conditions that require electricity for heating/air-conditioning purposes. Developing nations have very low PCEC as compared to their developed counterparts. It is expected that in developing nations (such as Bhutan) the electricity requirement will not grow similarly to that of developed nations as lessons for energy conservation and management are learnt from developed nations.

[6] Statistical Year Book of Bhutan 2013

[7] GDP data from UN Statistics Division

Figure 2.12: HDI index vs. per capita electricity consumption of selected countries for year 2000

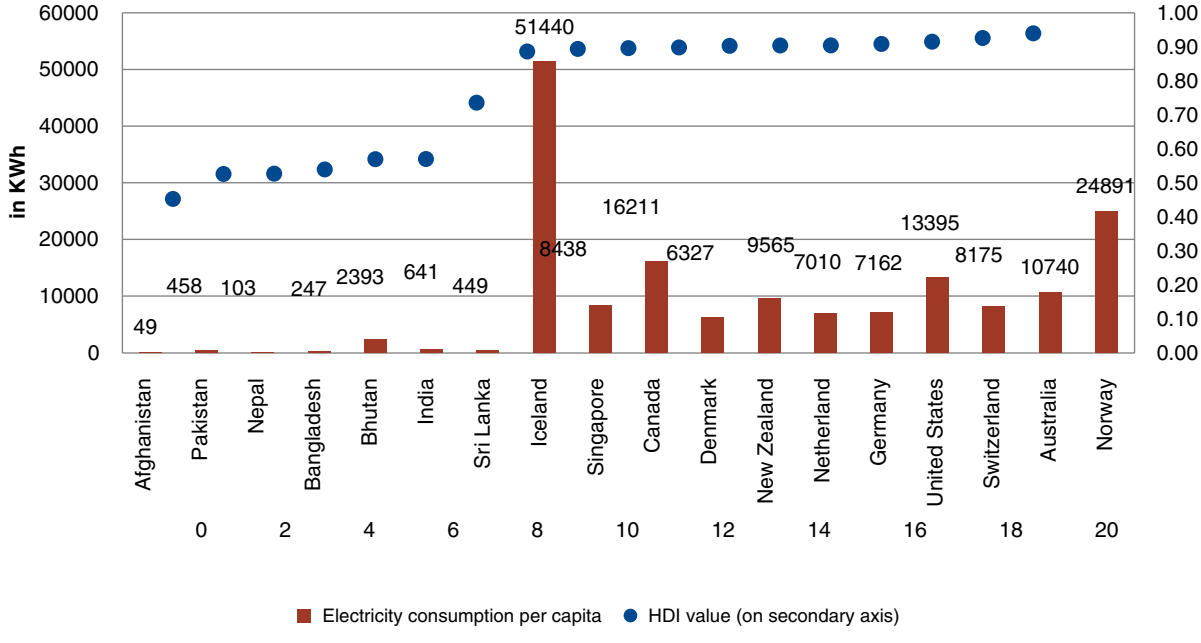


(Source: UNDP Human Development Report; Work Bank)

** Bhutan data source (HDI for year 1999-UNDP and PCEC-ADB database)*

**Per capita electricity consumption for Afghanistan not available)*

Figure 2.13: HDI index vs. per capita electricity consumption of selected countries for year 2010

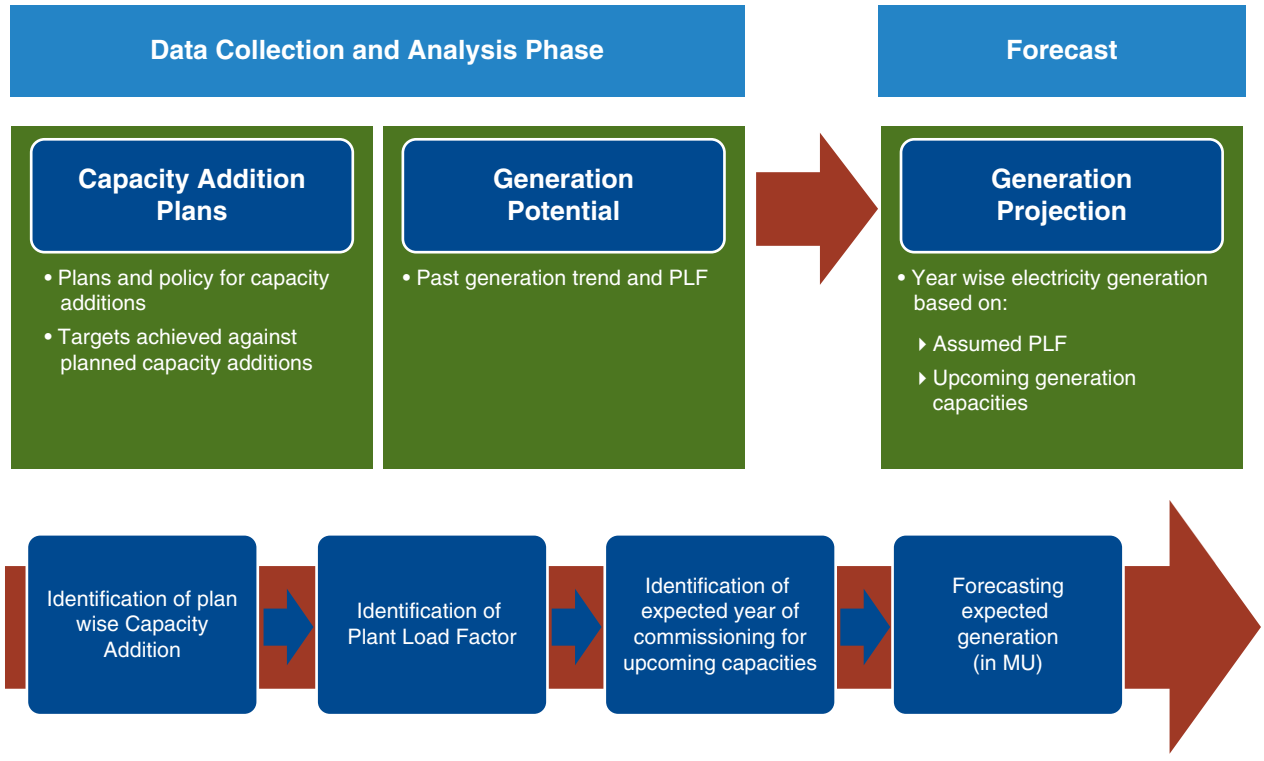


*(*Other data source: For Afghanistan PCEC data 2009-IRENA; Bhutan PCEC data 2010-World Bank data base)*

Methodology-Electricity Supply Forecast

To assess the electricity supply for this paper, the performance of the presently installed hydropower generation plants and RGoB's future plans for capacity addition have been analyzed. Figure 2.14 highlights the methodology of electricity supply forecast undertaken for this study.

Figure 2.14: Methodology for forecasting electricity supply



Present Status: In year 2015, the total installed hydropower generation capacity of Bhutan was 1614 MW (which includes 8 MW of mini/ micro hydro generation capacity). The five hydro projects Chhuka, Kurichhu, Basochhu-I & II, Tala and Dagachhu account for 99 per cent of installed hydro generation capacity in Bhutan. It was observed that all the four hydro power plants generate maximum electricity in the month of July, August and September whereas these power plants generate the least electricity in the month of January, February and March. The average Plant Load Factor (PLF) of the operational hydropower plants was observed to be around 58 per cent (based on past generation data).

Capacity Addition Plans: With an existing large hydropower generation capacity of 1606 MW, Bhutan aims to achieve total installed hydro power generation of 11,814 MW and 26,534 MW by 2020 and 2030 respectively. A total of 14 hydropower plants with cumulative capacity of 10,334 MW were envisaged to be added by 2020 as per the National Transmission Grid Master Plan (NTGMP) of Bhutan in April 2012. However, later on the capacity of three hydropower plants was revised taking the total expected installed hydropower capacity to 11,072 MW.

Bhutan's Electricity Generation Projections up to 2050

Based on information collected from various representatives of authorities in Bhutan, from the 14 hydropower projects planned only six projects with a total capacity of 3,658 MW are expected to be commissioned by 2020 while the rest are expected to be commissioned after 2020. It is expected that about 45 per cent of the target of 11,814 MW will be achieved by 2020.

Therefore the following key assumptions have been made for forecasting the electricity supply projections.

- It has been assumed that all the capacity addition in future would be hydro based as Bhutan is rich in hydropower resources.
- Commissioning of hydropower plants have been considered up to 2027 based on the information received.
- It has been assumed that Bhutan's total installed hydropower generation capacity by 2020 would be 5,398 MW with an annual energy generation of 24,096 MU (based on average generation from existing operational plants during 2013 to 2015 and expected energy generation from under construction hydropower plants).

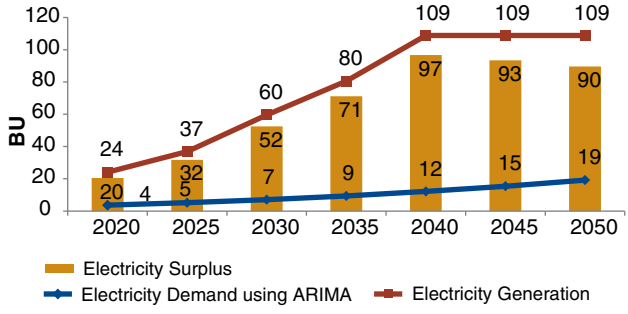
- The expected installed hydropower capacity by 2027 would be 12,118 MW with an annual generation of 46,868 MU.
- Similarly, it has been assumed that the planned hydropower capacity target of 26,534 MW would be installed by 2040 instead of 2030, which indicates that capacity addition would grow at a rate of 6.2 per cent between 2027 - 2040.
- No further hydropower capacity addition was considered after 2040. Based on the above assumptions Bhutan is expected to generate 59 BU and 108 BU annually by 2030 and 2050 (refer Figure 2.15).

Bhutan's Yearly Trading Potential

To calculate the annual trading potential available with Bhutan for exports, Bhutan's electricity demand up to 2050 has been considered using ARIMA Lag 2 (1,2,0) using R technique. The ARIMA Lag 2 model projections obtained show decreasing electricity intensity for GDP and decreasing electricity elasticity for future GDP growth of eight per cent in comparison to output obtained from the electricity intensity of the GDP model.

Based on the above methodology and assumptions, the annual tradable surplus available with Bhutan in 2030 and 2050 would be 52 BU and 89 BU respectively as shown in Figure 2.15.

Figure 2.15: Projected electricity trading potential of Bhutan up to 2050



As per NTGMP, plans are underway for the transfer of huge electricity surplus from Bhutan to India. Figure 2.16 and Figure 2.17 show the transmission grid plan of Bhutan for 2020 and 2030 respectively as per NTGMP.

Figure 2.16: National Transmission Grid Master Plan for Bhutan by 2020

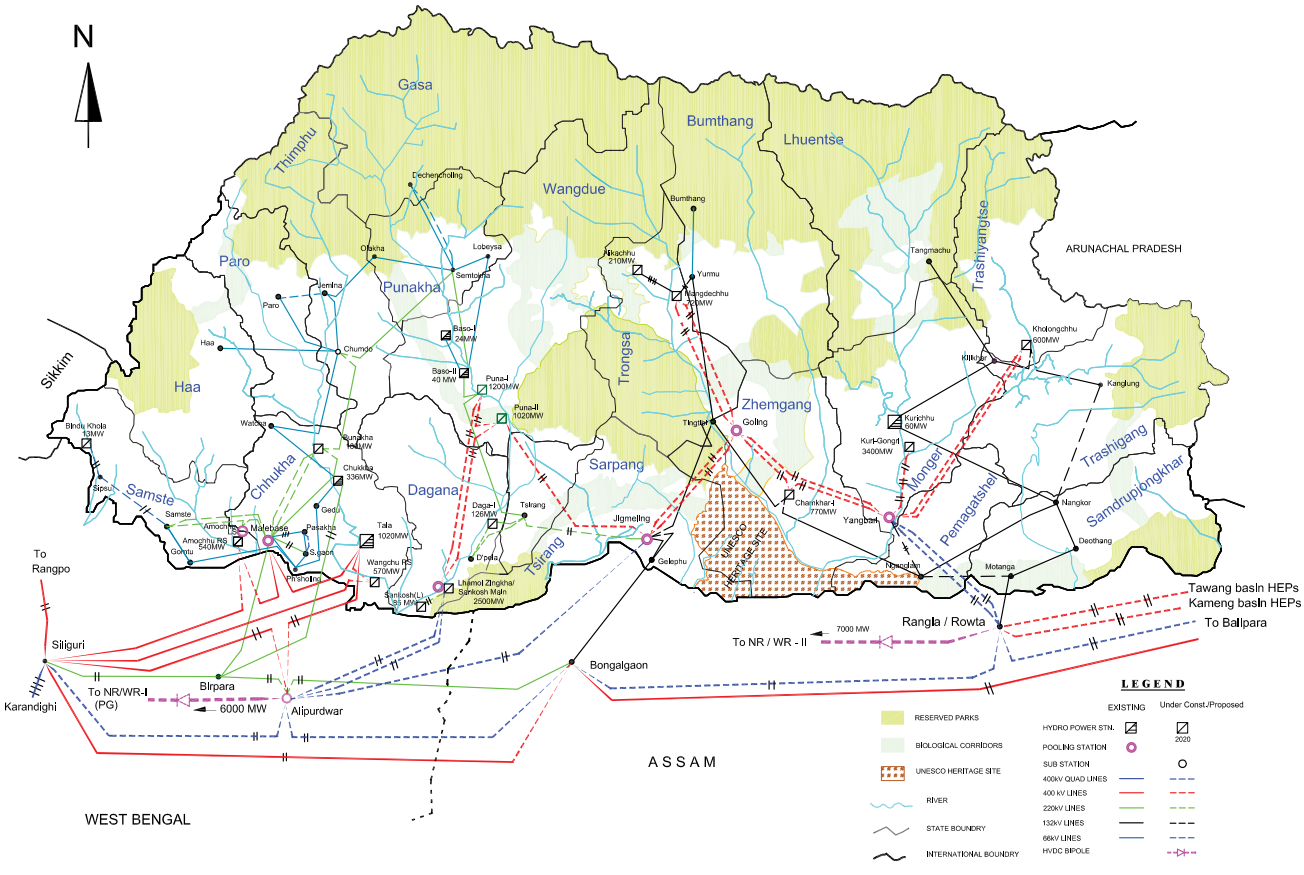
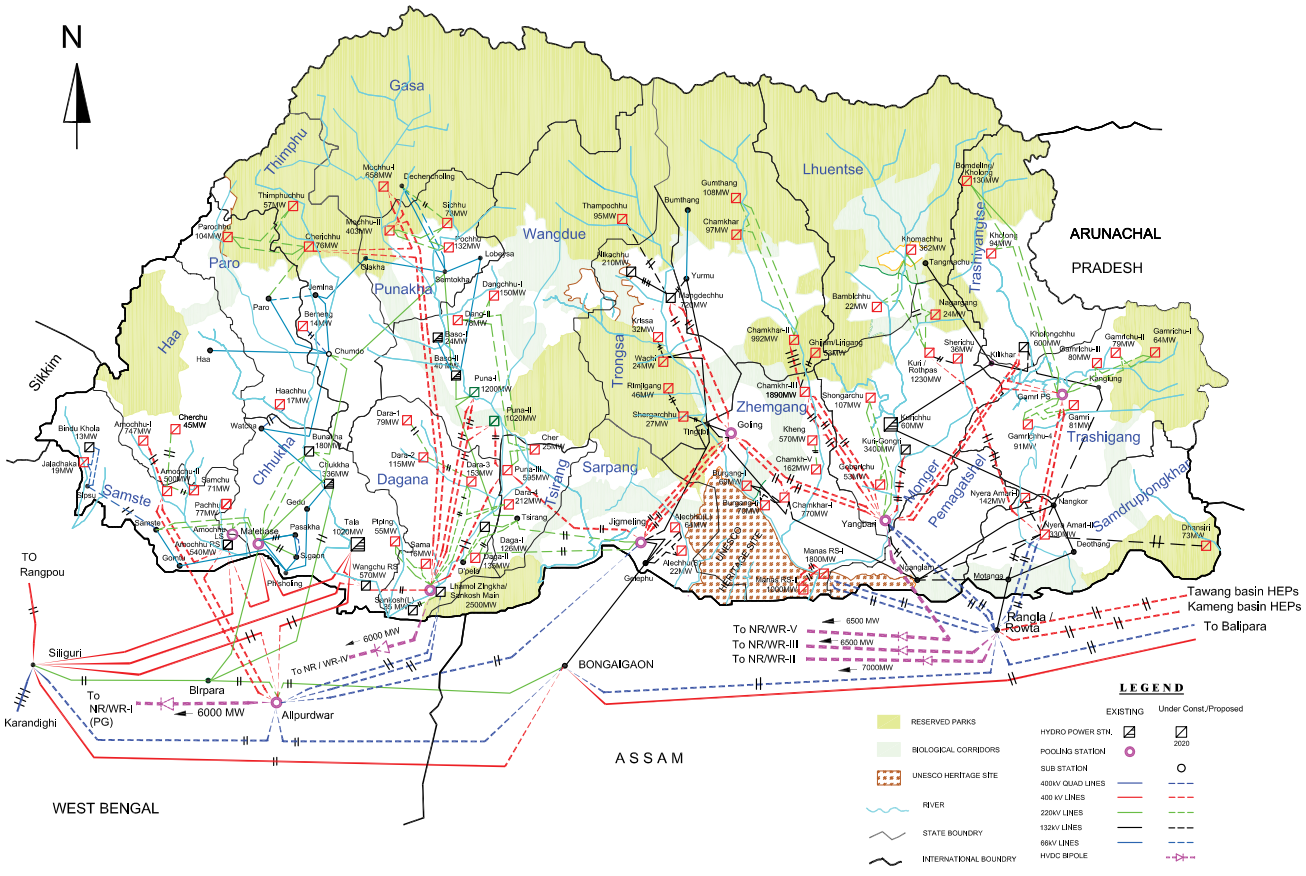


Figure 2.17: Prospective Bhutan Grid by 2030



3 Impact of Power Export on Bhutanese Economy

Bhutan's Economy

The import and export of commodities by a country is an economic activity whose underlying assumption is to satisfy the consumer with minimum expenditure. Countries are trading merchandise to boost the economy and to optimize resources. Foreign trade statistics are instrumental in gauging the overall economic performance in relation to other countries. Foreign trade statistics are vital to the policy maker, the economic planner and the public in general. In the sections below, the impact of Bhutan's power export on its economy is discussed.

Hydroelectricity has a tremendous impact on Bhutan's economy; during 2007 with the commissioning of the Tala hydro plant, a high surge in the growth rate of Bhutan's GDP (12% in 2006 to 21% in 2007) was observed.

It is further expected that after commissioning of Punatsangchhu-I HEP in 2017, Bhutan's economy would again witness a high surge.

Bhutan is primarily an agrarian economy. It is one of the fastest growing countries of the world with an average nominal GDP growth rate of 14 per cent and average real GDP growth rate of 8.2 per cent. The prominent sectors i.e. agriculture and related sectors, construction, electricity and water, community and personal services etc., have a higher contribution in the overall GDP. However, in this agrarian economy other sectors are also showing an equal or greater presence in the last few years. During the last ten years, the agriculture sector's contribution in the overall nominal GDP is decreasing and reached 17 per cent in 2012 from 24 per cent in 2003 (Table 3.1).

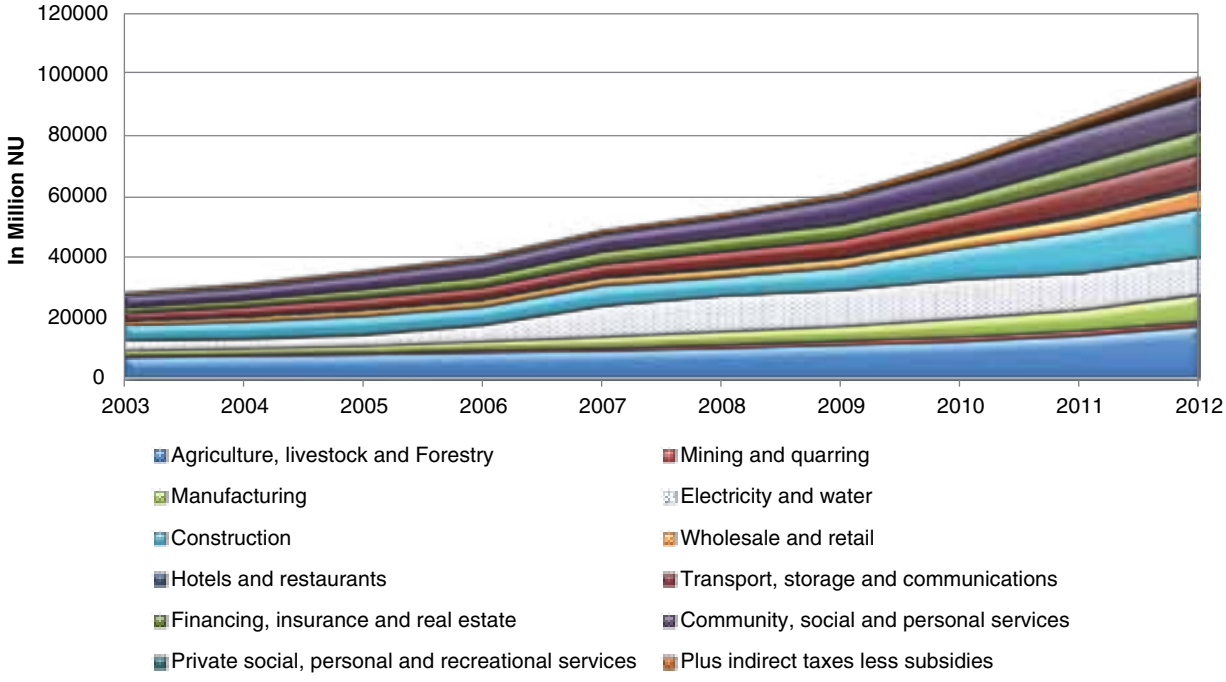
Revenue from power exports are one of the major contributors to Bhutan's GDP that varied in the range of 11 to 21 per cent of the GDP during 2003-2012. It is expected that Bhutan's GDP would be driven by expansion in the industry sector mainly through the ongoing hydropower construction and expected starting of new hydropower projects in the future.

Table 3.1: Sectoral contribution in Bhutan's GDP at current price

Sector	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Agriculture, livestock and Forestry	24.4%	24.0%	22.3%	21.4%	18.7%	18.4%	18.2%	16.8%	16.1%	17.0%
Mining and quarring	2.0%	1.4%	1.5%	2.2%	1.8%	2.3%	2.3%	2.2%	2.3%	2.0%
Manufacturing	7.2%	7.2%	7.1%	7.6%	8.2%	8.4%	8.2%	8.7%	8.2%	9.0%
Electricity and water	11.6%	9.7%	10.1%	13.1%	20.4%	21.1%	19.3%	17.6%	13.9%	12.4%
Construction	17.3%	18.0%	17.2%	14.8%	13.7%	11.4%	12.2%	14.2%	16.2%	16.0%
Wholesale and retail	5.0%	5.4%	5.8%	5.7%	5.0%	4.9%	4.8%	5.2%	5.4%	6.3%
Hotels and restaurants	0.5%	0.5%	0.6%	0.7%	0.7%	1.0%	0.9%	0.8%	1.1%	1.4%
Transport, storage and communications	9.1%	10.3%	10.8%	10.1%	9.0%	9.8%	9.8%	9.6%	11.0%	10.4%
Financing, insurance and real state	6.7%	7.2%	8.1%	8.5%	8.3%	8.4%	8.1%	7.6%	8.2%	7.8%
Community, social and personal services	12.6%	12.0%	12.4%	12.0%	10.7%	10.8%	13.0%	12.8%	12.7%	11.3%
Plus indirect taxes less subsidies	0.4%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.4%	0.4%	0.4%
Gross Domestic Product	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

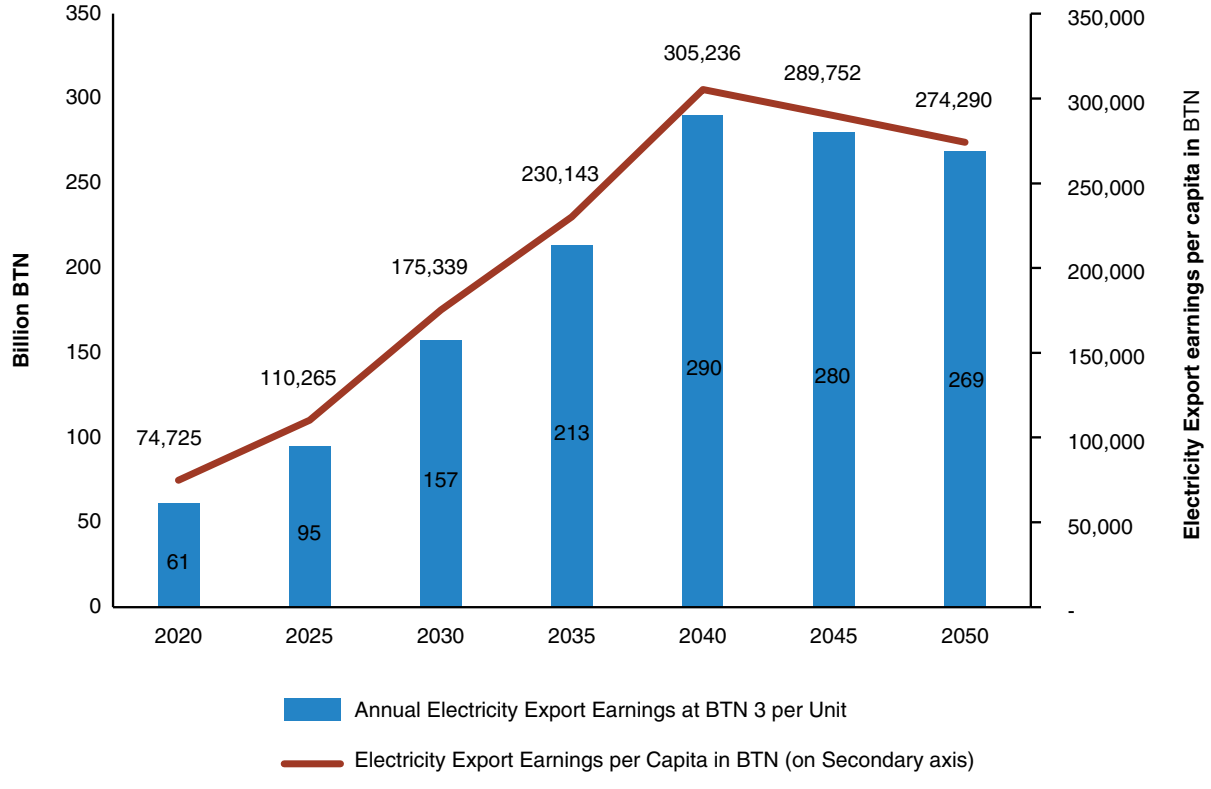
Source: National Accounts Statistics, 2013, National Statistics Bureau

Figure 3.1: Bhutan's sectoral percentage contribution in GDP (from 2003-2012)



As seen in Table 3.1 the electricity sector shows a lot of fluctuation in the percentage contribution of nominal GDP due to a large jump in electricity exports after the commissioning of the Tala Hydropower plant. After that the electricity sector generated a continuous revenue stream while the nominal GDP was growing continuously. The agriculture sector shows a continuous decline in GDP contribution due to the high pace of growth in other sectors. The construction sector also shows an incremental growth due to the construction of hydro plants as well as other infrastructure projects. The export of surplus electricity has huge potential to add to Bhutan's overall economic growth. Figure 3.2 highlights the expected annual electricity export earnings and electricity export earnings per capita

Figure 3.2: Annual electricity export earnings and electricity export earnings per capita from export of surplus electricity up to 2050

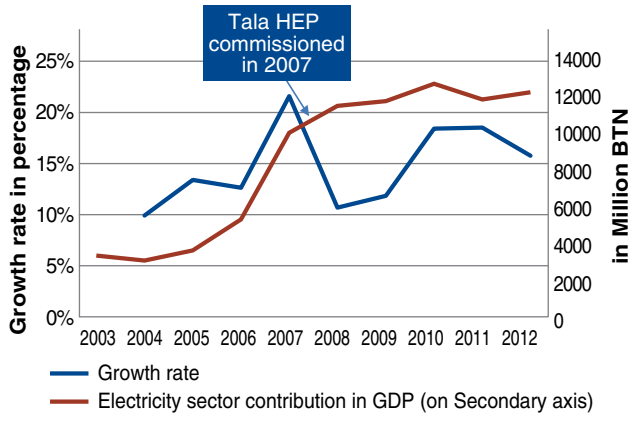


for Bhutan from sales of surplus electricity up to 2050 considering export of electricity to India at BTN 3 per kWh and population growth as per UN World Population Prospect 2012.

Impact of Power Exports on GDP

The electricity sector is one of the major contributors to Bhutan's GDP, for the last ten years its direct contribution varied in the range of 11 per cent to 21 per cent. Table 3.1 highlights Bhutan's GDP and the electricity sector's contribution to the GDP. It is evident from the Figure 3.3 that there was a surge in Bhutan's GDP growth in the year 2007 due to the commissioning of the Tala Hydropower plant and large power exports to India. It is expected that by 2025 as per the RGoB's plans for commissioning hydropower plants, the **GDP will increase by 75-100 per cent through the contribution of the electricity sector at the current level of GDP.**

Figure 3.3: GDP growth and electricity sector revenue generation



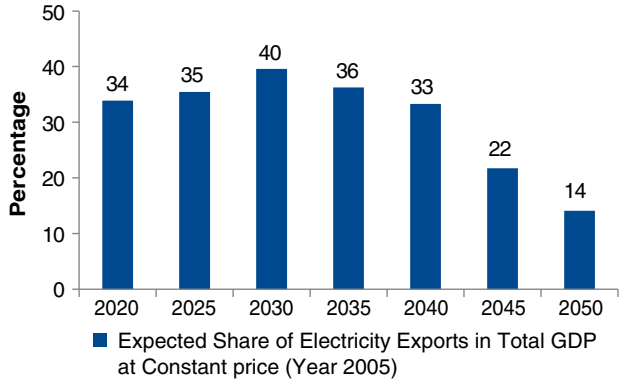
Expected Electricity Export Revenue Share in GDP (at 2005 Constant Price)

To estimate the expected share of revenue from electricity exports in the total GDP up to 2050, the following points have been considered:

- GDP (at constant price of 2005) growth rate of 8.2 per cent[8] was observed between the period 2003 to 2012 and the same growth rate has been assumed up to 2050.
- The average electricity export price of BTN 3 per kWh has been used for projecting the share of revenue from electricity exports in the total GDP up to 2050.
- Electricity surplus is considered from the previous section.

Figure 3.4 highlights the share of electricity exports in total GDP (at constant price of 2005).

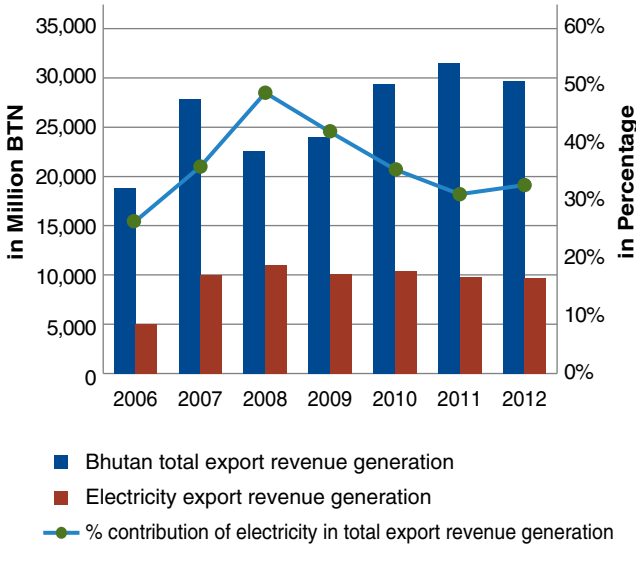
Figure 3.4: Share of electricity exports revenue in total GDP (at constant price of 2005)



Impact of Power Exports on Bhutan's Total Exports

Figure 3.5 depicts the electricity export contribution in total export earnings. It clearly indicates that power exports are creating a valuable asset for the country which would generate a continuous revenue generation stream (around 10,000 Million BTN till 2016). A big jump in revenue stream is expected as per Bhutan's future power capacity addition plans. Export of electricity contributed by 26 per cent to 48 per cent of Bhutan's total export revenue generation from 2006-2012.

Figure 3.5: Bhutan's electricity export revenue and total export revenue generation (in million BTN)



Source: Selected economic indicators of Bhutan: March 2014

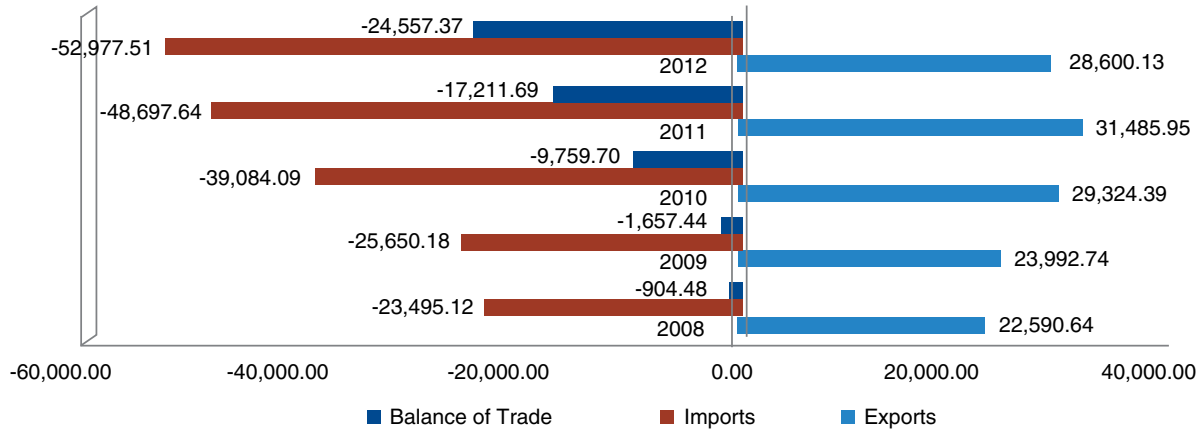
[8] GDP Data from UN Statistics Division

Impact of Power Exports on Balance of Trade and Debt

The balance of payments statistics are designed to show the difference between the total payments made to foreign countries and the total receipts from foreign countries. Thus, it provides a systematic summary of economic transactions, for a specific time period, between an economy and the rest of the world. The transactions include goods, services, income, transfers and financial claims.

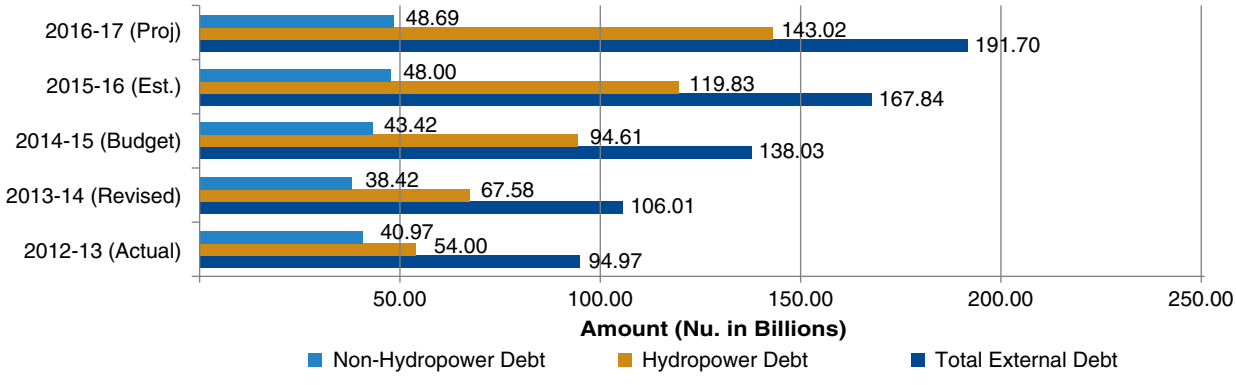
It is clearly visible that, Bhutan's imports are increasing sharply and so also is the balance of trade (in negative). Bhutan is importing large amounts of equipment and material needed to build hydropower plants. The situation is expected to continue for the next few years. Due to the construction of new hydro plants, Bhutan's debts are increasing continuously and the thresholds have been breached for several indicators for prolonged periods of time.

Figure 3.6: Bhutan's balance of trade in millions of BTN (2008-2012)



However, these projects are expected to give good economic dividends in the future, boosting future GDP growth and exports. The risk is minimal for the projects because of the good track record of project implementation, commercial viability, and close economic and political ties with India. Bhutan's main provider of financing for hydropower projects and the key consumer of its electricity exports is India.[9]

Figure 3.7: Bhutan's estimated, projected external debt requirement



Source: SEI March 2014

The substantial hydro-power related imports and rapid growth of economy have resulted in a sharp widening of the current account deficit. The IMF suggested a comprehensive set of policies that could minimize such pressure in the future as Bhutan continues to increase growth and raise the living standards through hydro power development. Intergovernmental projects between India and Bhutan have minimal risk as the risk bearer is the government.

Growth is projected to average around 8.5 per cent over the course of the Eleventh FYP, boosted initially by the construction of hydropower facilities and then by electricity generation in later years. As a result, the current account deficit is projected

[9] Joint IMF/World Bank Sustainability analysis, 2009

to increase to more than 27 per cent of the GDP by FY17. The expansion of hydropower capacity over the medium-term poses challenges for macroeconomic management. External financing should be monitored closely so that pressures on the overall balance of payments position remain contained. **However, if this transition is well managed, per-capita income could double to around US$5,000[10] by FY19.**

Assessment of debt sustainability risks of intergovernmental hydropower projects

Debt sustainability risks are minimal as:

(i) Construction risks are borne by Government of India.

(ii) Power rates are determined at the time of the project commissioning, when the actual project cost is known, and are set to allow revenues to service debt and a financial return.

(iii) Hydropower project are insured (and re-insured) for natural disaster.

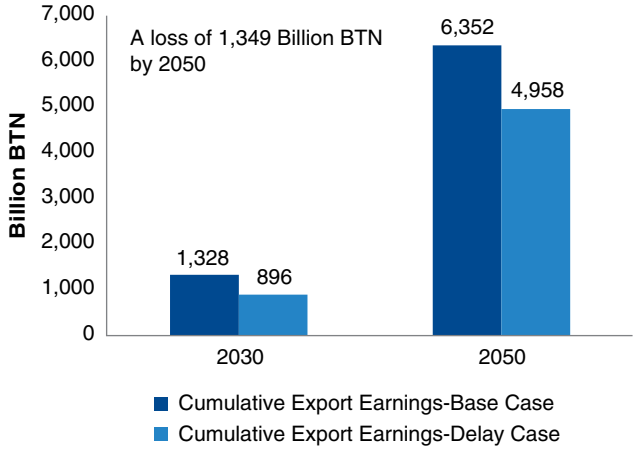
The only risk is hydrological after commissioning of the project, if electricity, once the project is commissioned, could not be generated.

As mentioned above the risk of these high debt hydro projects is minimal and these projects would continue to create revenue stream assets for future earnings. The debt increment due to these hydro projects should be treated separately for calculating the sustainability indicators due to the nature of the debt (minimal risk and future continue revenue stream).

Impact of Delay in CBET-5 Year Delay Scenario for Bhutan

In the above sections, CBET's impact on the Bhutanese economy has been discussed. However, if there is a slippage of five years in the projects then it is expected to have significant impact on the export earnings of Bhutan. Figure 3.8 highlights the expected losses to Bhutan if the above base case is delayed by five years. Base case is discussed in the Figure 3.8 and according to the same export earning has been calculated taking the assumption of 3 Nu/unit cost. In the case of delay, five years slippage has been considered for future projects (except for under construction projects) and cumulative electricity export earnings have been calculated according to that. **Bhutan has no leeway to delay these hydro projects, as it may result in cumulative loss of export earnings to the tune of 1,349 Billion BTN by 2050, considering five years slippage in the addition of capacity.**

Figure 3.8: Five year slippage/delay impact on Bhutan's electricity export earnings



[10] IMF reports on Bhutan, report no: 14/178, 2014.

4 Agreements and Key Issues

Bhutan has a decade long experience in CBET, which has contributed significantly to its economy. However, there are a few key issues which need to be addressed for the continuous growth of Bhutan's power sector. Some of the key issues are briefly discussed below.

- **Financing requirement:** The NTGMP of Bhutan has planned for a cumulative installed capacity of 10 GW by 2020 and 26 GW by 2030. The total investment required for building hydro projects and associated transmission system is US$ 12.62 billion[11] by 2020 for planned installed capacity of 10 GW as per NTGMP. Bhutan's GDP and domestic finance sources are limited compared to the power sector's requirement for large amounts of finance. Power sector financing in Bhutan mostly relies on international funding for hydro power development. Bhutan therefore needs to develop a long-term financing strategy by involving the World Bank, ADB and other multilateral agencies.
- **Increased developer risk:** In Bhutan, so far the projects have been developed primarily through a combination of bilateral grant and concessional loan from the Government of India (60% grant and 40% loan). In the upcoming projects, GoI is substantially reducing the grant component and increasing the debt component (40-30% grant and 60-70% loan) resulting in increased risk for the developer. The threshold limit for the debt indicator has already been breached for a long time by Bhutan's power sector. Therefore it needs to develop risk mitigation measures for the projects that are being financed by India.
- **No provision for Short Term Open Access (STOA):** As per the existing arrangement generating stations in Bhutan are settled based on the actual generation. In STOA transactions, accounts are settled on the basis of schedule. The developers are unclear despite having an evacuation capacity in the existing transmission line; how it could be utilized for STOA. This issue requires Bhutan's involvement in India's power market by integrating its power system with that of India's which calls for a uniform grid-code for efficient and smooth operation.
- **Open access (OA) and connectivity issues:** International private players have recognized the opportunities in Bhutan's power sector. However, the major issue or big hurdle for them is to get the permission for OA and connectivity.
- **Under injection/over drawn issue in long term:** As per the current provision, India needs to take all the surplus power from the Tala, Chukha and Kiruchu plants of Bhutan. These plants are not covered commercially under ABT mechanism. In the long term, a 10 GW export capacity of power without the ABT mechanism, under and over injection may create a grid imbalance in India.
- **Curtailment of power and redressal mechanism:** Curtailment of power may be necessary in case of tripping of cross border links or congestion over international inter-connections or any other constraints in the transmission corridor in the long term.
- **Coordinated scheduling and settlement procedures:** After having a high export capacity in the range of 10 GW, Bhutan and India would require coordinated scheduling and settlement procedures for the safety of the grids of both countries and for maintaining the grid frequency.

Recent developments and agreements: Recently, several developments have occurred to facilitate CBET within the SA region. Some of the recent developments in the region have been summarized below.

[11] Cross-Border Electricity Trade in South Asia: Challenges and Investment Opportunities, 2014 IRADe

SAARC Inter-Governmental Framework Agreement (IGFA) on Energy Cooperation

During the 18th SAARC Summit, the eight member states' foreign ministers signed an agreement on energy cooperation "SAARC Inter-Governmental Framework Agreement (IGFA) for Energy Cooperation (Electricity)' on 27 November 2014. The proposed objectives of the IGFA are:

1. Realize the common benefits among the SA countries leading to optimal utilization of regional electricity generating resources, enhanced grid security, and electricity trade arising from diversity in peak demand and seasonal variations.
2. Enable the transmission planning agencies of the governments to plan the cross-border grid interconnections through bilateral/trilateral/ mutual agreements between the concerned states based on the needs of the trade.
3. Work towards exempting export/import/duty/ levies/fees, etc., for cross-border trade and exchange of electricity between buying and selling entities.
4. Ensure non-discriminatory access to respective transmission grids as per the applicable laws, rules, regulations and inter-governmental bilateral trade agreements.

The following aspects will be finalized subsequent to agreement among the task force members:

a) Develop regional regulatory guidelines;

b) Prepare guidelines to cover principles on open access, settlement of energy imbalances, transmission pricing, transmission planning etc. in term sheet format;

c) Identify and highlight consequent changes/ amendments required in the legal, regulatory and policy frameworks of the respective countries to operationalize regional regulatory guidelines;

d) Country-wise strategy, specific recommendations and road map for electricity trade within the SA region.

Inter-governmental Agreement[12]

The current Bhutan-India experience in CBET demonstrates the efficacy and effectiveness of the governmental agreement and arrangements. Intergovernmental hydropower projects in Bhutan are being undertaken under a unique arrangement between India and Bhutan, reflecting the close links between the two countries. Under the "10,000 MW by 2020" bilateral cooperation agreement signed on 26th July 2006 and the protocol to the agreement signed on 16th March 2009, the RGoB and GoI agreed to develop five intergovernmental projects (Chukha, Kurichhu, Tala have been commissioned, and Punatsangchhu I, Punatsangchhu II, Mangdechhu are under construction).

Under the intergovernmental agreement, a Detailed Project Report (DPR) is to be prepared by the GoI undertaking company/authority. The report reviews all the technical and financial aspects of the project. After the DPR is finalized and endorsed by the two countries, a Project Agreement between Bhutan (Ministry of Foreign Affairs) and India (Ministry of External Affairs) is signed, which establishes the following:

- Sole ownership of the project lies with the RGoB.
- Government of India will take the sole responsibility for funding the IG projects (including the additional cost).
- Royal Government of Bhutan will set up a project authority for the construction, operation, maintenance and evacuation of the surplus power.
- The GoI will purchase all the surplus power from the project.
- The project authority will hand over the project to the RGoB within two years of completion of the project.
- The tariff cost will be determined by the "cost plus" approach after the commissioning of the project. (Cost plus includes the costs of the project, financing costs, operation and maintenance charges, accelerated depreciation and market conditions and a net return of 15%)
- The tariff will be reviewed every three years.
- India will finance the project as per the mentioned terms (share of grant versus loan financing from India, simple - non capitalized interest rate, amortization period, with the first repayment starting one year from the mean date of commercial operation).

[12] Joint IMF/World Bank Sustainability analysis, 2009

Interim Arrangement for Dagachhu Hydro Power Corporation (DHPC)

The Dagachhu Hydro Power Corporation (DHPC), a 126 MW hydropower project in Bhutan is a joint venture of Druk Green Power Corporation Limited (DGPCL) and Tata Power Company Limited (TPCL). The project is at an advanced stage of commissioning and is likely to start commercial operations shortly. The Tata Power Trading Corporation Limited (TPTCL) intends to sell the power procured from this plant in the short term market in India. The Royal Government of Bhutan and GoI signed an interim arrangement for DHPC due to the complexities for undertaking short term power trade in CBET.

Interim arrangement agreed for DHPC:

- Settlement of accounts for all the power imported from Bhutan shall be at the Indian periphery.
- Schedule of injection of Dagachhu power (15 minutes time block-wise) at Indian periphery is made available by NLDC Bhutan/designated nodal agency to NLDC India/ERLDC on day ahead basis.
- Power imported by TPTCL from DHPC shall attract all the relevant provisions of regulations of the Central Electricity Regulatory Commission (CERC). Point of Connection (POC) charges shall be payable for interchange of power by the Dagachhu project at Indian periphery as per the CERC regulations which shall be payable by TPTCL.
- The POC charges should be charged at single injection point irrespective of the number of points of actual injection.

Conclusion

CBET is a boon for the Bhutanese economy; Bhutan through its high hydro potential would be able to double its per capita income and reach new heights of prosperity. Investors/developers would have great opportunities for getting attractive returns at minimum risk in Bhutan CBET projects.

It is expected that Bhutan's long term power plan would create an opportunity of exporting 80,000-90,000 MU annually and create a stable yearly revenue generation stream. This revenue generation stream would provide a big boost to the GDP to the tune of 40 per cent of the current GDP. However, the monthly power export would fluctuate a lot as per the seasonal variation.

The power generated from the existing and the prospective hydropower plants would be largely sold to India. Concomitantly, the import requirements associated with the construction of these power plants are expected to maintain pressure on the debt and current account deficit during the construction stage of these projects; however, currently financing such projects is not an issue. The balance of trade is expected to move from deficit to surplus, once these projects start production. Similarly, the public debt as well as external debt position will improve significantly, as the various hydropower projects start generation.

Hydropower projects are the backbone of Bhutan's economy and would continue to be in the next coming years. The risk in inter-governmental projects is very low; however after having a good track record of power trade between India-Bhutan, the mode of project execution is shifting from IG to JV and PPP mode with minimal risk.

Slippages in CBET projects will hugely impact the export earning capacity of the projects as the increase in domestic demand will reduce surplus electricity in the future. Therefore, Bhutan would not like to delay these upcoming hydropower projects, as the delay would cause the country to lose huge export earnings.

Bibliography

- Population and Housing Census of Bhutan, (2005)
- Energy Balances and Electricity Profiles (2010), United Nations Statistics Division; http://unstats.un.org/unsd/energy/
- Statistical Year Book of Bhutan, 2012, 2013; http://www.nsb.gov.bt/publication/files/pub9ot4338yv.pdf
- National Tranmission Grid Master Plan Vol-I, CEA-2012;http://www.cea.nic.in/reports/articles/ps/ntgmp_volI.pdf
- National Transmission Master Grid Plan Volume-II, CEA-2012
- World Bank Data Source-2013; http://databank.worldbank.org/data/home.aspx
- ADB Data Source-2014
- Embassy of India: Thimpu, Bhutan; http://www.indianembassythimphu.bt/pages.php?id=38
- Electricity Act of Bhutan-2001. http://www.nationalcouncil.bt/wp-content/uploads/2011/02/Electricity_En_01.pdf
- Tariff Determination Regulation, BEA-2007; http://www.bea.gov.bt/wp-content/uploads/2013/12/Tariff-Determination Regulation.pdf
- Selected Economic Indicator, 2003,2007,2012,2014; http://www.rma.org.bt/RMA%20Publication/SEI/SEI%20DEC2012.pdf
- National Accounts Statistics, RGoB-2013; http://www.nsb.gov.bt/publication/files/pub7mz4450wg.pdf
- Operating procedures for Eastern Region (ERLDC: POSOCO), 2014; http://www.erldc.org/op.pdf
- Annual Transmission System Performance Report for the Year, NLDC, BPC-2013; http://nldc.bpc.bt/index.php/downloads/2013-07-08-11-33-58
- The Hydro-Electrical Power Sector in Bhutan: An Economic Assessment, 2013
- Bhutan: In Pursuit of Sustainable Development (RGoB), 2012; http://sustainabledevelopment.un.org/content/documents/798bhutanreport.pdf
- Joint IMF/World Bank Debt Sustainability Analysis Bhutan, 2012; http://www.imf.org/external/pubs/ft/dsa/pdf/dsacr09334.pdf
- Economic Development Policy of the Kingdom of Bhutan (RGoB), 2010; http://rtm.gnhc.gov.bt/wp-content/uploads/2013/10/EDP.pdf
- Alternate Renewable Energy Policy-2013 (RGoB); http://www.moea.gov.bt/documents/files/pub0ip10496bv.pdf
- Afghanistan: Renewable energy country profile, IRENA; http://www.irena.org/REmaps/countryprofiles/asia/Afghanistan.pdf
- Bhutan National Human Development Report: 2000, RGoB; http://hdr.undp.org/sites/default/files/bhutan_2000_en.pdf
- Bhutan Country Strategy 2010–2013, Austrian Development Corporation; http://www.entwicklung.at/uploads/media/CS_Bhutan_2010-2013_July2011_01.pdf
- 4th Round of Discussion on Business Opportunities in BIMSTEC countries 2013, ASSOCHAM; http://www.assocham.org/old-site/docs/brief-note-on-BIMSTEC.pdf
- Dispute resolution procedure, 2009, BEA; http://www.bea.gov.bt/wp-content/uploads/2013/12/dispute-regulation-procedure.pdf
- Cross-Border Electricity Trade in South Asia: Challenges and Investment Opportunities, 2014 SARI/EI concept paper

About SARI/EI

Over the past decade, USAID's South Asia Regional Initiative/Energy (SARI/E) has been advocating energy cooperation in South Asia via regional energy integration and cross-border electricity trade in eight South Asian countries (Afghanistan, Bangladesh, Bhutan, India, Pakistan, Nepal, Sri Lanka and the Maldives). This fourth and the final phase, titled South Asia Regional Initiative for Energy Integration (SARI/EI), was launched in 2012 and is implemented in partnership with Integrated Research and Action for Development (IRADe) through a cooperative agreement with USAID. SARI/EI addresses policy, legal and regulatory issues related to cross-border electricity trade in the region, promotes transmission interconnections and works toward establishing a regional market exchange for electricity.

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For more information on the South Asia Regional Initiative for Energy Integration (SARI/EI) program, please visit the project website:

www.sari-energy.org