Department of Renewable Energy
Ministry of Economic Affairs
Royal Government of Bhutan
ISBN 978-99936-703-2-2

Bhutan Energy Data Directory 2015

Bhutan

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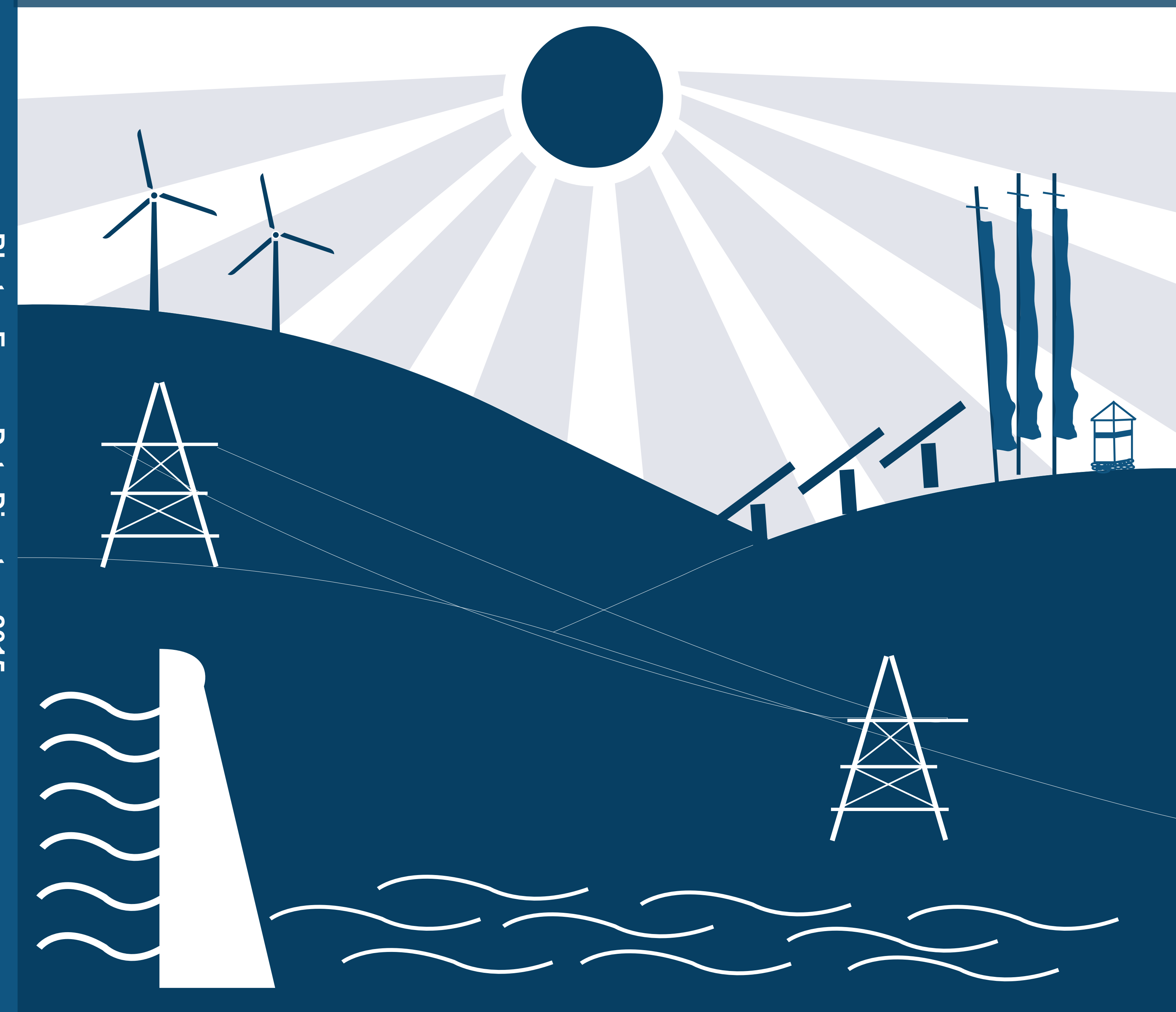

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Published by
Department of Renewable Energy
Ministry of Economic Affairs
Thimphu, Bhutan

Post Box No. 266
Tel. +975 2 334826/ 339501
www.moea.gov.bt

Printed by Bhutan Printing Solutions, Thimphu, Bhutan

FOREWORD

Over the years, Bhutan has witnessed steadfast growth in the economy and has been able to make impressive progress in achieving the Sustainable Development Goals, which are prudently embedded in the five-year plans. In the current Eleventh Five-year Plan, the Royal Government of Bhutan accords the highest priority to enhance the energy security of the Country. This is important since almost all other fossil energy needs are met through imports and electricity generation is predominantly dependent on the hydropower, which might be adversely affected by the climate change if alternative plans are not put in place.

Nonetheless, the Royal Government of Bhutan is continuously striving to be self-reliant and self-sufficient. This effort can be seen manifested in its policies and strategies of energy sector, which is all geared towards diversifying the energy-mix through the promotion of renewable energy technology and demand side management initiatives.

The Department of Renewable Energy has updated the Energy Data Directory 2005 with the financial support from the Norwegian Government under Energy+ Partnership Programme administered by the Asian Development Bank under TA 8630-BHU. This Energy Data Directory 2015, which has been updated based on extensive field surveys and detailed energy audits of the relevant sectors, provides the energy scenario through three lenses viz: the energy supply, the energy demand and the energy balance with a section on growth forecast under baseline and energy efficient scenarios.

In 2014, the total energy consumption in the Country is estimated at 650,220 TOE (tons of oil equivalent) with the highest consumption being in the Building Sector. However, the maximum growth from 2005 to 2015 is noted in the Industry and Transport Sectors with an increase of over 200% in terms of energy consumption. It is also found that biomass continue to serve as the primary energy resource for the Country followed by the use of electricity generated from hydropower plants. Over the last one decade, the study shows that the electricity consumption of an average Bhutanese has increased almost by three folds while the annual fuel wood consumption has tapered off slightly.

Nevertheless, I hope, the Bhutan Energy Data Directory 2015 will serve to be useful for all the stakeholders to evaluate and understand the impacts of the policy interventions in the energy sector in particular and the economy at large.

Tashi Delek.

(Dasho Yeshi Wangdi)
Secretary, Ministry of Economic Affairs

ACKNOWLEDGEMENT

The Bhutan Energy Data Directory 2015 is an initiative of the Department of Renewable Energy, Ministry of Economic Affairs, Royal Government of Bhutan and the study was conducted by the consultant, Ernst & Young LLP, India with funding from the Government of Norway and Asian Development Bank under the Energy Plus Programme: Clean Energy Development in Bhutan.

The Department of Renewable Energy and Ernst & Young LLP are grateful to the Government of Norway for providing the opportunity to conduct this study and the Asian Development Bank for providing continual support throughout the programme.

The Department of Renewable Energy and Ernst & Young LLP express gratitude to all stakeholders: Bhutan Electricity Authority, Bhutan Power Corporation Limited, Department of Cottage and Small Industry, Department of Engineering Services, Department of Forest and Park Services, Department of Geology and Mines, Department of Human Settlement, Department of Hydro-met Services, Department of Hydropower and Power Systems, Department of Industry, Department of Revenue and Customs, Department of Trade, Druk Green Corporation Limited, Greener Way, National Statistics Bureau, Natural Resources Development Corporation Limited, Road Safety and Transport Authority, Thimphu Thromde and others for their valuable contribution and support without which this energy data directory would not have been possible.

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List of Acronyms

AC	Air conditioner
AED	Alternate Energy Division, DRE, MoEA
ATF	Aviation Turbine Fuel
BAU	Business as Usual
BEE	Bureau of Energy Efficiency, India
BIG	Bhutan Industrial Gas
BOC	Bhutan Oil Corporation
BOD	Bhutan Oil Distributor
BPC	Bhutan Power Corporation Limited
BPCL	Bharat Petroleum Corporation Limited, India
BSB	Bhutan Standards Bureau
CAGR	Compounded Annual Growth Rate
CDB	Construction Development Board
CFL	Compact Fluorescent Lamp
CSI	Cottage and Small Industries
DES	Department of Engineering Services, MoWHS
DHPS	Department of Hydropower and Power Systems, MoEA
DOI	Department of Industry, MoEA
DOT	Department of Trade, MoEA
DPD	Damchen Petroleum Distributors
DPCL	Druk Petroleum Corporation Limited
DRE	Department of Renewable Energy, MoEA
EDP	Economic Development Policy 2010
EE	Energy Efficiency
EV	Electric Vehicle
FI	Financial Institution
FO	Furnace Oil
GDP	Gross Domestic Product
GNHC	Gross National Happiness Commission
HSD	High Speed Diesel
HV	High Voltage
IFC	International Finance Corporation
IOC	Indian Oil Corporation
KPI	Key Performance Indicator
LEAP	Long Range Energy Alternatives Planning
LED	Light Emitting Diode
LV	Low Voltage
MEPS	Minimum Energy Performance Standards
MoF	Ministry of Finance
MOIC	Ministry of Information and Communications, Bhutan
MOWHS	Ministry of Works and Human Settlement
MV	Medium Voltage

NABL	National Accreditation Board for Testing and Calibration Laboratories
PCD	Planning & Coordination Division, DRE, MoEA
PM	Particulate Matter
PRGF	Partial Risk Guarantee Fund
RE	Renewable Energy
RMA	Royal Monetary Authority
RSTA	Road Safety and Transport Authority
S&L	Standards & Labelling
SKO	Superior Kerosene Oil
TA	Technical Assistance
VFD	Variable Frequency Drive

List of Units

‘000	Thousand
GWh	Gigawatt hour
kW	Kilowatt
Kl	Kilo litre
kV	Kilo Volt
kWh	Kilowatt hour
kVA	Kilo Volt Ampere
GJ	Gigajoule
M	Million
MW	Megawatt
Nu	Ngultrum
TJ	Terajoule
TOE	Tonnes of oil equivalent
USD	United States Dollar

EXECUTIVE SUMMARY

Bhutan is one of the smallest yet emerging economies, landlocked between China and India. The country spreads over 38,394 sq. km and is inhabited by a population of around 745,153 (NSB, 2014). Cradled in the mountainous terrain of the Himalayas, industrial and mechanized development has taken its time to imbibe into the Bhutanese economy with the construction of modern infrastructure proving to be cumbersome and expensive. Even back in 2009, the economy was primarily reliant on agriculture and forestry that provided livelihood to 70% of the population (MoEA, 2009).

On the trade front, Bhutan is intrinsically linked with India. It is to be noted that all petroleum products are imported from India. With more than 80% of Bhutan's imports coming from India and an exchange rate at par with the Indian Rupee, Bhutan's consumer inflation follows that of India's (World Bank, 2014). On the energy front, chief commodities which are imported include petroleum products and other light oils which accounted for more than 30% of the import portfolio in 2012.

The rate of GDP growth, after reaching a high of 11.73% in 2010 has moderated to around 2.05% in 2013 (NSB, 2014). Hydropower, cement, wood and food products constitute the primary industries of Bhutan, with agriculture (17% of GDP in 2012), construction (16% of GDP in 2012) and electricity and water supply (12% of GDP in 2012) comprising the major economic activities of the country. Like other developing countries, Bhutan has recognized the importance of energy for social development and poverty reduction through economic development. A high growth rate in rural electricity access in the last decade is a major indicator of the effort put in by the Government. Bhutan's advantage critically hinges on the excess supply of electrical energy which earns large revenue catering to the current account deficits, consequently balancing trade. Even the industrial development has mainly relied on the availability of relatively cheap hydroelectricity. Currently, hydropower is the main resource for electricity generation whereas biomass (in the form of fuelwood) is the main resource for meeting residential energy needs, such as cooking and space heating. Imported fossil fuels include mainly petroleum products and coal. Among these, petrol and diesel are used for transport while kerosene and LPG (liquefied petroleum gas) are mainly used in the building sector.

The Bhutan Energy Data Directory 2015 focusses mainly around the 'priority energy consuming sectors' which includes energy consumption in Building (residential, institutional and commercial), Industry and Transport sectors, and the energy supply primarily in the form of electricity, fossil fuels and biomass. As the energy data directory mainly revolves around the energy demand and supply in the priority sectors, it also takes into consideration the scattered, but developing usage and potential of renewables like solar, wind and waste. The essential feature of the energy data directory is the energy balance which caters to map out the demand and supply of energy in the country while highlighting the sectors, where the energy is flowing into. Given the energy consumption at the sectoral level, it is easy to identify which sector consumes how much of energy at the aggregate level. However, for designing the policy or action plan to improve the efficiency of energy usage it is imperative to understand the type and volume of fuel that is being consumed at the aggregate level and trends of the same. For the estimation of energy consumption in the three primary sectors: Building, Industry and Transport, the study relies mostly on the primary data gathered through nation-wide surveys and secondary research on the publications of the various government agencies and institutions which report on energy consumptions. The surveys conducted were concentrated on the volume and pattern of fuel consumption in the different sectors whereas the secondary data was sufficient to estimate the aggregate energy consumption. The household survey conducted covered 1875 households and 75 non-residential buildings across all dzongkhags accounting for the consumption of different fuel types. In the Industry and Transport sectors, the secondary data were validated and characteristics established with the help of comprehensive industry audits and vehicular and road surveys. While this exercise gives a snapshot of the energy dynamics of the economy, the directory further provides the future scenario of the fuel mix: First with the energy situation projected with the growth rates as it has been over the last decade and second with a sample scenario of Energy Efficiency interventions in the economy.

In 2014, Bhutan consumed 650,220 TOE of energy. The maximum energy consumption was noted in the Building and Industry sectors with 78.8% of the total consumption. The Building sector consumed 270,356 TOE while the Industry sector consumed 241,972 TOE. The Transport Sector noted 18.64% share in the energy consumption (121,218 TOE) in 2014 with the remaining 2.6% energy being consumed for agricultural and auxiliary activities.

The total fuel consumption in Bhutan is dominated by biomass in the form of fuelwood, biogas and briquettes – amounting to 234,369 TOE (36%). This is followed by electricity at 28% - amounting to 180,092 TOE. Other than biomass and electricity, other major sources include coal (97,567 TOE) constituting 15%; and diesel, which amounts to 102,107 TOE (16%). The remaining, petrol, kerosene and LPG – together constituting around 5% of the total fuel mix.

The fuel break up also depicts the dependency of the economy on the different fuels and measures the shifts in dependency over time. Due to significant increase in electrification in the last decade, Bhutan has seen a paradigm shift in the fuel dependency from biomass (mainly fuelwood) to electricity.

Building Sector: The Building Sector has been categorized into two segments: Residential segment; and the Commercial and Institutional segment. The residential segment mainly comprises of urban and rural households while the commercial and institutional segment includes schools, universities, army camps, government office buildings, hotel, shops and restaurants. The building sector energy consumption scenario is discussed below:

i) Residential: In comparison to the year, 2005, the consumption of electricity has increased by a Compounded Annual Growth Rate (CAGR) of 10.1% in 2014 whereas biomass and kerosene consumption has decreased from 2005 to 2014 at a CAGR of 1% and 6.9% respectively. The use of biomass is probably substituted by the use of LPG and electricity as indicated by the increase in the use of LPG (CAGR of 6.9 %) mainly for cooking purposes and the increase in use of electricity for heating.

ii) **Commercial and Institutional[1]:** The institutional and commercial segment has shown a high increase in the consumption of electricity with a CAGR of 8.4% compared to 2005. An unexpected growth by CAGR 5.5% in the use of biomass is observed while there is a drastic fall in kerosene use by a CAGR of 9.9%.

Industry Sector: The total number of industries in the country has been increasing over the years. It is observed that the heavy industries are largely electricity-intensive while the small and cottage industries also depend mostly on electricity. This is one of the prime reasons as to why the demand for biomass has fallen in the Industry sector over the last decade by CAGR of 21%. Apart from electricity, the other main fuel used in industries is coal and its derivatives.

Comparing with the data reported in 2005, the electricity consumption in industries increased by a CAGR of 15.27% from 2005 to 2014 and the coal consumption also increased by a CAGR of 9.93%[2].

1 Due to the overlapping characteristics and trends in institutional and commercial buildings across regions, the estimation for population in this segment has been a limitation. For simplicity, they have been clubbed together and their energy consumption considered more as a residual of the residential consumption.

2 The Bhutan Energy Data Directory 2015 also considers the use of coke and similar derivatives of coal being used in the industries. Hence, for the CAGR calculation only coal is being considered as the 2005 Data Directory does not consider the derivatives. Same logic is followed for biomass and its components.

Transport Sector: The analysis of vehicle types shows that diesel and petrol are the main fuels used in road transport along with some minor amount of electricity. While diesel is also used in the industrial sector for heating operations and power generation, petrol is used exclusively for road transport. Vehicles and transport fuels are among the top 10 imports of 2014 based on the value of the import. In 2014, the total use of ATF, Petrol and Diesel increased by a CAGR of 13.4%, 6.3% and 9.5% respectively as compared to 2005.

Uptake of renewable and alternate energy will result in decreasing import of fuels (mainly diesel and petrol). This is due to more energy efficient usage of energy and increase in usage of domestically produced energy (electricity) which serves as the objective of energy efficiency interventions in the economy. While there are substantial emissions from conventional vehicles, electric vehicles are emission-free. Introduction of electricity in the transport sector has already taken off as indicated by the 61 electric vehicles being registered in the country as of December, 2014 (RSTA, 2015). Development of supportive infrastructure in this regard can revolutionize the domestic economy, with a possibility of substitution of petroleum products for electricity as a vehicular fuel consequently reducing the burden on government budget. Renewable energy and its technical understanding is common knowledge to many countries and forms a promising solution for energy crisis. However, the penetration of such technologies on a nationwide level is low for most developing and less developed economies. Though these technologies are mature enough to be used in place of conventional technologies, the upfront cost of implementation is quite high (Loiter, 1998). The scenario for renewable energy development in the country is driven by policy and uncertainty of the decision maker because the population is more often than not, heavily dependent on the conventional technologies. Though renewable energy supply seems promising, the challenges still remain in terms of new innovation, technology, efficiency, system stability, user acceptance and cost reduction. The challenges in renewable energy supply remains to be addressed at policy level.

Information management in terms of energy and resources is highly decentralized and gathering data often becomes a challenge when complete data is not available at a single source and possibility of information mismatch also exists. Keeping the constraints in mind, there is a need for a common information pool for energy data management which can be accessible to the major stakeholders who can periodically update information in the portal in a common comprehensive format. Although, such attempts have been made by certain departments at a decentralized level, there is a need to develop a more robust structure that can cater to all the key stakeholders enabling easy access to relevant energy related information, increasing datapoints with better inter-departmental information and communications.

1. INTRODUCTION

While the world looks forward to development with low GDP-emission intensity, Bhutan is already a carbon-neutral economy. Bhutan emits 2.2 million tonnes (NECS, 2015) of carbon dioxide equivalent (CO_2e) against the sequestration by forests (70.46% land cover according to Land Cover Mapping Project, 2010, NSSC). According to the World Bank, the country's current carbon emission rate is a negligible 0.8 metric tons per capita. Not only is Bhutan carbon neutral, it is also a carbon sink (World Bank, 2012), making it one of the few countries in the world to have negative carbon emissions. Despite this, Bhutan aspires to further reduce its greenhouse gas emissions by 2020, while also going 100% organic by 2020 and zero-waste by 2030 (Mellano, C, 2015). With the increasing energy demand in the process of development and consequently increasing pollution, Bhutan plans to utilize cleaner energy as much as possible. The idea is well documented in the Intended Nationally Determined Contribution (INDC) submitted by the country for the Paris Conference of Parties – COP 21.

During the period 2000-2013, emissions from the energy sector increased by 191.6% from 0.27 million tons of CO_2e in 2000 to 0.79 million tons of CO_2e in 2013. During the same period, emissions from industrial processes increased by 154.3% from 0.24 million tons of CO_2e to 0.6 million tons of CO_2e. Emission from waste management also increased by 247.54% from 0.047 million tons of CO_2e to 0.16 million tons CO_2e.

Currently, hydropower is the main resource for electricity generation in Bhutan whereas biomass in the form of fuelwood cater to the majority of the residential energy demands, such as cooking and space heating, especially in the rural areas. Wood is also used for construction purposes and by some industries that use fuelwood, woodchips and briquettes for heating. Imported fossil fuels which mainly include petroleum products like kerosene and Liquefied Petroleum Gas (LPG) are also used in the residential and commercial building sectors while petrol, diesel and Aviation Turbine Fuel (ATF) are mainly used for transport. The heavy industries, which are primarily dependent on electricity as the base fuel, have also shown increasing dependency on diesel (mainly HSD) and coal of various types. With the country having more than 95% of its households connected to the grid (BPC, 2015), dependence on electricity has had far reaching impacts in the change of fuel-mix over the last decade. Electricity is generated from hydro-sources, which is not only non-polluting but also has very low impact on the environment. The hydropower resources which are mainly 'run-of-the-river' type have little impact on the environment because they are built on deep gorges resulting in much lesser submergence of land[3] . With the Dagachhu Hydropower being commissioned in 2015, the current capacity for electricity in Bhutan from large hydropower alone stands at 1606 MW which, more than suffices the domestic demand in the summer months. Bhutan is currently a net power surplus economy. However, in the lean winter seasons, Bhutan imports electricity from India.

In this scope of inclusive development in the energy consuming sectors, it is essential to maintain a record of the quantum of energy used in the various sectors and the pattern of usage. This would not only provide a ready reference to the sectoral energy supply and consumption numbers but also develop a database of energy for further development work in the light of imbalance in the global resource constraints and increasing demand of energy.

Apart from electricity, Bhutan has abundance of biomass and the diversity is rich in terms of medicinal values. Albeit the acute deficit in domestic fossil fuels there does exist some amount of coal in the country. The domestic coal is partly consumed within the country (for

3 In consultation with Department of Hydropower and Power Systems officials industrial processes) while the remaining is exported to India and Nepal. However, a large amount of coal is imported from India by the heavy cement and ferro-alloy based industries.

Similar to other least developing countries (LDCs), the reliance on energy for social and economic development and poverty reduction is a preponderating issue for Bhutan. A major indicator of the effort put in by the Government using a 'Carrot and Stick' policy for inclusive development in the energy consuming sectors is apparent. On one hand, there is an increasing usage of cleaner energy through the increased rural electricity access in the last decade and through subsidies for the low voltage electricity consumers while on the other hand the Government is trying to curb the dependency on fossil fuels by imposing heavy tariff on conventional vehicles, which are the major consumers of petroleum fuel. Even on the economic front, Bhutan's advantage critically hinges on the excess supply of electrical energy which earns large revenue catering to the current account deficits, consequently balancing trade. Even the Industrial development has mainly relied on the availability of relatively cheap hydroelectricity and currently the country looks forward to promoting usage of electricity in the transport sector as well.

The first Energy Data Directory for Bhutan was developed by the erstwhile Department of Energy, under the Ministry of Trade and Industry with the consultants from The Energy and Resources Institute (TERI) in 2005. The energy data directory was developed as part of the Department's Integrated Energy Management Master Plan project. This was the 'first-ever' comprehensive analysis of the energy sector in Bhutan, covering all aspects of energy consumption and supply. Thereafter, the data directory has served as the baseline for numerous development initiatives concerning energy. Although, there were some researches on the energy usage and patterns following the Data Directory 2005, this document has not undergone update since then.

The Energy Data Directory is being updated under the Energy Plus Programme funded by the Government of Norway. The main objective of the Bhutan Energy Data Directory 2015 is, therefore, to update data from Bhutan Data Directory-2005 and carry out a comprehensive analysis of the energy supply and demand situation in the country, which can be used to assess the change in the pattern of energy consumption across Bhutan and also serve as a baseline information for the analysis of future energy demand–supply scenarios and their implications on socio-economic aspects such as environment, economy, industrial development, employment, health, and education.

Approach and Methodology:
The study is specially focused on deriving the energy consumption in the major sectors: Building Sector, Industry Sector and the Transport Sector while the remaining consumption is attributed to Agriculture sector and other auxiliary consumptions. For the estimation of energy consumption in these sectors, the study relies mostly on the primary data gathered through nationwide surveys and secondary research on the publications from the various government agencies and institutions which report on energy consumptions. The surveys concentrated on the volume and pattern of fuel consumption in the different sectors whereas the secondary data was used to estimate the aggregate energy consumption.

Buildings Sector: The surveys covered 1,875 households and 75 non-residential buildings across dzongkhags accounting for the consumption of different fuel types.

- **Residential segment:** The main end-uses that contribute towards energy consumption in the residential sector are cooking, space heating, lighting, and others such as entertainment, cold storage, etc. A comprehensive primary survey of 1875 households[4] across 20 Dzongkhags was carried out to estimate the energy consumption in the residential sector. Secondary sources of information includes the Bhutan Power Corporation's Power Data Handbook – 2014, Bhutan Living Standard Survey conducted in 2012, Bhutan Statistical Yearbook from 2004 to 2014 and Baseline Study of Fuels -2013 carried out under GEF/UNDP Project.

- **Commercial and Institutional segment:** Energy used for commercial activities, such as in shops and hotels; in institutions, such as hospitals, schools, religious institutes, and government offices; and for municipal services, was estimated using primary and secondary data. Secondary data on energy consumption was available from the Bhutan Power Corporation's Power Data Handbook – 2014 Bhutan Living

4 Removing the no-response samples

Standard Survey conducted in 2012 and Baseline Study of Fuels -2013 carried out by GIF and the Royal Government of Bhutan. Primary data was collected for 75 Institutional units and extrapolated for deriving the total consumption of the population. Commercial figures are derived from Energy Audits in buildings and secondary fuel usage data reported by BPC and DoFPS.

Industry Sector: The energy consumption data was collected from agencies such as the Bhutan Power Corporation Limited, Department of Geology and Mines, Department of Industry, the industries themselves and further verified by Energy Audits conducted by certified Energy Auditors in 39 industrial units and one hydropower plant (to study and analyse the energy performance of a typical hydropower plant station). The audited figures helped to comprehend the characteristics of fuel usage and consumption of various fuels in different industries.

Transport Sector: The vehicle audits were carried out to understand and develop an idea about the pattern of energy consumption by different types of vehicles in Bhutan. The vehicle population data was collected from the RSTA (Road Safety and Transport Authority) and the study by the EY for the Energy Efficiency interventions in the Transport sector. Petroleum fuel import data was collected from the Department of Trade, petroleum product distributors, and also from the Department of Revenue and Customs. To further update the figures and fill in the gaps in the data, the study- Technical Support to the Low Emission Capacity Building (LECB) Programme on Decision Support Tool for the development of NAMAs in Bhutan was also referred.

The following is a content overview of the Energy Data Directory 2015:

- **Institutional Structure:** This chapter in the directory provides introduction to the key institutions who are the stakeholders of the energy sector in the country. The institutional structure presents the main roles of the institutions in the scope of energy supply and consumptions through various fuels being produced, traded and consumed in the country.
- **Supply of Energy:** The directory presents the energy supply scenario in the country and the trend in supply over the years, presented in the form of Compounded Annual Growth Rate (CAGR)[5] .
- **Energy Demand:** Given the supply of the different fuels, the sector demand for energy has been studied where the supply of different fuels has been mapped onto the different sectors. This enables development of the energy balance for the country where the total aggregate supply is equated to the aggregate demand for energy in the economy segregated into different sectors and different activities under sectors.
- **Energy Balance and Fuel Mix:** This chapter focusses on the energy balance in the country. The content is a conclusive analysis to the sectoral energy scenarios and fuel mix, aggregating the energy consumption and supply at the national level. This helps to comprehend the pattern consumption of the energy in the country and the contribution of each sector and each fuel to the total energy usage.
- **Conclusion and Way Forward:** In this final chapter the future energy demand scenarios are presented. Two scenarios have been developed till the year 2030: The first scenario depicts the energy demand situation of the country in the Business-as-Usual case which is then compared to the Energy Efficient scenario, where energy efficiency interventions have been taken into account[6].

5 CAGR is a measure of a compounded growth from initial to final year. To compare the growth, CAGR was chosen to understand the cumulative growth over the years

6 Detailed methodology is provided in Appendix 7.1

2. INSTITUTIONAL STRUCTURE

This chapter looks into the various agencies which are in the planning and co-ordination, regulations and operations in the scope of energy through management of various fuels' supply and consumption in the country.

2.1 Key Institutions and Organizations related to the Energy Sector in Bhutan

The Royal Government of Bhutan has ten ministries which work in bringing the goal of national development to reality. The ten Ministries are:

- ► MoEA : Ministry of Economic Affairs
- ► MoE : Ministry of Education
- ► MoF : Ministry of Finance
- ► MoFA : Ministry of Foreign Affairs
- ► MoH : Ministry of Health
- ► MoHCA : Ministry of Home and Cultural Affairs
- ► MoIC : Ministry of Information and Communications
- ► MoLHR : Ministry of Labour and Human Resources
- ► MoWHS : Ministry of Works and Human Settlement
- ► MoAF : Ministry of Agriculture and Forests

However, the activities under the scope of energy in Bhutan is mainly planned and coordinated by two ministries: Ministry of Agriculture and Forests, and Ministry of Economic Affairs, with the former focusing on the administration of biomass, planning and designing policy for utilization and maintenance of forest resources and the latter being responsible for policy formulation, planning, coordination and implementation of both conventional and renewable energy generation, consumption and exports as well as import of fossil fuel.

The agencies which are responsible for planning, coordination and implementation of energy related policies and programmes are listed in figure 1:

1. The Department of Renewable Energy (DRE)
DRE was established in December 2011 with the mandate to serve as the central coordination agency and the focal point of Royal Government of Bhutan (RGoB) on all matters related to Renewable Energy development and Energy Efficiency initiatives in the country. Figure 2 elaborates on the organogram of DRE and its constituent divisions.

Specific functions of the divisions are as follows:

Alternate Energy Division (AED): AED carries out implementation of the policy regulations related to Renewable Energy. The division is responsible for investigation, identification, design and planning of RE systems covering solar, wind, bio fuels, fuel cells, geothermal and small hydropower plants. AED also implements pilot/ demonstration RE projects and manages the tendering of all reconnaissance, pre-feasibility, feasibility and DPR studies for RE projects. The division serves as the focal point for RE.

Planning and Coordination Division (PCD): PCD is involved in formulation of policies and regulations for Renewable Energy, Energy Efficiency and Conservation.

It is responsible for planning and coordination of programmes and initiatives for RE projects and Energy Efficiency measures. PCD is also mandated to administer and implement subsidy programmes and initiatives on RE projects and EE&C measures. Techno-economic clearances and technical sanctions for RE projects are routed through this division. The division is also responsible for energy data collection and analysis.

Research and Development Division (R&DD): R&DD carries out applied research and development in Renewable Energy and Energy Efficiency technologies. The division carries out promotion of Renewable Energy and Energy Efficiency while it is also tasked with analysing market opportunities and risks for energy systems. The division is to develop testing and certification procedures and testing facilities, including the development of minimum energy performance standards and labelling design for equipment and appliances. R&DD promotes the use of energy efficient processes, equipment, devices and systems, and carries out promotion of innovative financing of Energy Efficiency projects and preparation of educational contents on efficient use of energy and energy conservation.

Figure 1: Key Institutions and Organizations related to the Energy Sector

Planning And Coordination

Department of Renewable Energy	**Department of Trade**	**Department of Geology and Mines**
Policy, Planning and Assessment of renewable energy	POL section looks after the import of petroleum products	Responsible for managing mining of minerals and coal
Department of hydro-MET Services	**Department of Hydropower and Power Systems**	**Department of Industry**
Record and assess wind, solar and hydro resources	Policy and planning of hydropower generation	Looks after the operations of industries and licensing
Department of Forest and Parks Services	**Department of Livestock**	**Department of Cottage and Small Industry**
Record and maintain information on biomass (wood)	Develop policies, strategies and guidelines, to ensure efficient livestock services	Planning and Coordination of small and cottage scale industries

Regulatory Authorities

Bhutan Electricity Authority	**Road Safety and Transport Authority**	**National Environment Commission**
Regulation of electricity generation and distribution in the country	Monitoring, Planning and coordination of transport and communications	Design, monitoring and regulation of environmental laws

Operating Players

Druk Green Power Corporation

Generation of electricity and sales to Bhutan Power Corporation and export to India

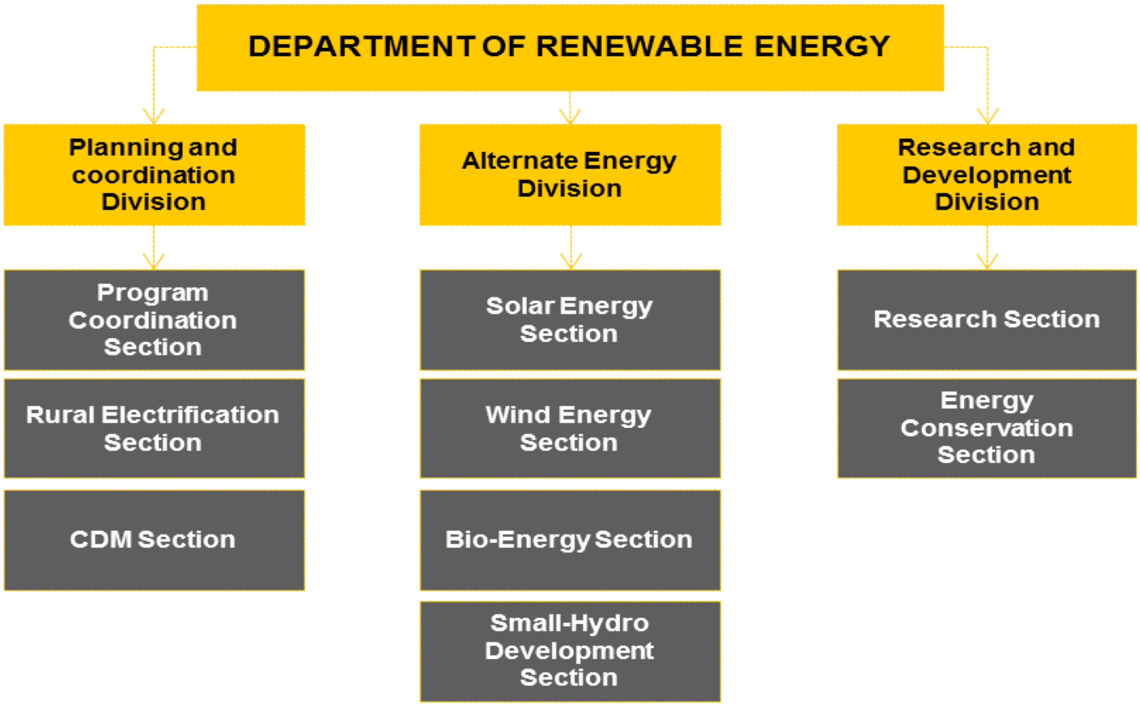
Bhutan Power Corporation Limited

Transmission and Distribution of electricity

Natural Resources Development Corporation Limited

Management of natural resources such as timber, sand and stone and making resources available, affordable and accessible

Figure 2: Organogram of the Department of Renewable Energy



2. Department of Trade

One of the mandates of the Department of Trade (DoT) is to ensure free, smooth and predictable trade and enhance market access. "The Royal Government of Bhutan, recognizing private sector as an engine of economic growth, is committed to provide all support necessary particularly in terms of creating an enabling environment to promote entrepreneurship and business activities for gainful employment of the youth and population at large" (DoT, 2015).

DoT represents the Government at bilateral, regional and multilateral levels pertaining to trade and economic cooperation. DoT develops licensing procedures, which ensures a fair and equitable marketplace, and provides safe products and services for consumers. It is also responsible for formulation of export policy and strategy for export while actively facilitating export. The Department is responsible for developing trade information database and providing information to the public.

The Petroleum, Oil & Lubricant (POL) section under the Department of Trade records the petroleum fuel imports providing a vital source for calculating energy supply from imports.

The trade records on fuels provide valuable understanding of the country's energy dependency on imports and devise suitable policies to cater to the issue of energy security.

3. Department of Hydro-Met Services

The primary objective of the Department is to "observe and understand weather, climate and hydrology to provide appropriate meteorological, hydrological, flood, glaciers and related services in the country" (DHMS, 2015). DHMS provides weather, water, climate and related environmental services such as daily forecasts of weather and severe weather warnings, early warnings, agro-meteorological services and hydro-meteorological data.

Data on energy utilization from water, wind and solar potential in the country is assessed by the DRE on the hydro-meteorological data provided by DHMS.

Some of the key responsibilities of DHMS are:

- Provide an effective national source of hydro-meteorological data, service, and advice to meet the needs of the general public, emergency services and other specialized users.
- Develop effective hydro-meteorological and flood warning services network and database to provide appropriate and timely services and products.
- Strengthen institutional and capacity development to staff and
- Strengthen cooperation with national, regional and international organization to carry out research and development study related to hydro-meteorology and water resource

4. Department of Industry

The Department of Industry (DoI) promotes sustainable industrial development in the country and regulates large and medium scale industries and FDI enterprises covering the industrial sector classified broadly under manufacturing and services.

The department is responsible for developing industrial policies and strategies, and providing support to promoters and industries. The Department also develops, manages and provides services related to Industrial infrastructures.

DoI implements the Companies Act of the Kingdom of Bhutan and enforces environmental laws pertaining to large and medium scale industries.

5. Department of Geology and Mines

The Department of Geology and Mines (DGM) under the Ministry of Economic Affairs carries out geological mapping and mineral exploration in the country. DGM carries out geotechnical and engineering geological investigations, and monitors seismic activities and climate change induced geo-hazards such as landslides. DGM also conducts research on Glacial Lakes and propose remedial measures for GLOF risk reduction.

The Department maintains and disseminates mines and mineral information such as the coal being extracted, exported and imported in the country.

6. Ministry of Agriculture and Forests

The Ministry of Agriculture and Forests (MoAF) strives to ensure sustainable social and economic well-being of the Bhutanese people through adequate access to food and natural resources.

The MoAF is the ministerial body which provides the statistics of biomass. The rural population, in particular, is still highly dependent on biomass as a source of cheap and easily accessible form of energy.

The Department of Forests and Park Services (DoFPS) under MoAF has the mandate to uphold the Constitution of Bhutan's mandate to maintain a minimum of 60% of the country's geographical area under forest cover for all times to come whereas the Department of Livestock looks into developing the policies, strategies and guidelines, to ensure efficient livestock services. DoFPS is also responsible for conservation, protection, sustainable management and utilization of state forests, state soil, water resources and biodiversity.

The Natural Resources Development Corporation Limited (NRDCL) on the other hand, branched out from the erstwhile Department of Forest and is now a 100% Government owned Investment Company which manages and provides services related to timber, sand, stone and other natural resources.

7. Ministry of Information and Communication

Major contributor to current account deficit is the import of petroleum products. Although, the vehicular sales and imports are not in the purview of the MoIC, registration, traffic and efficient transport planning can significantly reduce fuel consumption and pollution.

Road Safety and Transport Authority: The Road Safety and Transport Authority (RSTA) was established in 1997 by consolidating all motor vehicle related activities such as vehicle registration, driver licensing, road worthiness testing, vehicle emission, passenger transport service regulation, traffic regulations, road safety, etc. under one organization. The Authority is mandated to carry out implementation of road safety strategies, and to develop, promote and administer road safety education and training programs. Their responsibilities also involve improvement of the efficiency and effectiveness of transport passenger facilities and networks to meet the needs of the community.

The Department of Civil Aviation: The Department was established in 1986. The Department's primary roles are outlined below:

- Promotion of civil aviation through formulation of clear development policies that are in accord with international principles as well as are environmentally sustainable.
- Development of aviation regulations in line with international standards and their enforcement on the aviation industry through regular safety oversight activities.
- Development of infrastructure and provision of aeronautical services for safe, efficient, and economical civil air transport service in Bhutan.

2.2 Laws and Policies Pertaining to Energy Sector

The primary laws and policies that govern or have direct influence on the development of the energy sector in Bhutan are: Electricity Act of Bhutan 2001, Bhutan Sustainable Hydropower Development Policy 2008, Foreign Direct Investment Policy 2010, The Economic Development Policy of the Kingdom of Bhutan 2010, Alternative Renewable Energy Policy 2013.

The Electricity Act of 2001 provides the framework for the institutional governance of the electricity sector in Bhutan. Some of the provisions of the Act have been superseded by the creation of new institutions. The Bhutan Sustainable Hydropower Development Policy of 2008 provides the framework and guidelines for accelerated hydropower development in the country. The Policy allows the government of Bhutan to further develop hydropower projects with public, private or public-private-participation and in collaboration with other development partner countries, mainly India. The Foreign Direct Investment Policy also is supportive of private sector participation in the development of medium and large hydropower projects and other RE projects and provides incentives for foreign entities to invest in Bhutan's energy sector.

The Alternative Renewable Energy Policy 2013 expounds on the government's objectives for developing the RE sector in the country and provides the framework to address key issues relating to the promotion of RE systems and public and private sector participation in the development of RE projects. The policy recognizes the growing energy sector challenges of Bhutan, in the form of increased reliance on a single source of electric power, dependence on imported fossil fuels for transport facilities against the threat of climate change, and proposes the exploration of untapped and salient Renewable Energy resources of Bhutan to increase the nation's energy security. This policy aims to promote the following clean Renewable Energy technologies: solar (both PV and thermal), wind, bio-energy and geothermal, pico/micro/mini/small hydro and waste to energy (WTE). The Sustainable Hydropower Development Policy 2008 and the Economic Development Policy (EDP) 2010 acknowledge the need to have RE policy to advance the exploration and exploitation of RE sources thereby ensuring national energy security through a diversified energy mix.

The indicative target figures under the Alternative Renewable Energy (ARE) Policy 2013 for 2025 include electricity generation from Solar (5 MW), Wind (5 MW), Biomass (5 MW); energy generation from biomass energy system (3 MW equivalent), solar thermal system (3 MW equivalent) and fossil fuel energy substitution in transport sector worth 1000 kilolitres of oil equivalent to be replaced by 111,000 MWh and 20% of the state owned and 10% of the private vehicle fleet to be encouraged to run on clean and green fuels by 2025. The ARE policy also recommends the formulation of a Renewable Energy Master Plan by 2016, which shall dictate the actual renewable energy target figures.

3. SUPPLY OF ENERGY

This chapter covers the different fuels which are used as a source of energy supply in the country. This information has been collated on the basis of secondary data available with the associated stakeholders who maintain the necessary records in the particular domains.

3.1 Electricity

The structure and policy of the power sector has witnessed substantial changes in the past decade with the initiation of reform process. Including the 126 MW Dagachhu project, the current installed generation capacity is 1,606 MW. The three-mega projects of Punatshangchhu-I, II and Mangdechhu accounts for 2,940 MW of power. This would take the country's installed generation capacity to 4,546 MW by 2020. The total installed electricity-generating capacity in Bhutan, as of 2014, is approximately 1,606 MW from major hydropower plants, 8.2 MW from other small hydro and 10,352 kVA from diesel generators owned by BPC (BPC, 2014). Besides these, there are a few solar PV (photovoltaic) power plants for home-lighting systems and 600kW wind power plant connected to the grid.

The domestic electricity demand has been growing steadily over the years keeping pace with the growth in the economic activities of the country. The peak demand had reached to 314 MW in 2014 as compared to 284 MW in 2013. During the year 2013, 13,299 customers were added and in 2014, BPC serviced 159,796 customers (BPC, 2014). The addition has been mostly through service connection of the rural homes in the country side brought about by extensive Rural Electrification coverage.

Major Hydropower Generation Plants:
Details on the major hydropower generating plants in Bhutan have been given below:

1. Basochhu Hydropower Plant
Brief Description: The Basochhu/ Rurichhu rivers were identified in the mid-1970s by hydropower engineers as a potential source of energy production in the medium-size range. The project taps the water from the Basochhu stream, which has a catchment area of 162 sq.km, above the Basochhu waterfall through a 2.6 km long headrace tunnel and a 1.4 km long penstock. The two generating units have a total capacity of 24 MW and a mean annual energy generation of 105 million units (MU).

The Lower Stage project taps 8m^3/s water from the tail-race of Upper Stage and 2m^3/s from the Rurichu stream, which has a catchment area of 64 sq.km. It has a 2.53 km long penstock. The two generating units have a total capacity of 40 MW and a mean annual energy generation of about 185 million units.

Catchment Area	226 sq.km
Net Head	356/459m for Upper/ Lower Stage
Installed Capacity	24/40 MW for Upper/ Lower Stage
Number of Units	2 x 12/ 2 x20 MW for Upper/ Lower Stage
Mean Annual Generation	291 GWh
Type	Pelton

2. Chhukha Hydropower Plant
Brief Description: The Chhukha Hydropower Plant is Bhutan's oldest mega power plant. Out of the country's several major river basins, the Wangchhu, which uses the discharges of Thimphu, Paro and Haa valleys, was chosen as the project site as it offered the best scope for constructing the first power project due to the existence of road links and other infrastructures. The project's first 84MW hydro-turbine unit was commissioned on September 7, 1986 and by 1988 all the other three units were commissioned. The Chhukha hydropower plant project cost was around Nu. 2,465 million and generates over 1,800 MU annually. Most of the generated energy is exported to India.

Catchment Area	3,108 sq.km
Net Head	435m for Upper/Lower Stage
Installed Capacity	336 MW
Number of Units	4 x 84 MW
Mean Annual Generation	1,800 GWh
Type	Pelton

3. Kurichhu Hydropower Plant

Brief Description: The Kurichhu Hydropower Plant is located at Gyalpozhing, Mongar, on the Kurichhu River in Eastern Bhutan. It is a run-of-river scheme, with a dam of 55 m height (from its deepest foundation), crest length of 285 m and a surface power house located at the toe of the dam. The Project has an installed capacity of 60MW consisting of four units of 15MW each and a mean annual energy generation capacity of 400 MU. The Kaplan turbine operates with a net head of 32 m and discharge of 53 m^3 /sec per unit. A unique feature of the project is the fish ladder for migration of fish.

Catchment Area	9,135 sq.km
Net Head	32 m
Installed Capacity	60 MW
Number of Units	4 x 15 MW
Mean Annual Generation	400 GWh
Type	Kaplan

4. Tala Hydropower Plant

Brief Description: The Tala Hydropower Plant is located in Chhukha, Western Bhutan, just downstream of the Chhukha Hydropower Plant. The first unit of the hydropower plant was commissioned on July 31, 2006, and the last unit was added on the bar on March 30, 2007.

All of the electricity generated is exported to India through three 440kV transmission lines. The power station is the country's fourth and biggest hydropower plant after the 336MW Chhukha Hydropower Plant commissioned in 1988, followed by Kurichhu (60MW) in 2001 and Basochhu (40MW) in 2005. Electricity revenue was expected to provide no less than 60% of the government's entire revenue in 2009.

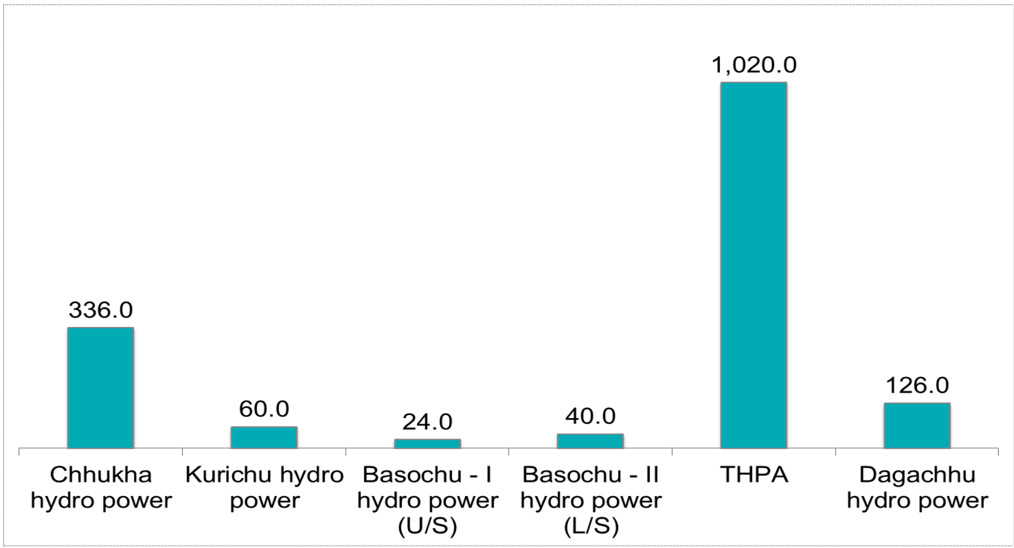
Catchment Area	4, 028 sq.km
Net Head	819 m
Installed Capacity	1,020 MW
Number of Units	6 X 170 MW
Mean Annual Generation	3,962 GWh
Type	Pelton

5. Dagachhu Hydropower Plant

Brief Description: The 126 (2x63) MW Dagachhu Hydropower Plant is located at Dagana in the south-western part of Bhutan. The run-of-the-river project is designed for an estimated mean annual generation of 515 GWh and in a 90% dependable year to generate 360 GWh. The Dagachhu project is the first Public-Private Partnership venture in the hydropower sector. The Dagachhu project is the first major project to be managed entirely by a Bhutanese management team. The Dagachhu project is also the first major hydropower project being promoted under the Clean Development Mechanism in Bhutan and first cross border CDM project in the world. Except for the royalty energy allocated to the RGOB, the total generated energy from the project is to be evacuated to India through a long-term power purchase agreement that has been entered into with the Tata Power Trading Company. The project was successfully commissioned in March 2015.

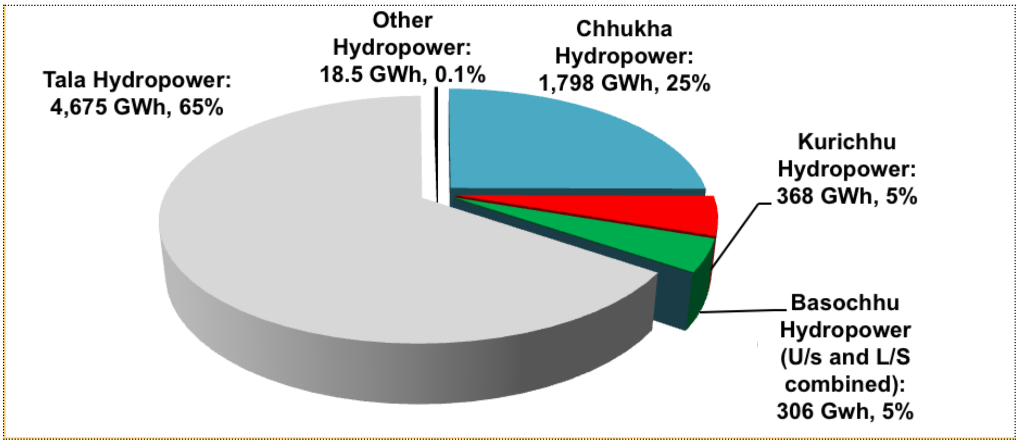
Catchment Area	676 sq.km
Net Head	282 m
Installed Capacity	126 MW
Number of Units	2
Mean Annual Generation	515 GWh
Type	Pelton

Figure 3: Installed Capacity of Large Hydro-power Plants (in MW)



(Source: Druk Green Power Corporation Limited, NSB Statistical Yearbook-2014)

Figure 4: Composition of Actual Generation in 2014, represented in GWh



(Source: Druk Green Power Corporation Limited)

The total generation capacity of the major hydropower plants has been illustrated in figure 3.

Figure 4 gives a comparative illustration of the proportion of the actual generation. Out of all hydropower generating plants, Tala hydropower plant has the largest capacity and also generates more than half of the cumulative power generation. It accounted for approximately 65% of the total electricity generation from hydropower in 2014, followed by Chhukha Hydropower Plant which generated around 25% of the total power in the same year.

The micro/mini hydro power plants on an average generate around 20GWh of electrical energy annually.

Apart from those owned by BPC, there are two operating plants constructed by DRE, namely Sengor (100kW) and Chendebji (70kW). These are operated by the community as off-grid source of electricity supply.

Salient Features of 70 kW Chendebji Micro Hydro Power Plant

Location	Chendebji, Tangsibji Gewog, Trongsa
Site	Chendebji village
Date of completion	18th August 2005
Cost of construction	Nu. 18.50 million
Source of Funding	e7
Elevation of Turbine axis	2496.03 masl
Elevation of intake	2554.35 masl
River/ stream	Lamchela chhu
Capacity	70 kW
Scheme	Run- of- the- river type
Catchment area	20.7 sq.km
Design Discharge	0.2 m^3/sec
Gross head	58 m
Net head	52 m
Efficiency	70%
Type of weir	Tryolean Weir
Length of the headrace channel	36 m
Type of penstock	Steel pipe
Length of penstock	831 m
Internal diameter of the penstock	468 mm
Thickness of the penstock	6 mm
Size of the power house	(5.6X 5X2.9)m
Turbine type	Cross flow, 1000 R.P.M, one unit
Generator type	Synchronous , one unit , 1000 R.P.M, 50 Hz

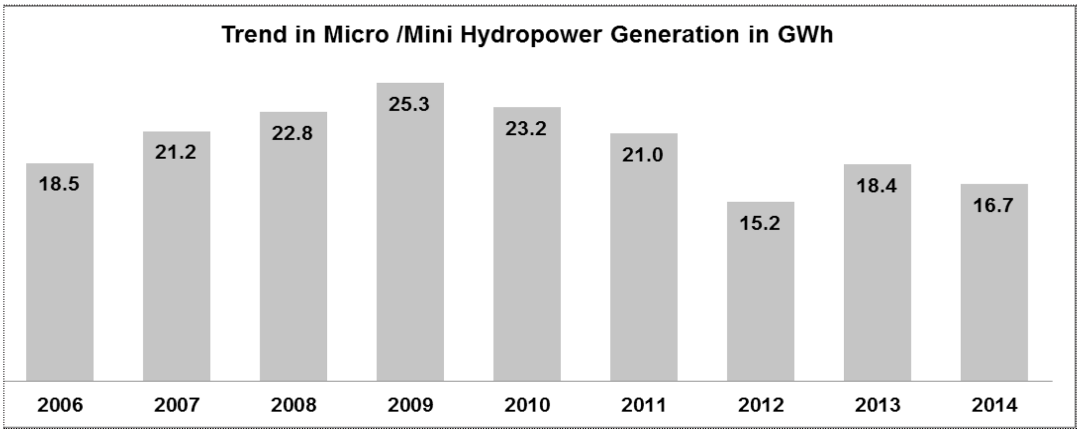
Salient Features of 100 kW Sengor Micro Hydro Power Plant

Location	Sengor, Saling Geog, Mongar
Site	Core Zone of Thrumshingla National Park
Date of completion	8th May 2007
Cost of construction	Nu. 23.00 million
Connectivity	105 km from Bumthang, 80 km from Mongar
Source of funding	UNDP-GEF
Altitude	3000m above sea level
River/ stream	Mangshing chhu
Capacity	100 kW
Scheme	Run- of- the- river type
Catchment area	7.0 sq.km
Design Discharge	0.131 m^3/sec
Effective head	101.5m
Length of penstock	415m (approx)
Length of headrace pipe	650m (approx)
Turbine type	100 kW Pelton Turbine
Generator type	Three- phase Synchronous Generator

There has been a slight decline over the last decade in the actual generation from micro-mini hydro-power plants but the decrease is not very stark considering the generation of BPC only, as depicted in the figure 5.

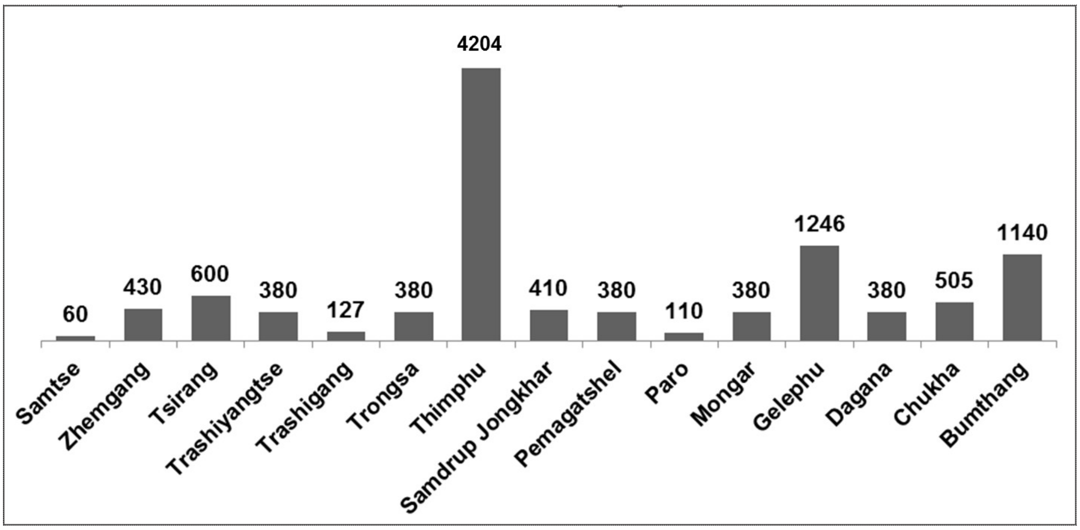
Besides the existing power projects, Bhutan also looks forward to further enhancing its hydropower potential to reach the total electricity generation target of 10,000 MW by 2020. Figure 7 shows the location of identified hydropower potential sites (>25 MW).

Figure 5: Annual Trend in Micro/Mini Hydropower Generation by BPC



(Source: Developed from BPC Power Data Handbook -2014)

Figure 6: Installed Power Generation Capacity in various districts through Diesel Generators owned by BPC (in kVA)



(Source: Developed from BPC Power Data Handbook -2014)

Apart from the hydropower plants, Bhutan relies on diesel generators for auxiliary usage in the plants or for certain usage in industrial or agricultural purposes. The installed capacity of diesel generators as owned by Bhutan Power Corporation is illustrated in figure 6.

The dependence on diesel generation has been on a decline. The access and availability of reliable grid-connected electricity across the country has been crucial for relieving the dependency on diesel generator sets. From the generation of around 1,650 MWh in 2006, the generation has dropped to 10.4 MWh in 2014.

Currently, majority of the transmission lines across the country transmits electricity to various parts through 132kV and 66kV transmission lines. Development of further high voltage transmission lines are expected to come about by 2020, which has the potential to reduce the losses incurred in the lower voltage transmission lines[7] .

7 Interview with Druk Green Power Corporation and Bhutan Power Corporation Limited

Figure 7: Existing and Potential Hydropower Plants in Bhutan

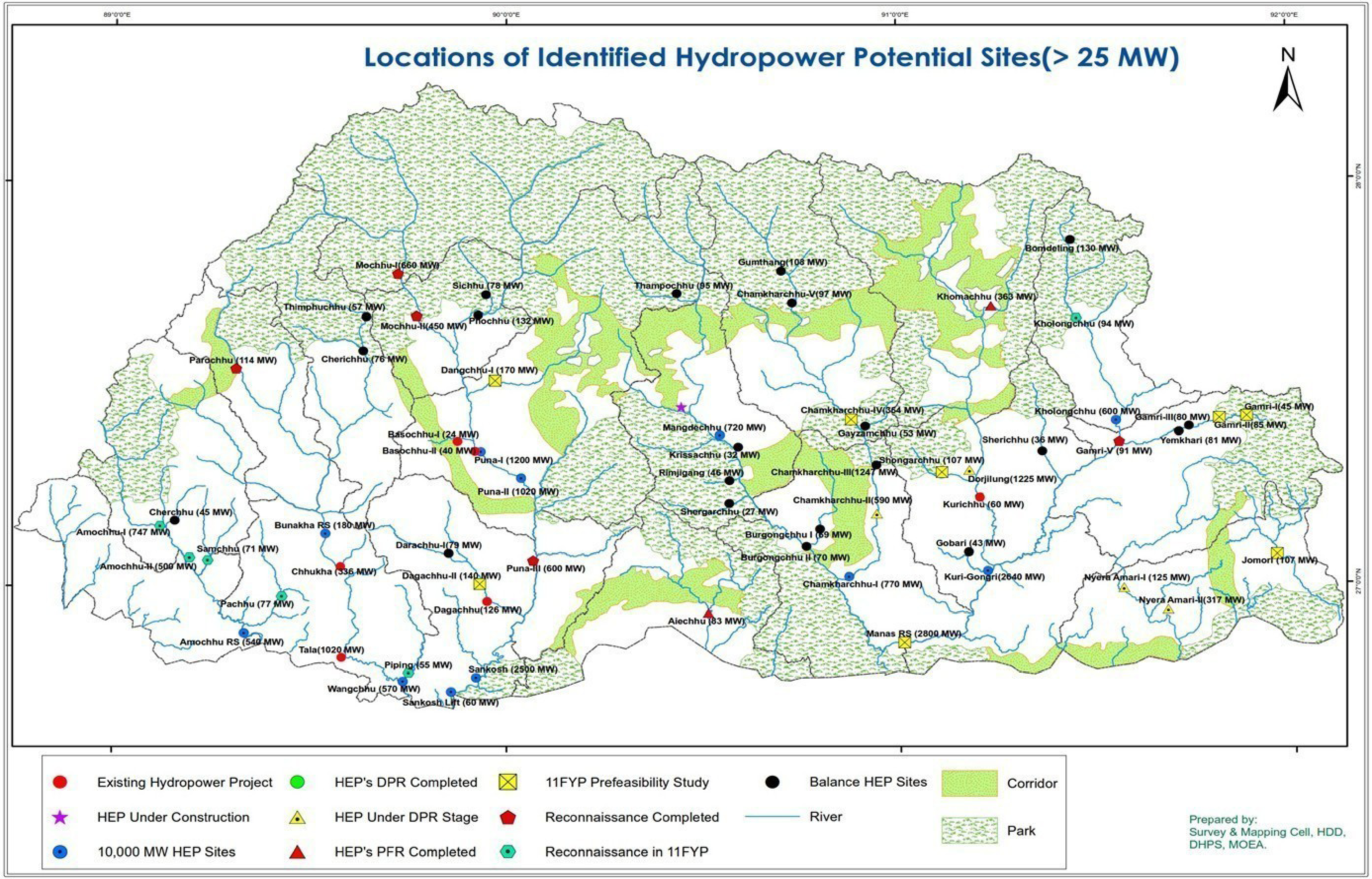
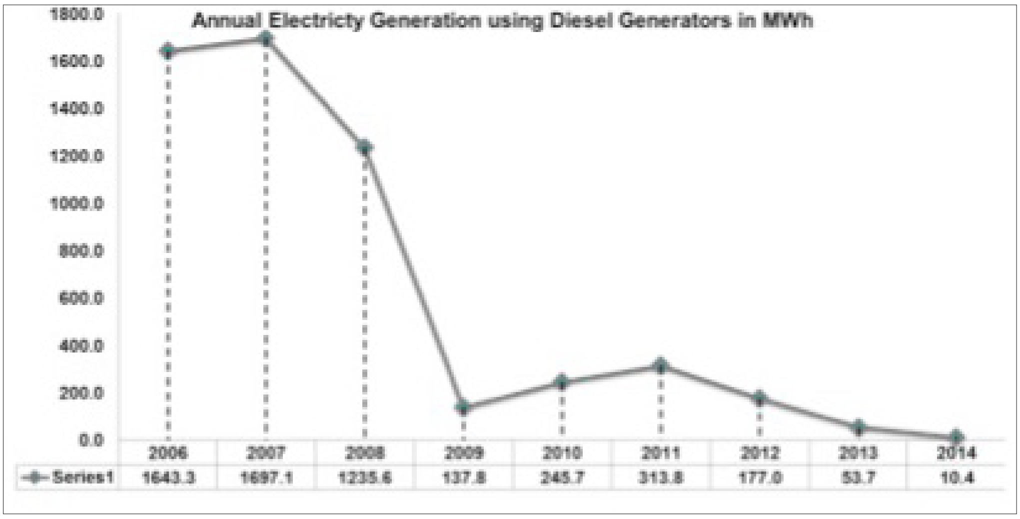


Figure 8: Annual Electricity Generation from Diesel Generators (in MWh)

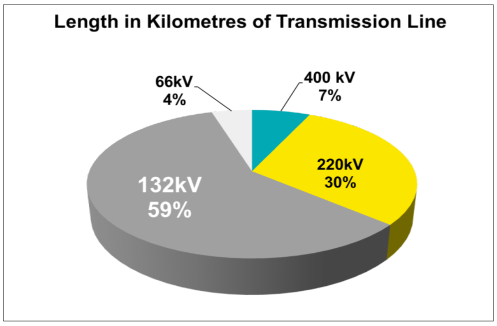


(Source: Developed from BPC Power Data Handbook -2014)

Around 59% of the total length of the transmission lines in the country transmits electricity at 132kV, followed by 220kV which forms 30% of the total length.

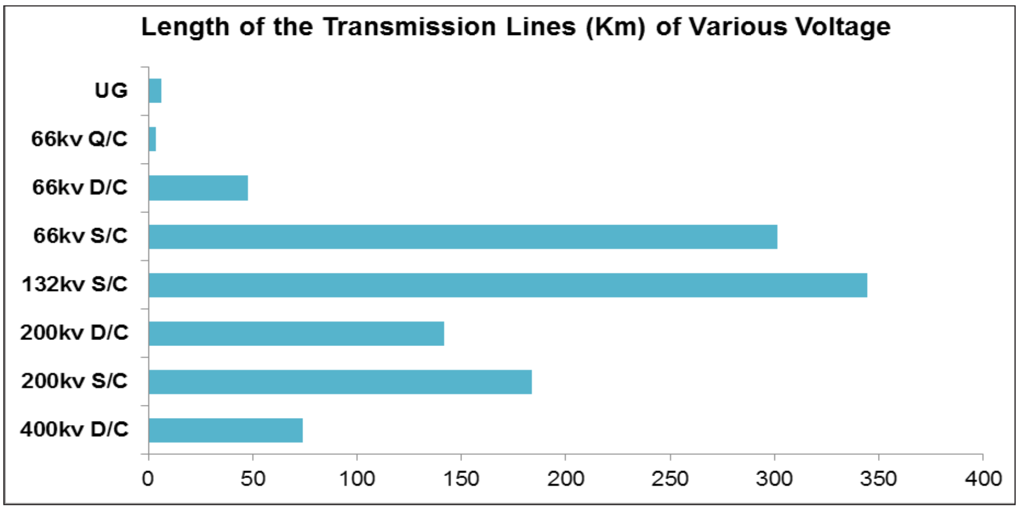
The 400kV lines have been recently established in 2015 which transmits electricity from Tala Hydropower station to Malbase and Pugli, both of which goes beyond the borders to India.

Figure 10: Transmission Lines Length Split according to Voltage



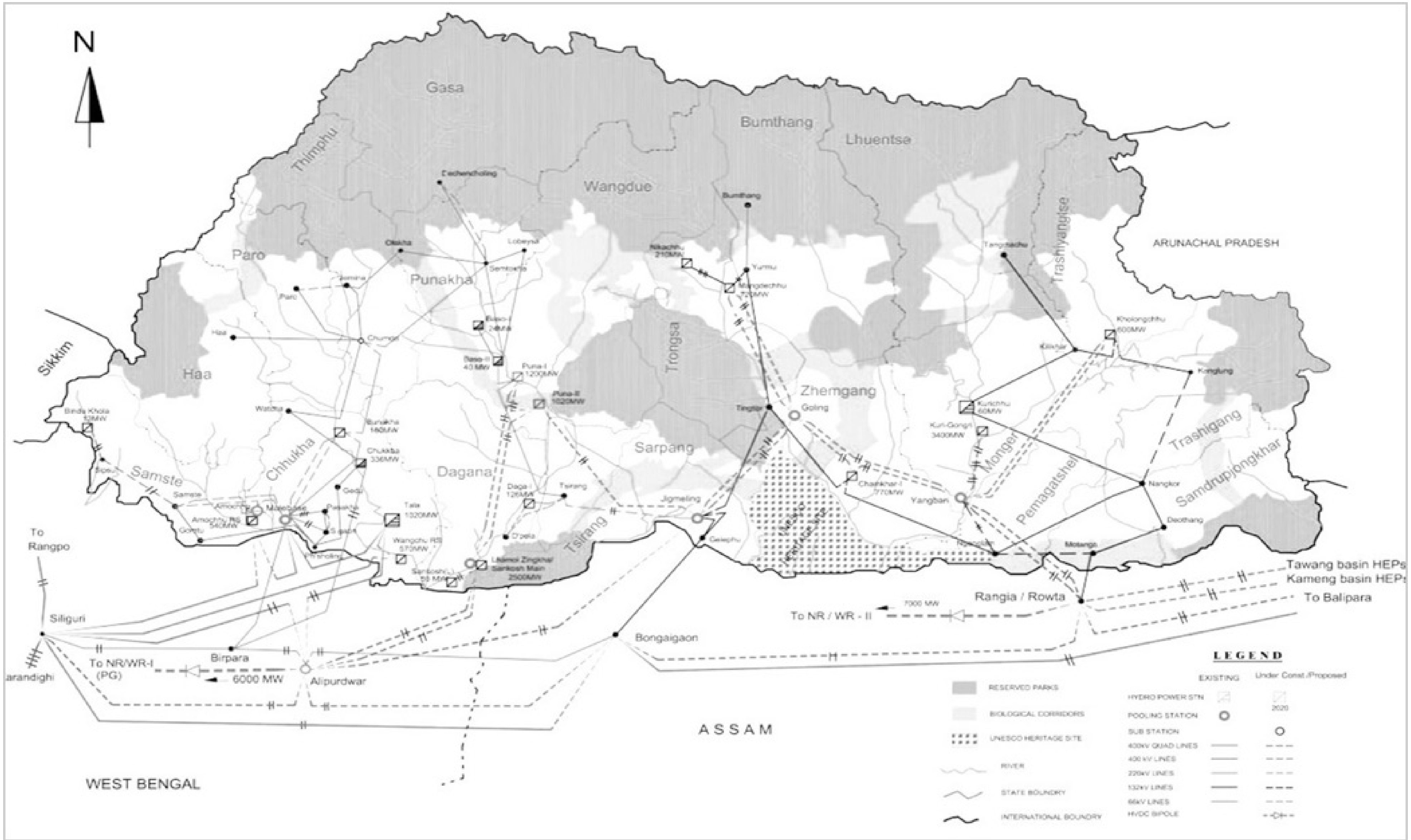
(Source: Developed from BPC Power Data Handbook -2014)

Figure 9: Length of the Transmission Lines (in Kilometres)



*(Source: Developed from BPC Power Data Handbook -2014, *D/C stands for double circuit, S/C stands for single circuit, UG for Underground and Q/C stands for Quadruple Circuit)*

Figure 11: Transmission Lines across Bhutan[8]



8 The 400kv Tala- Malbase and Tala-Pugli lines are not shown in picture

The transmission and distribution network is not only indicative of the access to electricity but also serves to demonstrate the probable loss in the system. Longer lines with lower voltage can lead to greater losses in the system. There are very few high voltage lines except for the 400kv lines of Tala-Malbase and Tala-Pugli. It is again a challenge to set up high voltage lines across the country due to the difficult terrain. There are certain pockets in the country, where very few population dwell and reaching those regions becomes highly cost intensive. Economically, it is more feasible that those regions generate decentralized means of power to cater to their needs through pico, micro, mini and small hydel or through other stand-alone renewable resources like solar and wind.

The Total Global System Losses excluding wheeling amounts to 3.87% of the total electricity sales. The wheeling losses have been excluded while calculating the domestic losses.

The Transmission losses including wheeling amounts to 10.59 GWh and Distribution losses amount to 44.17 GWh for the year 2014.

The domestic system loss in this case amounts to 80.63 GWh for 2014.

Table 1: Calculating Domestic Loss in Electricity Supply

Total Domestic Loss by Type - 2014	Percentage	Total GWh taken to calculate individual loss	Loss in Figure (GWh)
Global System Losses (GSL) excluding Wheeling	3.866%	2,085.46	80.63
Transmission Loss including wheeling	0.513%	2,064.30	10.59
Distribution Losses including HV Industries	2.156%	2,049.01	44.17

(Source: BPC Power Data Handbook, 2014)

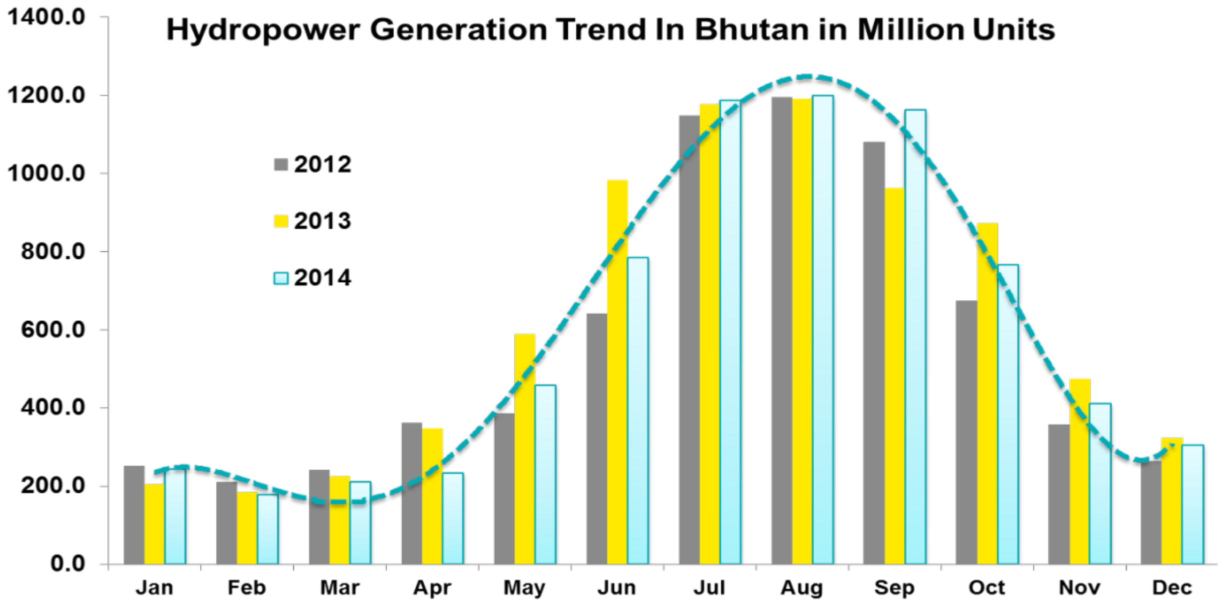
Given the electricity outreach in the country and the growing dependence on electricity as the basic fuel over firewood for heating and cooking purposes, the electrical demand in the country has risen over the decade (the same has been discussed in details in Chapter 4: Energy Demand). The power generated throughout the year depends on the run-of-the river which fluctuates seasonally. The availability of water in the river is high during the summer months and low during the winter months. From the figure No. 12, it can be seen that the generation is typically high during the months of June to October, when the snow melts and the river is well fed. The months from November to April represent a dry patch.

The Monthly Generation of electricity increases during the summer when the snow melts and the flow of water in the rivers is at peak during the monsoon. The months of July and August in the years 2012-2014 recorded the highest generation of almost 1,200GWh each month. However, during winter, most rivers are dry and consequently the months of January and February recorded the lowest generation for the years 2012 – 2014, at around 200 GWh each month.

Although the trend of electrical energy demand throughout the day remains similar for both winter and summer, the Peak Demand is significantly higher during the winters at all hours.

In particular, the peak demand in the Winter ranges to about 1.5 to 1.8 times that of the Summer electricity demand. The demand has risen further due to the increase in the number of consumers getting connected to the grid across Bhutan.

Figure 12: Monthly Trend of Hydro-power Generation in Bhutan (in GWh)



(Source: DGPC, NSB Statistical Yearbook-2014)

Further, most part of Bhutan being located in the cold Himalayan range, the demand for electricity is particularly high in the winter as compared to the summer months. The demand for electricity increases due to the increased demand for room heating compared to the summer months. Currently, more than 95% of the country remains electrified through grid connection. The rest of the population are either electrified through solar PV home lighting system or are yet to be electrified due to difficult terrains.

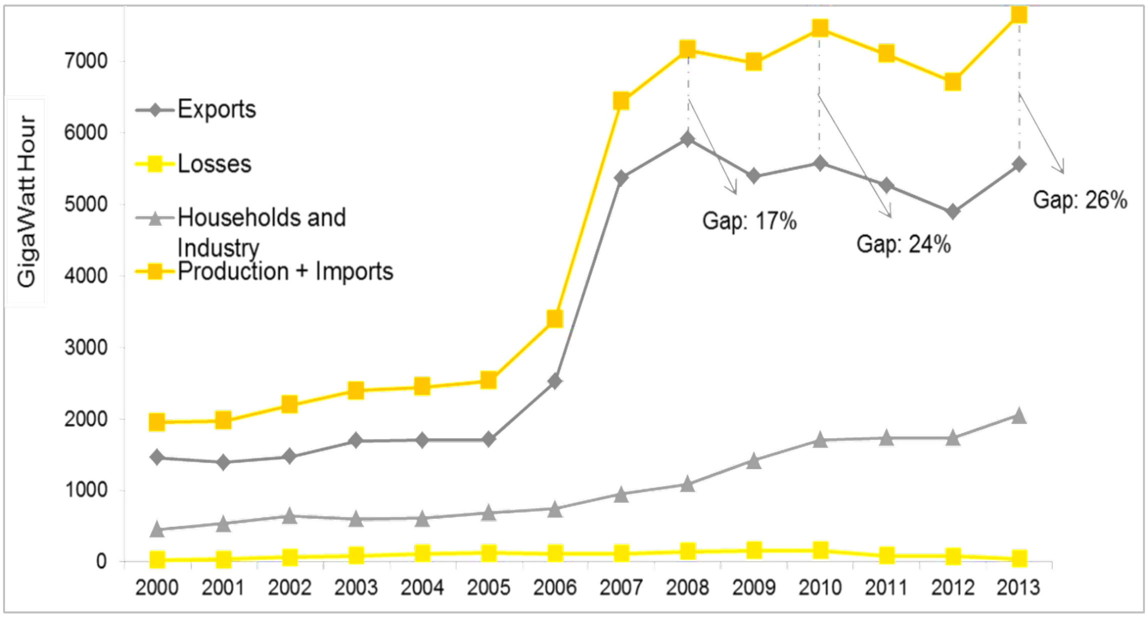
The increasing gap between the exports and total domestic electrical supply (Figure 13), from 17% in 2008 to 26% in 2013, shows that the exports has not been increasing proportionally with generation signifying increasing domestic consumption or losses in the economy. Savings in the domestic consumption, through energy efficiency and conservation interventions provides potential for increasing exports with the current capacity as well.

Since 2000, a large portion of the electricity generated in Bhutan is being exported. However if the recent trend is brought to concern, it has been observed that the amount of electricity available for export has not increased proportionally. Nevertheless, with the plans of further increase in the hydropower capacity to 10,000MW by 2020, Bhutan looks forward to generating added revenue from increased export of surplus electricity to neighbouring countries.

Table 2 represents the historical data related to electricity generation, trade, transmission and distribution in Bhutan. A significant portion of the total electricity generated is exported to India which increased from 1,460.5 GWh in 2000 to 5,179.3 GWh in 2014.

The domestic consumption without losses amounts to 1382.8 GWh in 2014. The figures in Table no. 4 are inclusive of the import of electricity from India in the lean seasons. For 2014, the total export amounts to Nu. 12,287.9 Million, whereas the import bill amounts to Nu. 371.3 Million.

Figure 13: Bhutan Power Demand and Supply Scenario (in GWh)



(Source: NSB Statistical Yearbook-2014)

Table 2: Installed Capacity and Electricity Generation Capacity in Bhutan

Installed Capacity for Generation of Power in Bhutan (MW)								
Details	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Total Installed capacity	**1,497.40**	**1,497.40**	**1,497.40**	**1,497.40**	**1,497.40**	**1,498.90**	**1,498.90**	**1,624.90**
Chhukha Hydropower Plant	336	336	336	336	336	336	336	336
Kurichhu Hydropower Plant	60	60	60	60	60	60	60	60
Basochhu(U/S) Hydropower Plant	24	24	24	24	24	24	24	24
Basochhu(L/S) Hydropower Plant	40	40	40	40	40	40	40	40
Tala Hydropower Plant	1,020.00	1,020.00	1,020.00	1,020.00	1,020.00	1,020.00	1,020.00	1,020.00
Dagachhu Hydropower Plant	-	-	-	-	-	-	-	126
Other hydro power plants	8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.2
All diesel generators	9.2	9.2	9.2	9.2	9.2	10.7	10.7	10.7

Annual Power Generation (GWh)								
Details	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Electricity generation	**7,161.70**	**6,918.80**	**7,330.20**	**7,066.50**	**6,827.00**	**7,551.10**	**7,166.30**	**7,005.20**
Chhukha Hydropower Plant	1,802	1,808	1,870	1,774	1,745	1,907	1,798	1,667
Kurichhu Hydropower Plant	386	370	378	362	361	379	368	335
Basochhu Hydropower Plant (U/S and L/S combined)	336	323	330	322	300	332	306	270
Dagachhu Hydropower Plant	-	-	-	-	-	-	-	305
Tala Hydropower Plant	4,610	4,396	4,726	4,588	4,405	4,914	4675	4409
Other Hydropower plants	24.8	21	25.6	20	15.2	18.5	18.5	18.5
All diesel generators	1.8	0.2	0.3	0.3	0.2	0.5	0.5	0.5

(Source: Consultation with DGPC; NSB Statistical Yearbook-2014)

Table 3: Export of Electricity from Bhutan

Year	Export to PTC in GWh	Domestic Sale in GWh	Export in Million Nu
2000	1,460.5	595.6	2,307.3
2001	1,392.6	679.9	2,237.8
2002	1,476.4	707.3	2,506.9
2003	1,695.8	714.3	2,867.9
2004	1,707.2	929.7	3,035.1
2005	1,713.6	1,114.1	3,956.6
2006	2,526.2	1,414.4	5,584.7
2007	5,372.6	1,628.0	10,936.3
2008	5,922.3	1,683.7	11,883.0
2009	5,400.5	1,828.0	11,268.7
2010	5,579.3	1,901.7	11,686.0
2011	5,273.0	2,012.0	11,019.3
2012	4,895.6	595.6	11,094.0
2013	5,557.5	679.9	12,904.5
2014	5,179.3	707.3	12,287.9
2015	5,175.6	144.7	11,197.7

Figure 14: Total Generation from Diesel Generator (in kVA)

Sl. #	Dzongkhag	DG Set	Installed Capacity (kVA)	2006	2007	2008	2009	2010	2011	2012	2013	2014
1	Bumthang	DG set - I	380	114,720.0	324,768.0	207,296.0	4,624.0	0.0	1,776.0	0.0	0.00	0.00
		DG set - II	380	461,424.0	589,360.0	375,376.0	6,768.0	3,168.0	2,000.0	740.0	0.00	0.00
		DG set - III	380	372,064.0	115,360.0	243,440.0	1,936.0	2,688.0	6,760.0	10,814.0	0.00	0.00
2	Chhukha	DG set	380	321,850.0	338,820.0	118,830.0	12,060.0	36,480.0	22,140.0	58,863.0	33,420.00	5,040.00
		DG set	125	44,480.0	1,120.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00
3	Dagana	DG set	380	6,000.0	6,500.0	6,100.0	0.0	240.0	7,100.0	0.0	4,600.00	0.00
4	Gelephu	DG set	350	2,234.4	0.0	0.0	0.0	0.0	0.0	500.0	0.00	0.00
		DG set	318	55.6	0.0	1,112.0	0.0	662.0	0.0	0.0	0.00	0.00
		DG set	515									
		DG set	63									
5	Monggar	DG set	380	3,008.0	99.6	800.0	289.0	0.0	12,615.0	4,672.0	2,117.00	560.00
6	Paro	DG set	110	0.0	0.0	0.0	0.0	0.0	192.0			
7	Pema Gatshel	DG set	380	1,866.0	602.0	1,858.0	423.0	576.0	1,424.0	1,488.0	0.00	0.00
8	Samdrup Jongkhar	DG set	380	4,008.0	11.0	70.0	33,467.0	139.0	1,868.0	2,533.0	1,088.00	0.00
		DG set	30									
9	Thimphu	DG set	625									
		DG set	318	0.0	11.0	0.0	0.0	0.0	0.0	3.0	0.00	0.00
		DG set	318	0.0	2.0	2.0	0.0	0.0	7,015.0	0.0	0.00	0.00
		DG set	1188	680.0	350.0	910.0	1,915.0	3,255.0	4,987.0	1,844.0	3,305.00	0.00
		DG set	1250	4,190.0	1,990.0	7,553.5	4,915.0	7,267.1	13.3	2,661.0	3,000.00	1,000.00
		DG set	380	384.0	128.0	320.0	528.0	880.0	1,072.0	386.0	2,173.00	917.21
		DG set	125	0.0	0.0	0.0	0.0	1,038.0	0.0	0.0	0.00	0.00
10	Trongsa	DG set	380	212,129.0	220,319.0	175,402.0	0.0	0.0	0.0	0.0	0.00	0.00
11	Trashigang	DG set	100									
		DG set	27									
12	Trashiyangtse	DG set	380	10,096.0	4,720.0	5,008.0	1,088.0	3,840.0	21,120.0	6,977.0	3,952.00	2,512.00
13	Tsirang	DG set	380	82,000.0	91,700.0	89,400.0	0.0	0.0	0.0	2,144.0	0.00	0.00
		DG set	60									
		DG set	160									
14	Zhemgang	DG set	380	2,112.0	1,264.0	2,160.0	69,808.0	185,464.0	223,745.0	83,389.0	0.00	352.00
		DG set	50									
15	Samtse	DG set	60									
TOTAL				1,643,301.0	1,697,124.6	1,235,637.5	137,821.0	245,697.1	313,827.3	177,014.0	53,655.0	10,381.2

(Source: BPC Power Data Handbook -2014)

Table 4: Import of Electricity from India to Bhutan

Year	Import in GWh	Import In TJ	Import in Million Nu
2000	34.4	123.8	51.6
2001	36.3	130.6	6.9
2002	70.3	253.0	24.3
2003	20.2	72.6	18.7
2004	20.4	73.6	30.7
2005	16.4	59.2	32.8
2006	32.5	116.9	63.1
2007	33.9	121.9	37.7
2008	13.4	48.1	14.3
2009	62.3	224.3	111.0
2010	128.5	462.7	233.9
2011	37.0	133.0	67.2
2012	56.1	202.0	110.3
2013	108.6	391.0	214.9
2014	187.6	675.5	371.3
2015	116.2	418.5	230.0

(Source: NSB Statistical Yearbook-2014 and consultation with DGPC)

3.2 Petroleum Products

Petroleum reserves have not been explored in Bhutan as yet and there is also no refinery for crude oil processing in the country. The RGoB has a long-term agreement with the Government of India for the supply of petroleum products. Under the agreement, the public sector oil companies in India, IOC (Indian Oil Corporation) and BPCL (Bharat Petroleum Corporation Ltd.) supply petroleum products to Bhutan. Petroleum products are imported directly by distributors in Bhutan. At present, there are three such petroleum distributors in Bhutan - Bhutan Oil Distributor (part of the Tashi Group of Companies), Damchen Petroleum and Druk Petroleum Corporation Limited. The petroleum product market is regulated by the POL section under the Department of Trade, Ministry of Economic Affairs, RGoB.

The amount of import in terms of its volume along with the diversity has significantly increased over the years.

Due to the increasing individual dependency on private vehicles and other forms of motorized transport, the total petroleum import bill has risen from Nu. 369 million in 1998 to Nu 8,432 million in 2014.

The most significant contribution to the import bill can be attributed to the usage of diesel in the country. The import bill for diesel itself constitutes 70% of the total import of petroleum.

The total import bill for diesel increased from Nu. 214 million in 1998 to Nu 5,911 million in 2014. Consequently, the total import bill is creating a burden on the government exchequer nullifying a large amount of revenue earned by export of electricity to India.

In 2014, the import of POL products touched Nu. 8,433 million whereas the export of electricity amounted to Nu. 10,634 million, nullifying 80% of the revenue earned through electricity exports to India (DoT, 2015).

Figure 15: Diesel Import Trend from 2006 to 2014 (in '000 kl)

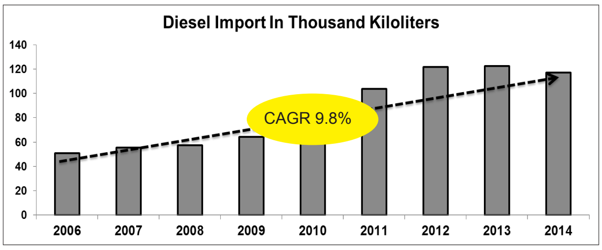


Figure 16: Petrol Import Trend from 2006 to 2014 (in '000 kl)

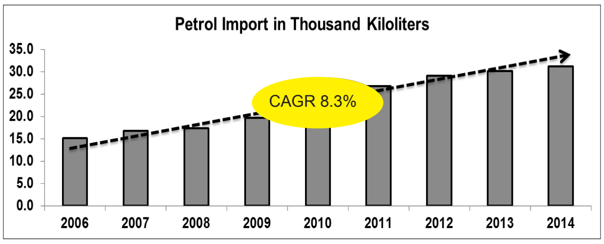


Figure 17: LPG Import Trend from 2006 to 2014 (in '000 kl)

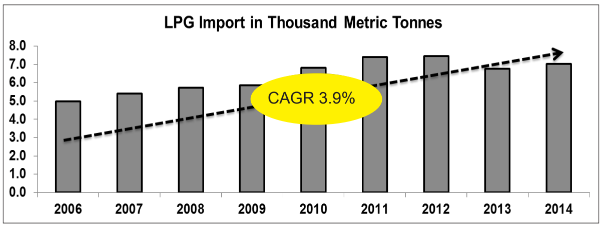


Figure 18: Superior Kerosene Oil Import Trend from 2006 to 2014 (in '000 kl)

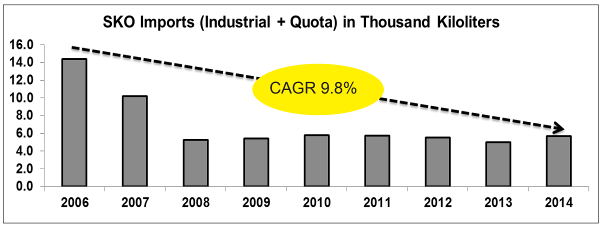
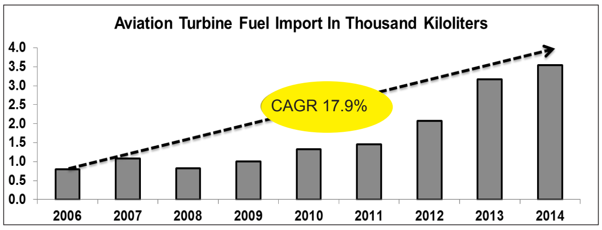


Figure 19: Aviation Turbine Fuel Import Trend from 2006 to 2014 (in '000 kl)



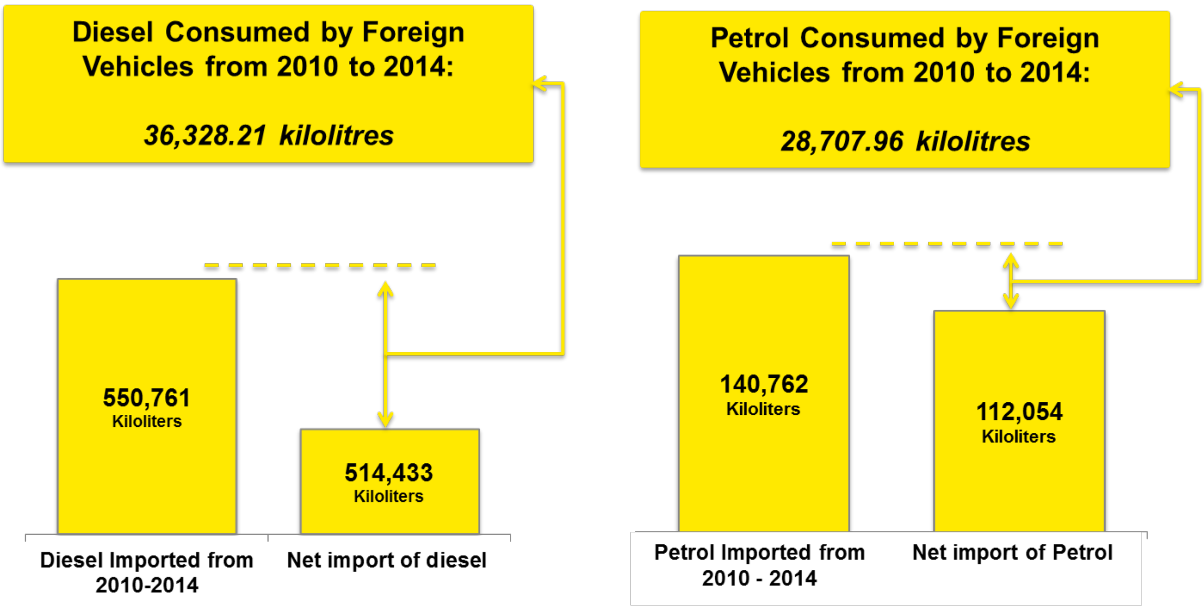
(Source: EY Analysis is based on information submitted by respective POL dealers compiled and tabulated by POL Section on February 2010 to 2014; IPCC Guidelines for National Greenhouse Gas Inventories. The projections have been made on the basis of their CAGR in the last 9 years imports dating from 2006 to 2014. The calculated CAGRs and the conversion factors have been listed in Annexure-7.3)

The major petroleum fuel imports include diesel, petrol, LPG and kerosene. Particularly, under Kerosene, Jet Kerosene used as Aviation Turbine Fuel is increasingly becoming an important fuel for the country as the aviation sector is growing and the number of flights from and to Paro airport has been increasing over the last decade which has resulted in a significant growth of ATF imports with a CAGR of 17.9%.

Due to the sharing of a porous border town like Phuentsholing with India and large cross border trade, many Indian goods' vehicles travel across to Bhutan and fuel their vehicles on their return. Reportedly, the National Statistical Bureau accounts that approximately 20% of petrol and 6.5% of diesel were re-exported from 2010 to 2014.

Although the percentage of re-fuelling of the total petroleum imports has been vacillating, the refuelling reached 11% of the supply in 2012. Re-fuelling of petrol increased significantly from 15.2% in 2010 to 23.2% in 2013 and remained close to 23% in 2014 (National Accounts Statistics, 2015).

Figure 20: Total Net Petroleum Imports for the period 2010 to 2014 (in kl)



Following are tables which represent the historical data related to petroleum trade in Bhutan.

Table 5: Import of Petroleum Products in 2014

Product	Diesel		Petrol		SKO Industrial		SKO (Quota)	
Dealer / Company	**kl**	**Million Nu**	**kl**	**Million Nu**	**kl**	**Million Nu**	**kl**	**Million Nu**
BOC / BOD / IOC	31,172	1,561	7,584	425	21	1	4,080	54
DPCL / IOC	14,292	761	3,860	225	0	0	1,092	14
DPD / IOC	8,251	412	1,838	107	0	0	501	6
BIG/IOCL	0	0	0	0	0	0	0	0
TOTAL (IOC)	53,715	2,734	13,282	757	21	1	5,673	75
BOD / BPCL	62,965	3,148	16,485	972	0	0	0	0
DPD / BPCL	594	29	1,522	90	0	0	0	0
TOTAL (BPCL)	63,559	3,178	18,007	1,063	0	0	0	0
TOTAL (IOC + BPC)	**117,274**	**5,911**	**31,289**	**1,820**	**21**	**1**	**5,673**	**75**

Product	LPG (MT)		Lubes		ATF		Furnace Oil	
Dealer / Company	**MT**	**Million Nu**	**kl**	**Million Nu**	**kl**	**Million Nu**	**kl**	**Million Nu**
BOC / BOD / IOC	5,765	150	246	43	3,546	218	0	0
DPCL / IOC	971	25	64	6	0	0	0	0
DPD / IOC	294	8	28	5	0	0	0	0
BIG/IOCL	0	0	0	0	0	0	0	0
TOTAL (IOC)	7,030	183	338	54	3,546	218	0	0
BOD / BPCL	0	0	121	20	0	0	0	0
DPD / BPCL	0	0	97	15	0	0	0	0
TOTAL (BPCL)	0	0	217	36	0	0	0	0
TOTAL (IOC + BPC)	**7,030**	**183**	**556**	**89**	**3,546**	**218**	**0**	**0**
Product	**L.D.O**		**Bitumen**		**Others**		**Speed**	
Dealer / Company	**kl**	**Million Nu**	**kl**	**Million Nu**	**kl**	**Million Nu**	**kl**	**Million Nu**
BOC / BOD / IOC	0	0	0	0	0	0	0	0
DPCL / IOC	0	0	0	0	0	0	0	0
DPD / IOC	0	0	0	0	0	0	0	0
BIG/IOCL	0	0	0	0	0	0	0	0
TOTAL (IOC)	0	0	0	0	0	0	0	0
BOD / BPCL	40	2	0	0	398	87	30	2
DPD / BPCL	0	0	0	0	0	0	0	0
TOTAL (BPCL)	40	2	0	0	398	87	30	2
TOTAL (IOC + BPC)	**40**	**2**	**0**	**0**	**398**	**87**	**30**	**2**

Source: Developed from data provided by the POL Section, Department of Trade, MoEA

Table 6: Major Petroleum Imports from 2006 to 2014

Product	Diesel		Petrol		Industrial)SKO)		SKO (Quota)		LPG (MT)		Lubes / Greases		ATF	
Year	kl	Million Nu	kl	Million Nu	kl	Million Nu	kl	Million Nu	MT	Million Nu	kl	Million Nu	kl	Million Nu
2006	50,654.0	1,405.0	15,216.0	570.0	9.0	0.4	14,370	115.8	4,980.4	90.1	751.3	70.6	801.0	27.6
2007	55,477.0	1,496.3	16,781.0	603.2	105.0	3.3	10,102	81.4	5,405.5	98.2	944.2	94.9	1,080.0	36.9
2008	57,245.0	1,654.8	17,393.0	604.4	66.0	2.7	5,186.0	41.6	5,724.7	124.5	771.8	89.8	828.0	38.3
2009	64,300.0	1,792.9	19,709.0	694.7	120.0	3.6	5,307.0	42.8	5,856.8	116.8	840.7	118.7	1,008.0	32.4
2010	85,620.0	3,250.6	23,422.5	951.2	240.0	8.0	5,540.0	52.6	6,834.2	138.2	587.9	73.1	1,332.0	50.1
2011	10,3611	3,562.8	26,761.1	1364.2	120.0	5.7	5,607.0	67.0	7,410.9	190.1	708.7	105.2	1,455.0	74.1
2012	12,1832	3,207.3	29,094.0	1626.8	0.0	0.0	5,547.0	72.7	7,469.2	151.7	574.7	100.6	2,070.0	121.7
2013	1,224,258	5,471.9	30,195.2	1746.2	12.0	0.7	4,978.0	64.9	6,778.0	177.1	574.5	79.6	3,168.0	197.1
2014	117,274	5,911.4	31,289.2	1819.9	21.0	1.2	5,673.0	74.6	7,029.9	183.0	555.5	89.3	3,546.0	217.6
Total Imports from 2006 to 2014	**778,437**	**27,753**	**209,861**	**9,980.6**	**693.0**	**25.5**	**62,310**	**613.3**	**57,489.6**	**1,269.5**	**6309.4**	**821.8**	**15,288**	**795.8**

(Source: Developed from data provided by the POL Section, Department of Trade, MoEA)

3.3 Coal and Derivatives

The trade and domestic use of coal is maintained by the Department of Geology and Mines, Royal Government of Bhutan. Coal is solely used in the industry sector, mostly in the cement and ferro-alloy industries and for construction purposes in the country.

The only coal mine in the country which has been in operation till 2014 is in Rishore, Samdrup Jongkhar with production of 121,891 tonnes for the year 2014. The coal which is extracted from this mine is mainly sub-bituminous type and some other coal of inferior quality compared to those imported which are mainly bituminous coal and anthracite.

3.3.1 Domestic Supply

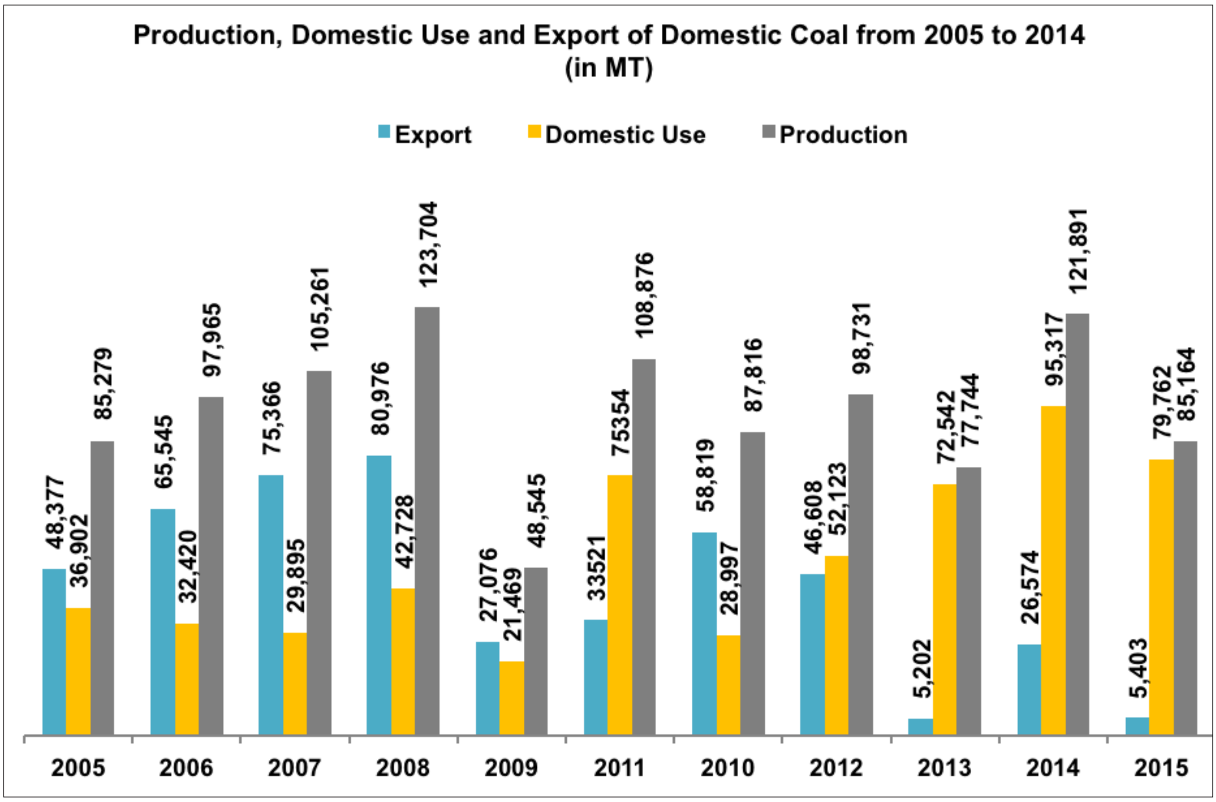
The overall production of coal in Bhutan has been increasing at a CAGR of 3.6%. Albeit erratic, the trend in the export has been decreasing over time whereas the domestic usage of coal has been increasing. Although the production is increasing at 3.6%, the growth is not sufficient for the higher increase in domestic consumption. This demonstrates dependency on import of coal. The trend in the production, export and use of domestically produced coal is given in figure 21.

3.3.2 Import

The domestic production also relies on imports of higher grade coal over and above the domestic production. To cater to this demand there has been a large import of 'other coal' amounting to 96,640 MT out of which 6,449 MT has been re-exported to Nepal. Derivatives of coal like coke and semi-coke are mainly used as reducing agents in the industrial processes. The import amount sums up to 43,503 MT out of which, again, 2,366 MT is re-exported to Nepal.

The export-import statistics of coal is given in table 7.

Figure 21: Production, Domestic Use and Export of Domestic Coal



(Source: Developed in consultation with Department of Geology and Mines)

Table 7: Export and Import Statistics of Coal for 2014

	Anthracite	Sub-Bituminous	Other Coal	Coke/ Semi-coke of Coal
	Tonnes	Tonnes	Tonnes	Tonnes
Production	0.0	121,891.0	0.0	0.0
Import	1,876.0	1.6	96,640.1	43,502.6
Export	0.0	23,537.7	6,449.3	2,365.9
Domestic Usage	**1,876.0**	**98,354.8**	**90,190.8**	**41,136.7**

(Source: Developed in consultation with Department of Geology and Mines and with reference to the Bhutan Trade Statistics 2014)

Considering the imports of all grades of coal, the total coal consumption amounts to 190,422 MT which constitutes of 1,876 MT of anthracite, 98,355 MT of sub-bituminous and 90,191 MT of other coal (mostly lignite).

Coal is mainly used for heating processes in most large industries. Again, due to availability of electricity, coal's use as a heating agent in industrial processes has been mostly substituted. Derivatives of coal such as coke and semi-coke of coal serves as an effective reducing agent in the industrial processes of heavy industries.

3.4 Biomass

The conservation of environment is one of the four pillars of Bhutan's development philosophy of Gross National Happiness (GNH) in which sustainable use of natural resources has been given the top priority. Accordingly, the Ministry of Agriculture and Forests (MoAF) has been consistent in its efforts in sustainably conserving and managing the environment through implementation of sound development policies, plans and programs. Bhutan's constitutional mandate to maintain 60% of the country under forest cover for all times to come is a security to preserve the environment. The Government's policies are also entwined with the constitutional provision and hence forest resources are used in a strict and sustainable manner. The country has about 72.8% of its area under forest cover (Bhutan NAPA, 2006) and is made up of fir, mixed conifer, chir-pine, blue pine, broad leaf, broad leaf mixed with conifer and scrubland. Broadleaf constitutes more than 38% of the forest area.

3.4.1 Fuelwood:

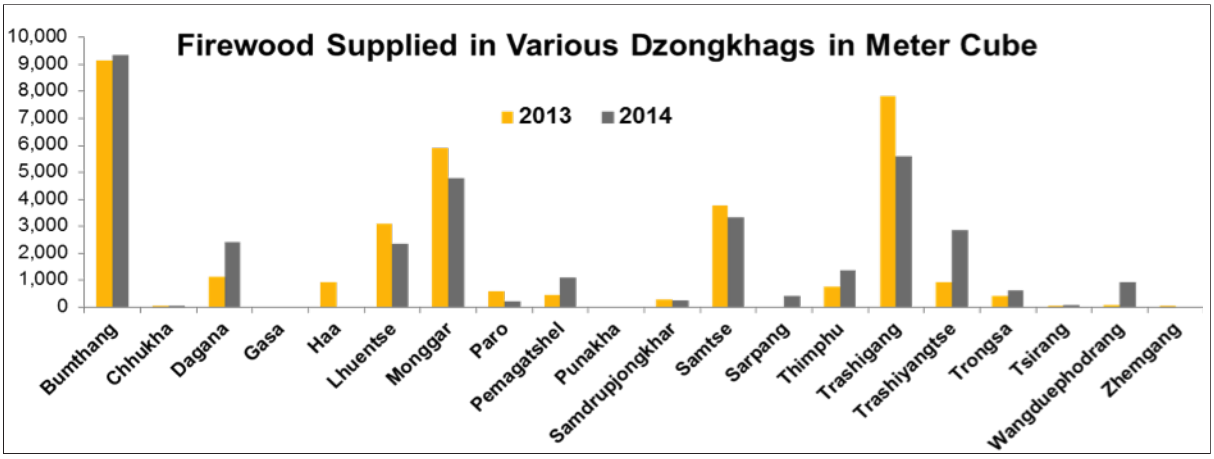
Historically, fuelwood usage has been very significant for Bhutan. Fuelwood consumption contributed to around 90% of the total energy usage in 2005. The following is an illustrative depicting the current supply which has not increased as much with the population growth and the energy requirements in the various sectors.

Table 8: Land and Forest Cover in Bhutan

Category	Type	Hectares	Percent	Total
Forest Area under Tree Cover	Blue Pine Forest	78,347	2.04%	0.70
	Broadleaf Forest	1,685,024	43.89%	
	Broadleaf with Conifer forest	34,838	0.91%	
	Chir Pine Forest	113,722	2.96%	
	Fir Forest	180,440	4.70%	
	Mixed Conifer Forest	612,919	15.96%	
Agricultural Areas	Wetland	31,911	0.83%	0.03
	Dryland	68,255	1.78%	
	Apple Orchard	2,081	0.05%	
	Citrus Orchard	5,488	0.14%	
	Cardamom Plantation	3,600	0.09%	
	Arecanut plantation	1,199	0.03%	
	Other Horticulture	16	0.00%	
Marshy Areas		320	0.01%	0.27
Meadows		157,546	4.10%	
Shrubs		400,535	10.43%	
Bare Areas		122,953	3.20%	
Degraded Areas		20,645	0.54%	
Snow Cover		285,435	7.43%	
Water Bodies		27,645	0.72%	
Built Up Areas		6,156	0.16%	
Non-built Up Areas		330	0.01%	
	Total area coverage	3,839,405		

(Source: Bhutan RNR Statistics – 2015, Ministry of Agriculture and Forests)

Figure 22: Timber and Firewood Supply in Bhutan (in m³)[9]



(Source: Developed from Bhutan RnR Statistics – 2015, Ministry of Agriculture and Forests)

3.4.2 Briquettes:
It is a hardened and densified form of biomass wastes produced under sufficient heat and pressure. Briquettes have high specific density (1,200 Kg/m^3) and bulk density (800 Kg/m^3) compared to 60 to 180 Kg/m^3 of loose biomass. Compared to fire-wood or loose biomass, briquettes give much higher boiler efficiency because of low moisture and higher density[9]. It is produced from waste wood and sawdust from the saw-mills in the country. The production of briquettes for the year 2014 amounts to 367.4 tonnes out of which 316.2 tonnes have been consumed against the production of 404.3 tonnes and a disposal of 400.4 tonnes from the last year (2013). The briquette type produced is saw-dust briquette which is usually used as an alternative for fuelwood in various heating purposes in the households and industries.

3.4.3 Biogas:
According to the Biogas Market Study conducted by Asian Development Bank in 2009, there is a significant population in the rural regions who own sufficient cattle to run an average sized (4-12 m^3) biogas plants.

This feasibility study concluded that a small scale domestic biogas programme (4-8 m^3) is possible with a technical potential of about 20,000 biogas plants especially in the southern belt and inner mountain valleys. However, the key barrier for the development in Bhutan is whether the households have enough number of cattle to feed the plant with the required amount of manure on a daily basis as the slurry content for the identified households is highly dependent on cow-dung.

Another barrier identified was the willingness and ability to invest in the installations. Currently, under ADB Grant, the Bhutan Biogas Project implemented by the Department of Livestock, MoAF with DRE as the executing agency, have embarked upon installing plants across the country. The Biogas plants are available in five different sizes; 4 m^3, 6 m^3, 8 m^3, 10 m^3 and 12 m^3. The numbers of different biogas plants that have been disseminate till December, 2014 and the estimated total biogas generation from those are given in table 9.

3.5 Other Potential Renewable Energy Resources

The primary energy needs of Bhutan are met from renewable energy sources of which hydropower and biomass comprise the largest share of energy use in the economy and contribute to over 80% of the energy supply mix. Hydropower potential in the country is estimated at around 30,000 MW of which approximately 23,760 MW is estimated to be techno-economically feasible for development. Bhutan also demonstrates significant potential for other renewable resources like

9 While timber refers to the entire wood stock of the tree, firewood refers to the various forms of wood that can be used for fire. Current laws limiting usage of two trees per family has curbed surplus access to timber but the firewood usage continues to remain as it is.

Table 9: Estimated Annual Generation of Biogas

Capacity of the Biogas Plants (m^3 or 1000 litres)	Number of Such Plants	Productivity of each size per day (m^3)	Daily Productivity of the all plants across the country
4	1,048	1.2	1,257.6
6	374	2	748
8	4	2.8	11.2
10	3	3.6	10.8
12	0	4.4	0
	1,429		**2,027.6**
Density of Biogas (Kg per m^3)	**1.214**	Biogas comprises of 60-65 per cent methane, 35-40 % carbon dioxide, 0.5-1.0 % hydrogen sulphide, rest being water vapour etc. Its density is 1.214kg/ m^3 (assuming about 60 % methane and 40 % CO2).	
Annual Generation of Biogas (Tonnes)	**898.45**	Total expected biogas supply in the country.	

solar energy, wind energy and municipal solid waste, which, have not been exploited at full potential.

3.5.1 Solar Energy

Solar Photovoltaic

Initial assessment of the U.S. Department of Energy's National Renewable Energy Laboratory (NREL) in 2009 on the solar potential in Bhutan shows that the country has an adequate radiation and temperature for generating solar power with 4.0 to 5.5 peak sun hours per day (Cowlin and Heimiller, 2009). The following table illustrates the total photovoltaic electricity production potential by district.

The assessment also reported that, although the best potential is in northern areas with low population densities, the solar resource throughout the country is suitable for photovoltaic development. The concerns cited were that the best areas are difficult to access through electric transmission infrastructure and load centers. Further in 2015, the Renewable Energy Resource Assessment conducted by the DRE, reported theoretical potential of Solar Photovoltaic power generation to be 3,706,328 MW (Fichtner, 2015) considering the entire solar irradiance available to the country's landscape. However, in the same report it was assessed that the total restricted theoretical development potential of Solar PV power generation for Bhutan is around 12,000 MW taking into consideration the rugged terrain, national protected areas and other restrictions.

The total technical potential estimates show that Bhutan has sufficient solar potential that can be developed for electricity generation. There are approximately 4,600 operating systems in the country out of which 2,750 are turned on-grid systems whereas 1,848 are off grid systems[10].

The total restricted theoretical development potential for solar power generation from solar PV is estimated to be around 12,000 MW.

The following table shows the generation and consumption of solar electricity in Bhutan for the 2014. It has been estimated that the annual electricity generation is 0.14 GWh, with 2,392 solar PV homelighting systems operating at a capacity of 50 Watt-peak.

10 Out of the installed solar home lighting systems, there is a proportion which is connected to the grid (on-grid) and those which are not connected to the grid (off-grid). In this study, to estimate the total generation of electricity, the number of systems, currently in operation was considered.

Table 10: Total photovoltaic electricity production potential by district

District	Productive Area (km^2)	Average Annual Solar Resource at Tilt = Latitude (kWh/m^2-day)	Average Annual DC Photovoltaic Production (million kWh_{DC}/yr)	Average Annual AC Photovoltaic Production (million kWh_{AC}/yr)
Bumthang	40.77	5.2	6,700	6,000
Chukha	28.20	4.8	4,300	3,800
Dagana	25.85	4.8	3,900	3,500
Gasa	47.03	5.3	7,800	7,000
Haa	28.58	5.0	4,500	4,000
Lhuntse	42.89	4.9	6,600	5,900
Mongar	29.17	4.8	4,400	4,000
Paro	19.31	5.3	3,200	2,900
Pemagatshel	15.33	5.0	2,400	2,200
Punakha	16.65	5.0	2,600	2,400
Samdrup Jongkhar	28.16	4.7	4,100	3,700
Samtse	19.58	4.7	2,900	2,600
Sarpang	24.84	4.7	3,700	3,300
Thimphu	26.94	5.3	4,500	4,000
Trashigang	33.07	4.9	5,100	4,600
Trongsa	27.21	4.9	4,200	3,700
Tsirang	9.57	4.9	1,500	1,300
Wangdue Phodrang	60.55	5.1	9,600	8,600
Trashiyangtse	21.74	4.9	3,400	3,000
Zhemgang	36.26	4.8	5,500	4,900
Total	**582**		**90,900**	**81,400**

(Source: Potential for Development of Solar and Wind Resource in Bhutan, 2009 - Shannon Cowlin and Donna Heimiller)

Table 11: Solar Electricity Generation in Bhutan in 2014

Solar systems Specifications	Value	Units	Source
Capacity of electricity generation	50	Watt-peak	Solar Energy Section, DRE
Probable Annual Electricity Generation per set	60	kWh	Multiplying the Watt-peak with the total feasible days for capacity utilization obtained from New Resource Assessment Report, DRE (1200 hours)
Total Operating systems	2,392	Number	IMS Survey Report
Annual Electricity Generation	0.14352	GWh	Calculated
Residential Users	2,120	Number	IMS Survey Report
Institutional Users	272	Number	IMS Survey Report
Residential Consumption	0.13	GWh	Calculated
Institutional Consumption	0.02	GWh	Calculated

Table 12: Installed Solar Water Heating System (Funded by RGoB)

No.	Users	Location	Capacity (LPD)	Commissioned Year
1	Gedagom Hospital	Thimphu	1,000	2009
2	Sangacholing Lhakhang	Chhukha	500	July, 2012
3	Guru Lhakhang	Paro	500	July, 2012
4	Naychen Dongkola Goempa	Paro	1,000	July, 2012
5	Lhakhang karpo	Haa	1,000	2012
6	Bjishong Middle Secondary School	Gasa	2,000	2014
7	Rigdhe Maha Guru Monastery	Samdrup Jongkhar	1,000	2014

Solar Water Heating

Considering the solar irradiation potential in Bhutan, it is theoretically feasible to tap solar water heating potential. However, due to lack of information and expertise in the field, and the relatively high cost of solar water heating systems, the technology has not been adopted abundantly in Bhutan. Currently there are a few numbers of solar water heating systems installed in institutional structures in the country which are listed in table 12.

3.5.2 Wind Energy

Bhutan has significant potential to develop wind power systems in the country with Wangdue Phodrang, Mongar and Chhukha being the most attractive sites for it, in terms of technical feasibility and logistical access (NREL, 2009). The U.S. Department of Energy's National Renewable Energy Laboratory (NREL) produced maps and data of the wind and solar resources in Bhutan with support from the U.S. Agency for International Development (USAID) and was reported in the document- 'Potential for Development of Solar and Wind Resource in Bhutan 2009'.

The report shows an assessment of the most attractive sites for the development of wind power generation and cost of setting up the projects.

The total restricted theoretical development potential of wind power for Bhutan is estimated to be around 761 MW, with the highest potential assessed to be 141.7 MW at Wangdue Phodrang followed by Chukha with 91.8 MW (Draft RE Assessment, DRE, 2015)

3.5.3 Waste to Energy Potential

The average household waste generation in the urban areas is 0.96 kg per HH per day while the per capita household waste generation is 0.253 kg per day. Average non-household waste generation rates are 2.362 kg per day per commercial establishment, 1.439 kg per day per office or 0.329 kg per employee per day (MoWHS, 2007).

High organic content of the urban MSW indicates an opportunity to give priority to the recycling of organic wastes through composting. Incineration can be used for generation of heat energy from mixed waste compositions.

The total Municipal Solid Waste (MSW) generated from the urban areas of Bhutan in 2007 was estimated at 43,697 tons per year. Household waste formed the major portion (40.3%) of the MSW followed by commercial sources at 34.7% of the sources surveyed. In the MSW composition study, organic waste formed the largest fraction of the MSW with 58.05%, followed by paper/paperboards (17.20%), plastics (12.73%), textiles/leather (4.72%), glass (3.69%), metals (0.67%), electrical/electronics (0.37%) and others 2.56%.

However, incineration is significantly costlier than using landfills. The waste generators: the individual households and the commercial sector, must therefore be willing to pay the additional cost, or else would need the support of government subsidies. Nevertheless, at a small-scale level, waste recycling turns to be doubly beneficial in terms of waste management and energy generation.

The benefit of waste-to-energy techniques is two pronged. On one hand, the issue of waste management is catered and on the other, there is an additional source of energy. The maximum electricity generation potential from household waste in 2014 is estimated to be 11,885 kWh a day which can be beneficial for community based supply of electrical energy.

Table 13: Waste to Energy Generation Potential from Household Waste in 2014

Year	Population	Household	Household Waste Generation (in MT)
2014	745,153	161,990	40,983
2015	757,042	164,574	41,637
2016	768,577	167,082	42,272
2017	779,666	169,493	42,882
2018	790,215	171,786	43,462
2019	800,154	173,947	44,008
2020	809,397	175,956	44,517
Per capita Kg of household waste generation/day			**0.253**
Amount of waste		MT / day	40.98
Calorific Value		Kcal / MT	1,201,000[11]
Generation factor (Assuming Incineration)		Kcal/ KWh	4,200[12]
Maximum Electricity Generation Potential from household waste in 2014		KWh / MT	290
		kWh / day	11,885.19

11 IPCC Guidelines for National Greenhouse Gas Inventories

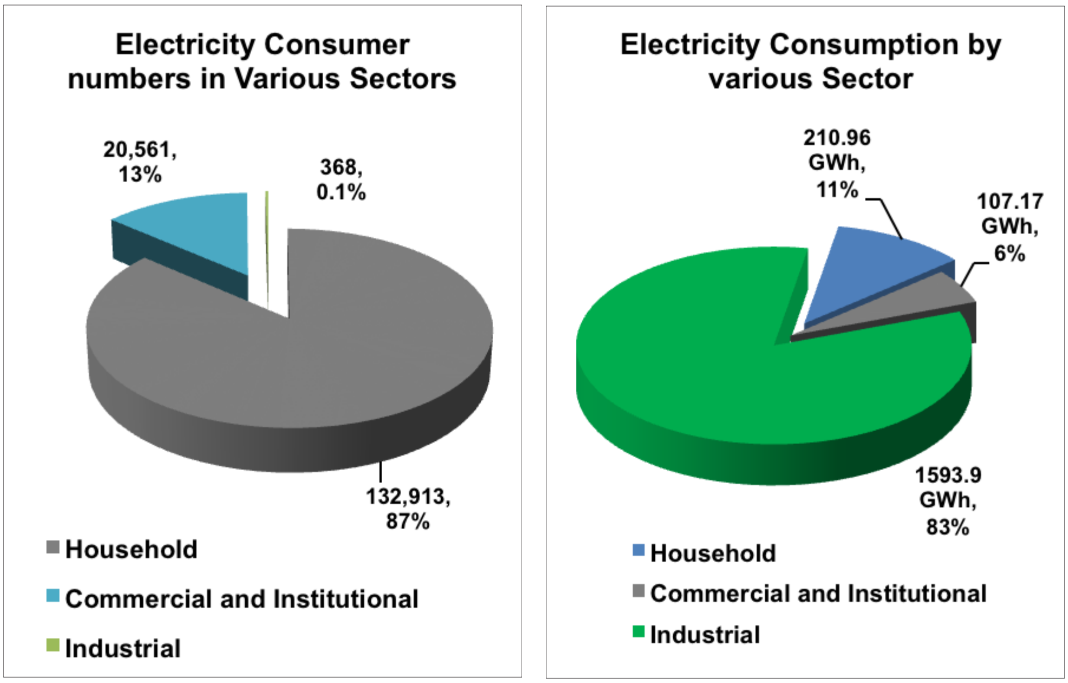
12 IPPC Reference document on Best Available Technologies for Waste Incineration

4. ENERGY DEMAND

This chapter provides the characteristics in energy consumption in the three energy-intensive sectors, namely the Building, Industry and Transport sectors. Survey and secondary research in these three sectors reveal the energy usage in terms of pattern, quantum, the type of fuels used and their applications in the different sectors. All three sectors demonstrate a high change in the consumption mix over the past decade. The Building Sector which used to be heavily dependent on fuelwood to cater its energy needs has shown increasing tendency to use electricity. After fuelwood, electricity has emerged as the main source of energy in Bhutan followed by diesel and coal. Fuelwood use is limited mainly to the Building Sector and used sparsely in the Industries. Electricity has gained a significant prominence since the last decade and is mostly used for heating and cooling in the industries; lighting in the buildings; and has started to be used in the Transport Sector as well, in the form of vehicular fuel.

The industries consume 83% of the electricity in the economy followed by the residential households consuming 11% and commercial & institutional buildings consuming around 6% of the total electrical energy supplied in the economy.

Figure 23: Electricity Consumption in 2014



(Source: Developed from BPC Power Data Handbook 2014)

4.1 Industry Sector:

The Industry sector of Bhutan, including the hydropower plants, contributes to more than 40% to the overall GDP of Bhutan. Energy audits have revealed that there are significant opportunities for optimization of process as well as equipment energy consumption in the large and medium scale industries where the consumption of energy is very high. The Cottage and Small Scale Industries are not energy intensive but are the largest employing industrial segments in the country. One of the key sources of competitiveness for industries is the relatively low electricity tariffs. The major industry clusters in Bhutan are based in Pasakha, Phuentsholing, Gomtu and Pugli. The sector is dominated by few major manufacturing firms based on Ferro-Alloys, mineral and mining and a large number of smaller firms dealing in handicrafts, food processing, construction, wood, saw-mills, poly-products and paper processing. The country has also witnessed a growth of 11.3% in the number of Cottage and Small industries (CSI) in the fiscal year 2013-2014. Thimphu region has the highest growth of 18% and a total of 1,701 CSI have been recorded to have come into operations in this period and the estimated total employment contributed by the CSI is 41,764 in 2014, compared to 34,246 in 2013 (DCSI, 2014).

Currently, Electricity is the major fuel input in the industry, and is mainly consumed in the ferro-alloy, steel and cement based industries of the industry . Power consumption in the saw-mills, briquetting, packaging, poly-products, wire and marble industries are quite small compared to the overall scenario (i.e. <0.5% = 6.6GWh per year). The thermal energy consumption in Industry is dominated by the use of coal. Coal is an important input in the industries in Bhutan. Liquid fuels represented by usage of diesel, kerosene oil and furnace oil account for less than 6% of the industry thermal energy mix. Fuel oils are mainly used in the food and beverage industries whereas coal is used mainly in the cement and ferro-alloy industry except for Druk Cements which uses only electrical energy.

Although there has been a continuous increase in the consumption of coal, the fuelwood consumption in the industry sector has been reducing drastically. This change is estimated to be brought about by substitution of fuelwood by electricity for the purpose of heating in the industry. Diesel in the form of Light Diesel Oil (LDO) and Hi-Speed Diesel are being increasingly used substituting the dependence on Industrial Superior Kerosene Oil (SKO) by a large extent.

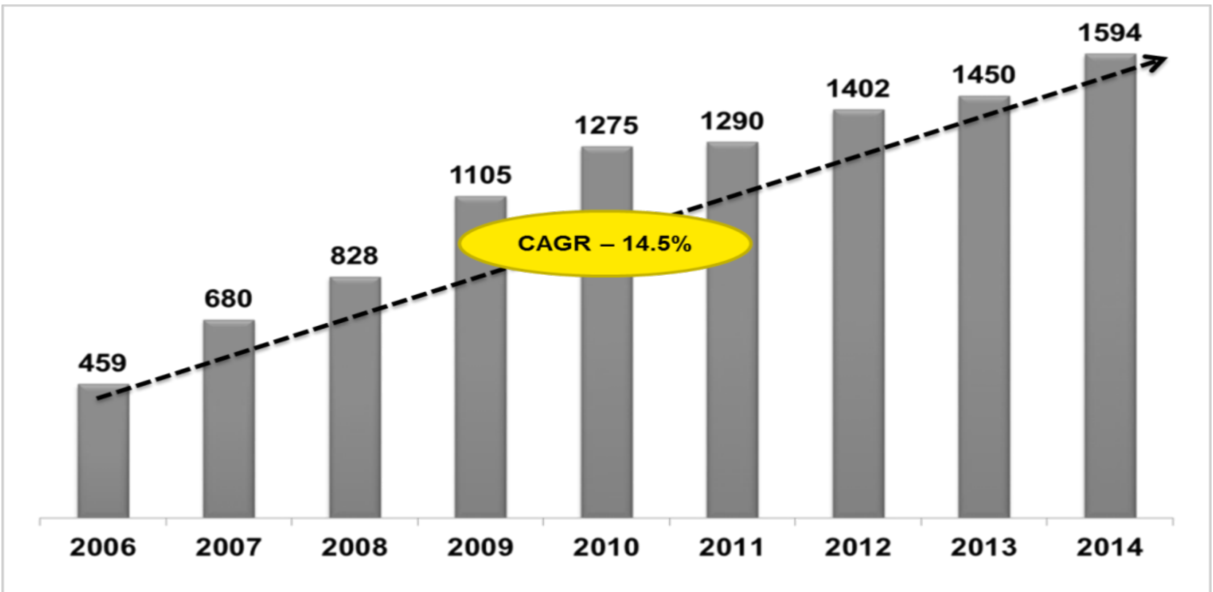
Energy consumption in the industry sector amounts to 241,972 TOE in 2014.Taking CAGR for all the fuel usage trends in the Industrial sector, in the last decade, electricity and coal are the most significant contributors to energy consumption.

Given the increasing trend in electricity consumption with a CAGR of 15.27%, electricity is expected to dominate the future scenario with diesel and coal following behind which have been growing at a CAGR of 14.94 % and 9.93% respectively.

Table 14: Energy Consumption in the Industries

Fuel	Units	2005	2014	CAGR
Electricity	**GWh**	443.75	1,593.9	15.27%
Kerosene	**KL**	275	21.0	-24.86%
Biomass	**MT**	94,743	11,439.2	-20.94%
Liquefied Petroleum Gas	**MT**	-	516.6	-
Diesel	**KL**	785	2,787.92	15.12%
Coal	**MT**	97,509	228,521.99	9.93%

Figure 24: Industrial Electricity Consumption (in GWh)[13]



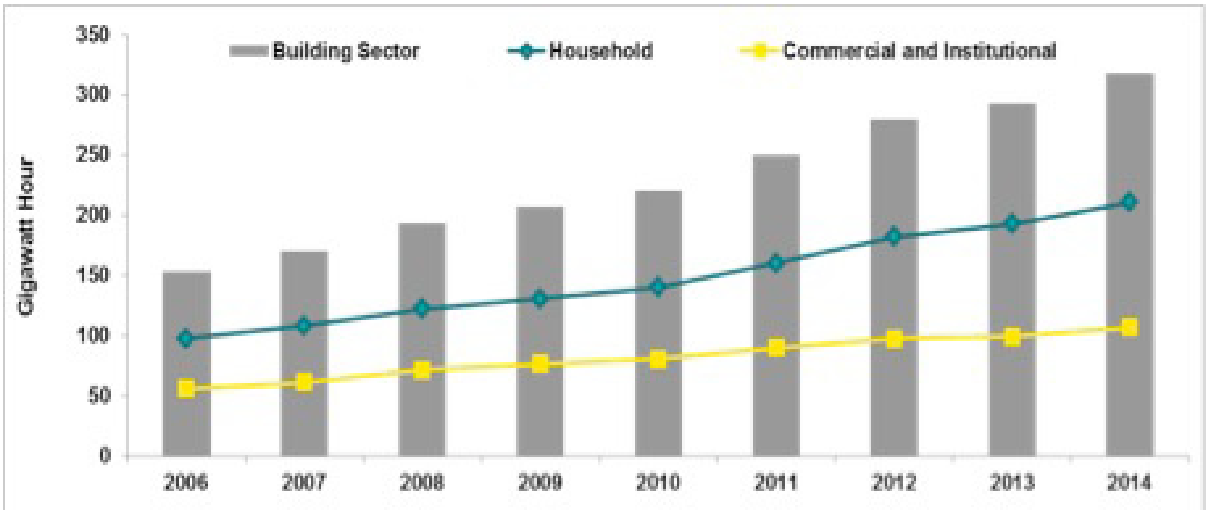
(Source: Bhutan Power Corporation, Power Data handbook-2014)

4.2 Building Sector:

The building sector contributes to 42% of the total energy consumption in 2014. Building Sector consumes energy primarily in the form of electricity, biomass and solid/ liquid fuel (LPG, kerosene etc.).

The building energy audit observations reveal that buildings in Bhutan have a high level of dependence on fuelwood for space heating and cooking. The energy usage pattern has also been documented across different typologies of buildings based on

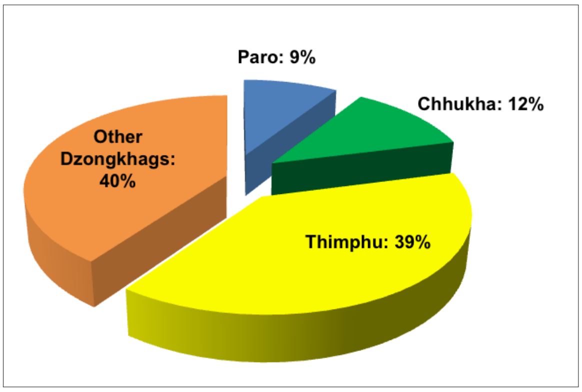
Figure 25: Electricity Consumption Split by Consumer Segments under Buildings Sector (in GWh)



(Source: Developed from Power Data Handbook 2014)

13 This accounts for the HV, MV and LV Industries' annual consumptions recorded by Power Data Handbook (2014)

Figure 26: District-wise Electricity Consumption in Building Sector



(Source: Developed from Power Data Handbook 2014)

Energy consumption in the building sector amounts to 270,356 TOE in 2014 with the Residential segment consuming 213,422 TOE of energy and Commercial & Institutional segment consuming 56,934 TOE of energy.

While the thermal energy consumption in buildings stands at 242,916 TOE, the electrical energy consumption is 27,440 TOE for the year 2014.

use. Thimphu is the highest electricity consuming district with the maximum consumption in urban residential sector.

The maximum electricity consumption in the building sector accrues to the usage of electrical appliances and equipment which are steadily increasing in demand. This is due to increasing number of buildings getting connected to the grid. The import of the major electricity consuming appliances is shown in table 16.

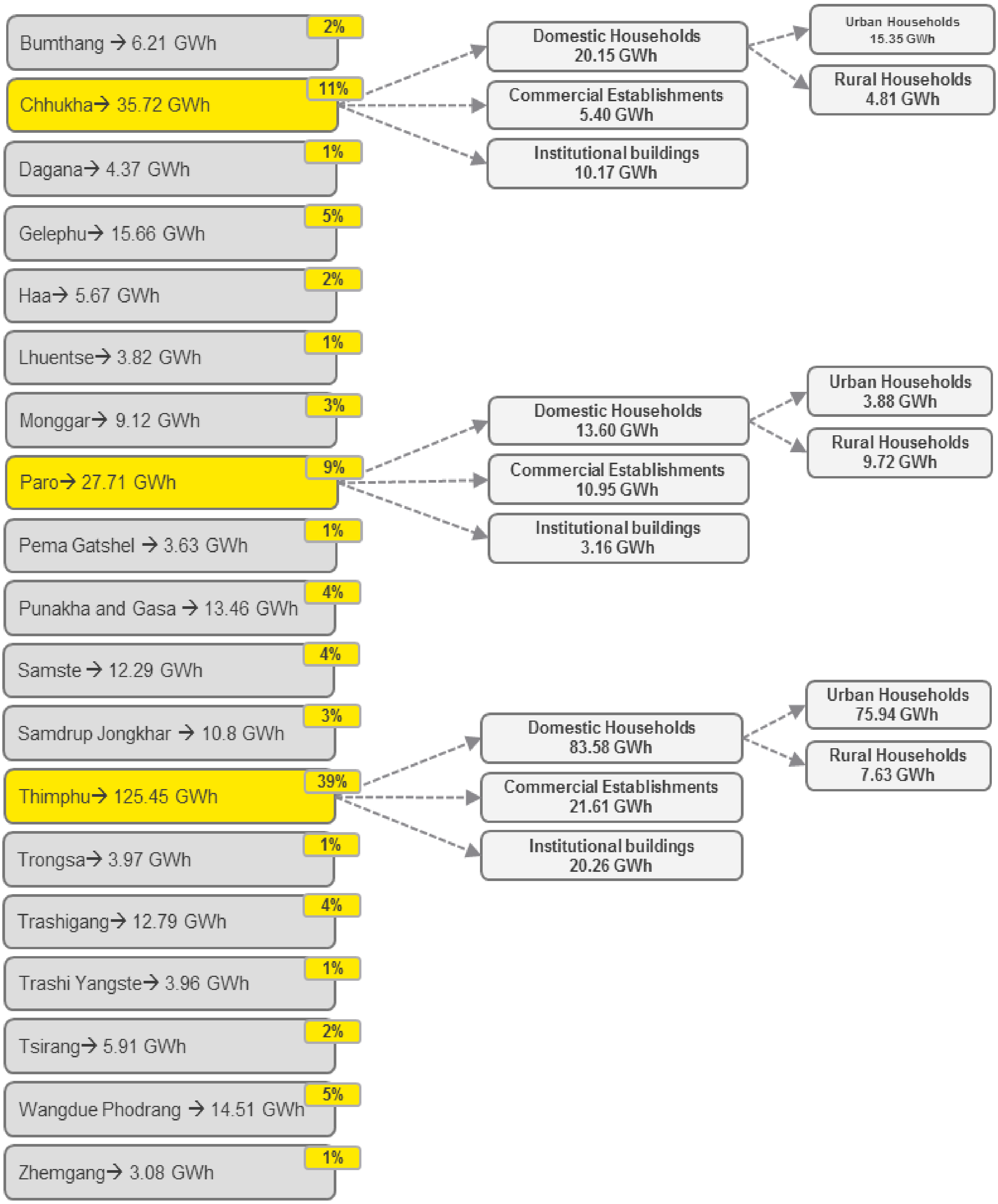
The increase in the usage of electrical appliances has contributed to a significant change in the residential households' energy consumption mix. The increasing dependency on electricity is indicated through the significant increase in the demand for appliances over the years. Figure 28 exhibits share of electricity consumption in each Dzongkhag in the Building Sector.

Table 15: Import of Electrical Appliances - Some Major Electricity Consumers

Major Appliances	Import CAGR - 2005 to 2014
Washing Machine	21%
Refrigerators	20%
Lighting Bulbs	13%
Television	7%
Electric Storage Water Boilers (Geysers)	35%
Household Fans: Ceiling Fans, Table Fans, etc.	16%
Air-Conditioners	17%
Microwave Ovens	21%
Storage Room Heaters	33%
Electric Cooking Appliances - Rice Cookers, Curry Cookers, etc.	10%

(Source: Bhutan Trade Statistics, 2005 to 2014)

Figure 27: Electricity Consumption in Building Sector by Dzongkhag



(Source: Developed from Power Data Handbook 2014)

4.2.1 Residential Segment:

Heating, cooking and lighting are the main energy end uses in the residential segment. There has been a considerable shift of the usage of fuelwood to electricity in the last ten years. In terms of the fuel-mix, the number may not seem prominent as the amount of fuelwood consumed by the residential households for the year 2005, constituted 91% of the total fuel-mix of the residential segment, while it is 87% in 2014. However, this indicates that the energy dependency of the residential households is trending towards a shift from biomass to electricity.

In the urban residential households, which are the highest electricity consumers in the Building Sector, Thimphu Dzongkhag consumes around 60% of the electricity. The total consumption of electricity in the building sector amounts to 319.13 GWh. It is worth noting however, that Thimphu accounts for only 48% of the number of grid-connected consumers, with an average population per electricity connection at 5.6, which is among the lowest in the country, this is an indication that with growing affluence and access to electricity, the per capita consumption is probable to increase significantly. The per capita electricity consumption in the average urban household is close to 2.5 to 3 times that of the rural household. With increasing access to electricity and electrical appliances, based on the trends observed, it is expected that the per capital electricity consumption would increase over the next ten years.

The residential segment of Building Sector has shown an increase in the demand for electricity and LPG with a CAGR of 10.07% and 6.77% respectively from 2005 to 2014. However, these fuels seem to have substituted fuelwood and a significant amount of kerosene, both of which reduced by a CAGR of 1.04% and 6.85% respectively. The energy used from fuelwood for cooking is being primarily substituted by LPG, electricity and biogas while the fuelwood for space heating is being substituted by mainly electricity.

4.2.2 Institutional and Commercial Segment:

The commercial and institutional segment under the Building Sector, as defined for this report, consists of non-residential buildings which includes the following types of establishments:

- Schools, hospitals, shops, hotels and restaurants
- Monasteries, Government institutions and offices,

Table 16: Energy Use Break up for Residential segment (Building Sector) – 2014

Fuel	Units	2005	2014	CAGR
Electricity	**GWh**	89.31	211.85	10.07%
Kerosene	**KL**	6442	3,402.0	-6.85%
Biomass	**MT**	543,503	494,831.2	-1.04%
Liquefied Petroleum Gas	**MT**	3522	6,348.6	6.77%

including the armed forces, the police, and municipal corporations

- Road construction units

Although, electricity has had far reaching influence on all sectors, the reduction in the usage of wood biomass in all sectors has been stark. However, in the Building Sector, usage of biomass is common but the amount used has reduced over time.

The institutional and commercial segment in Building Sector has shown an increase in the demand for biomass and electricity with a CAGR of 5.49% and 8.41% respectively. However, these fuels seem to have substituted a large amount of kerosene which has reduced by a CAGR of 9.94% in this segment.

Wood biomass in the form of firewood is used in many commercial buildings for cooking and heating. Institutional buildings also use fuelwood for heating and cooking along with usages in funerals, constructions, etc. A break up of the fuelwood usage in the institutions has been shown in figure 29, followed by energy use break up in institutional and commercial segment in 2014 given in table 18.

Figure 28: Firewood Usage in Institutions from official accounted supply

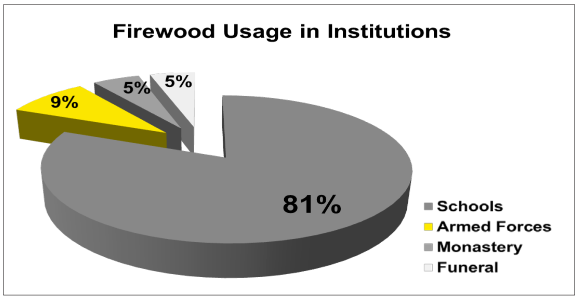


Table 17: Energy Use Break up in Institutional & Commercial segment in 2014

Fuel	Units	2005	2014	CAGR
Electricity	**GWh**	51.86	107.3	8.41%
Kerosene	**KL**	5,828	2,271.0	-9.94%
Biomass	**MT**	74,065	119,838.2	5.49%
Liquefied Petroleum Gas	**MT**	950	681.3	-3.63%

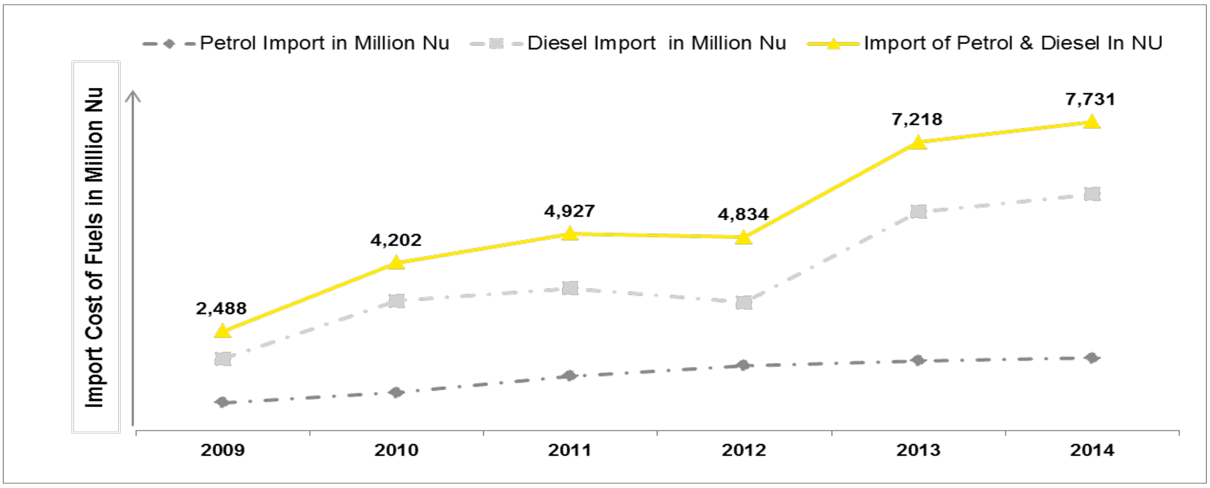
4.3 Transport Sector:

The transport sector is a critical element of infrastructure, as it plays a significant role in the overall development of a nation's economy through better communication and access to utilities. The transport system in Bhutan consists mainly of road and air transport services. Road transport is the most commonly used internal transport mode in Bhutan. The near absence of alternative modes of transport such as railways and navigable rivers within Bhutan reinforces the dominance of road transport for passenger and freight movement in Bhutan's overall transport system. The air transport system supports the heavy tourist attraction and business travellers from abroad.

Transport sector is one of the major consumers of energy in Bhutan and, almost all the energy used in the sector is derived from imported fossil fuels. Bhutan is a net power surplus country and the main driver of the economy has been export of electricity.

Bhutan exports up to 80% of the electricity it produces every year (BPC, 2013). Between 2007 and 2013, the country has been domestically consuming approximately 25% of the clean hydropower that it produces, exporting the majority to India. However, almost all of the revenue earned from exporting electricity is spent on fuel imported from India to fuel the nation's Transport Sector. There are more than 36,000 vehicles in the capital city, Thimphu alone (RSTA, 2014). Total value of imports of petroleum products in Bhutan for the year 2014 was Nu 8,432.66 million (NSB, 2014) of which petrol and diesel contributes to around 91% by volume.

Figure 29: Cost of Importing Diesel and Petrol



(Source: Statistical Yearbook 2014 – National Statistical Bureau)

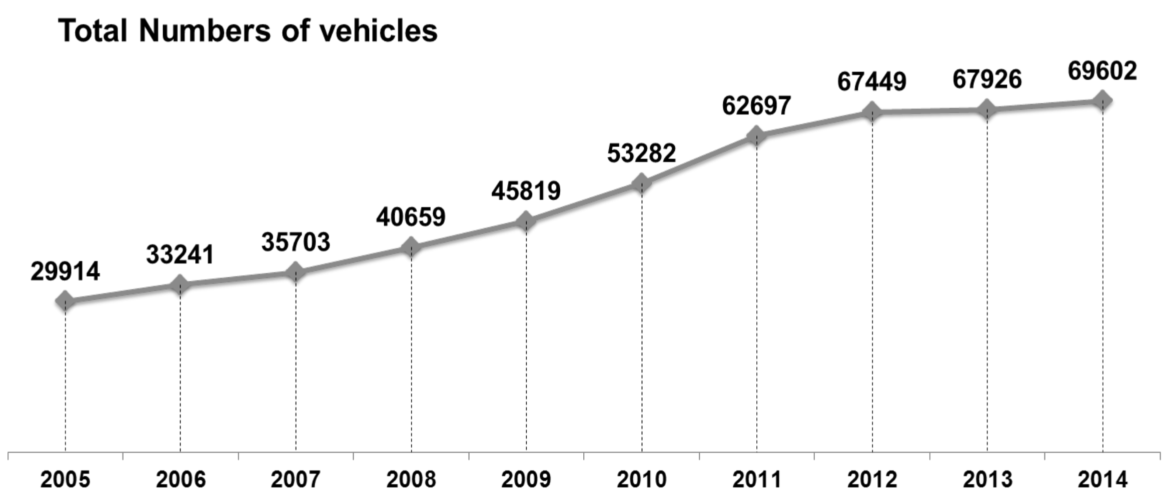
The Ministry of Information and Communication (MoIC) is the apex body responsible for all policies, regulations, and development of the transport sector in Bhutan.

Other important government and private institutions are:

- Road Safety and Transport Authority (RSTA): In order to stream line the transport system, all types of motor-vehicle-related activities – including registration and licensing, roadworthiness, emission tests, control over taxis, passenger transport services and other commercial vehicles–were consolidated under the Road Safety and Transport Authority (RSTA) since the beginning of 1997.
- Project Dantak of the Border Roads Organization of the Government of India,
- Department of Roads under the Ministry of Works and Human Settlement (MoWHS), which are responsible for the construction and maintenance of the highways and roads,
- Drukair Corporation Ltd. and Tashi Air Private Ltd. (trading as Bhutan Airlines), which are the only airlines in the country,
- Bhutan Postal Corporation Ltd. (Bhutan Post), which runs the city bus service in Thimphu city,
- Tourism Council of Bhutan; and private bus operators and tourist agencies.

The transport sector almost entirely depends on diesel, petrol and ATF to meet its energy requirements and has recently started using electricity with the introduction of electric and hybrid-electric vehicles. There are 61 electric vehicles registered till December, 2014 (RSTA, 2015). Shift from use of fossil fuel to clean hydro-power generated electricity is encouraged through implementation of tax exemption on electric vehicles. Although the hybrid electric vehicles are not exempted from taxation, the tax rates are lower compared to the conventional vehicles.

Figure 30: Transport Sector Characteristics in Bhutan (2014)



Year	2006	2007	2008	2009	2010	2011	2012	2013	2014
Growth	11%	7%	14%	13%	16%	18%	8%	1%	2%

(Source: Annual Info-Communication and Transport Statistical Bulletin, 2015)

The vehicle population characteristics are as follows:

- 53.2% of total vehicles are registered under Thimphu region, 36.2% under Phuentsholing region, 4.7% under Gelephu region and 5.96% under Samdrup Jongkhar region
- The total number of vehicles increased from 67,926 in 2013 to 69,602 in 2014, an increase of 2.46% from the year before whereas there was a huge dip in the total number of taxis from 5,191 in 2013 to 4,109 in 2014 accruing to a cumulative decrease of 20.8% from the year before.

There has been a huge growth in the vehicle population in the country from 29,914 vehicles in 2005 to 67,449 vehicles in 2012. Although, due to temporary prohibition on the import of vehicles imposed from March 2012 to July 2014, the growth was paced down to 1 – 2% during this period, the number of vehicles registered in the country reached 69,602 in 2014.

The maximum taxi registrations occur in Thimphu and so is the number in use due to larger concentration of the population living in the Thimphu city.

The taxis are the largest consumer of petrol amongst the different types of vehicles plying in the country. Although taxis are the sole largest consumer of petrol (2.25 kl) annually, the largest consumers of diesel are the trucks (4.9 kl) and buses (4.3 kl) followed by the taxis (3.9 kl) (EY analysis, 2015).

In comparison to 2005, the fuel consumption in Transport Sector has increased by almost two folds for all the fuel types. There has been a 6.34% CAGR increase in the consumption of Petrol, 13.38% CAGR increase in the consumption of ATF and an increase of 9.51% CAGR for diesel demonstrating a high dependence on diesel.

Table 18: Transport Sector Energy use Break-Up

Fuel	Units	2005	2014	CAGR
Petrol	**KL**	13,879	24,129	6.34%
Diesel	**KL**	48,702	110,281	9.51%
Aviation Turbine Fuel	**KL**	1,145	3,546	13.38%
Electricity	**GWh**	0	0.1	NA

5. ENERGY BALANCE AND FUEL MIX

The country's energy supply mix shows that there is still a large dependence on thermal energy (72%) out of which petroleum products contribute 21%, followed by the industrial consumption of coal and its derivatives which forms 15% and biomass (36%) in the building sector. The remaining source of energy is from electricity contributing to 28% of the aggregate fuel mix (Figure 31).

In 2014, Bhutan consumed 650,220 TOE of energy. The highest energy consumption is observed in the building sector (270,356 TOE) which comprises of 41.58% of the total energy consumed in the country while the energy consumption in the industry sector was 37.22% of the total consumption (241,972 TOE). The transport sector follows after the industry sector with 18.64% share in the energy consumption (121,218 TOE) with the remaining 2.56% being consumed in agriculture and other auxiliary sectors (Figure 32).

Figure 31: Total Energy Supply and Fuel Mix

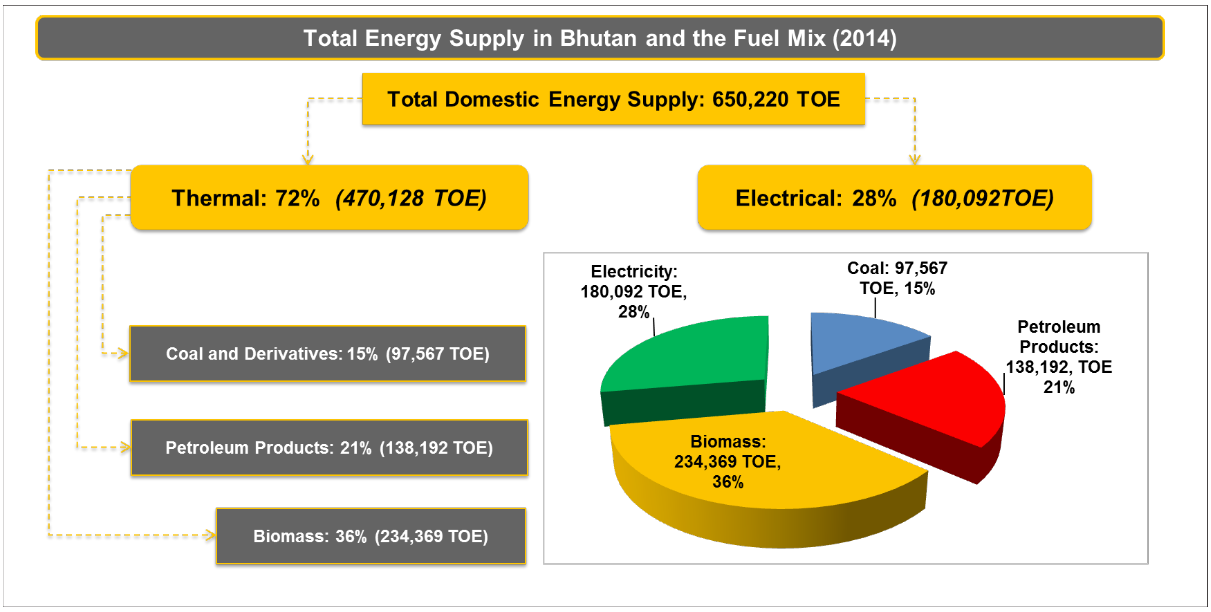
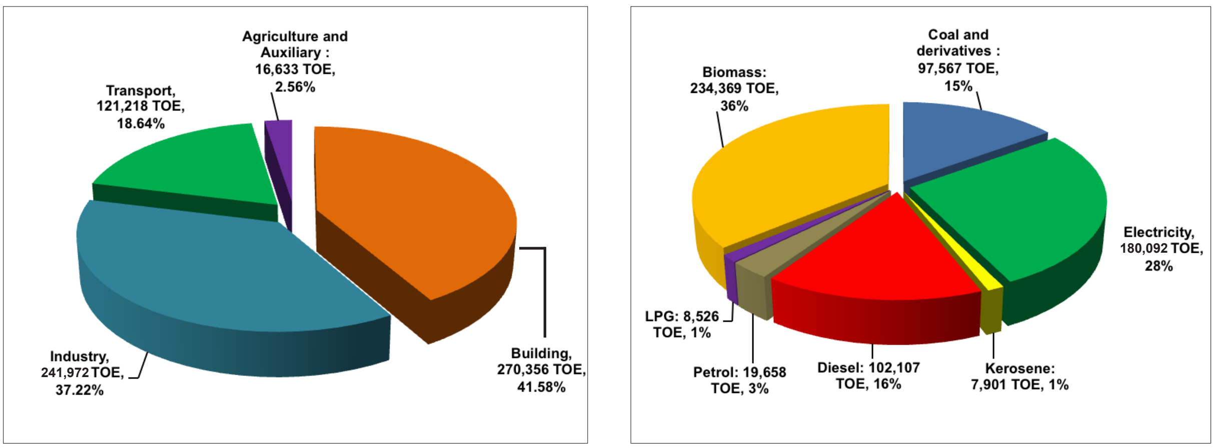


Figure 32: Energy Consumption in 2014 - Sectoral Break-up and Fuel Mix



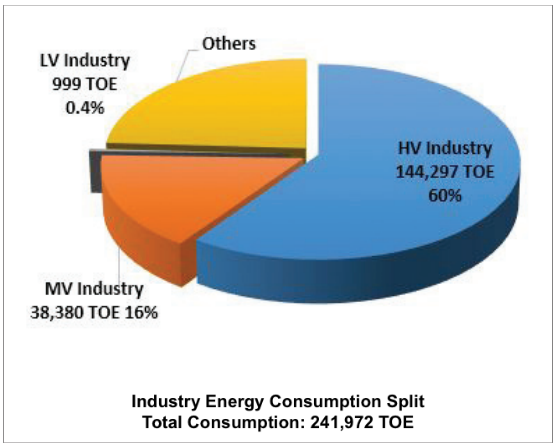
The fuel consumption in the country is dominated by biomass (fuelwood, biogas and briquettes) – amounting to 234,369 TOE (36%). This is followed by electricity at 28% - amounting to 180,092 TOE. Other than biomass and electricity, other major sources include coal (97,567 TOE) constituting 15% of the total fuel mix along with diesel which amounts to 102,107 TOE (16%). Other important sources of energy include petrol, kerosene and LPG – together constituting around 5% of the fuel mix. Given the aggregate consumption of energy, the per-capita consumption of energy has increased to 0.87 TOE in 2014 from 0.63 TOE per capita consumption of energy in 2005.

The Industry Sector has the most diverse fuel mix. For the Industry Sector, the high voltage industries are the major consumers of energy, consuming around 60% of the total energy in the sector. The heavy industries also have a diverse fuel consumption mix, while the medium and CSI are mainly dependant on electricity as the main fuel. The fuel consumption split shows that the major source of energy is electricity (57%) and coal (40%) making these the two most consumed fuel in the sector (Figure 33).

In 2014, the fuel composition in residential sector is dominated by biomass (87%) and electricity (8%). Biomass in the form of firewood, briquettes and biogas are still the ideal choice for cooking and heating in the rural areas. Particularly in the residential building sector, fuelwood usages have reduced from 91% in 2005 to 87% in 2014 (Figure 34).

Increasing electricity access and LPG has substituted fuelwood usage in heating and cooking, but

Figure 33: Industry Energy Consumption Split and Fuel Mix for 2014



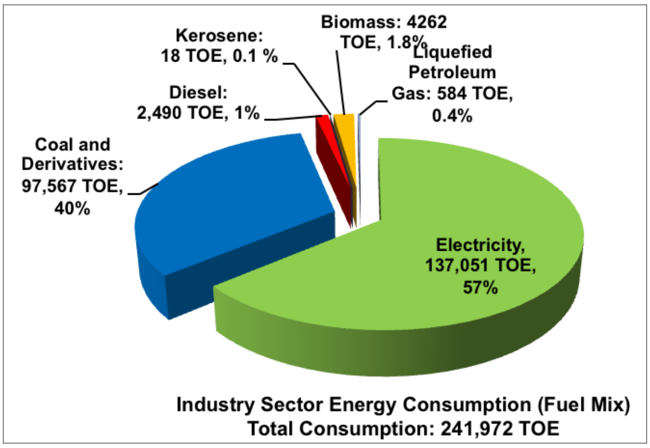
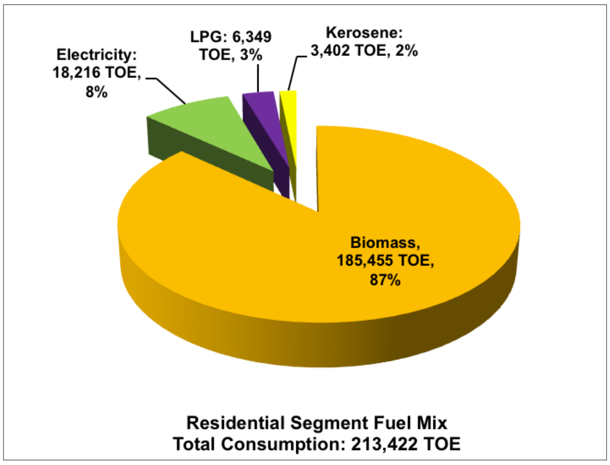
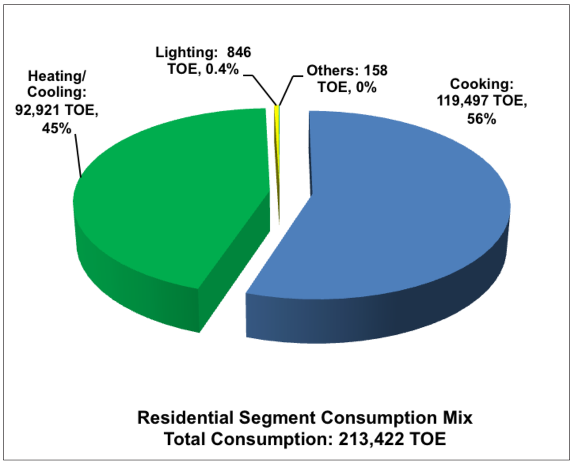


Figure 34: Residential Energy Consumption Split and Fuel Mix for 2014



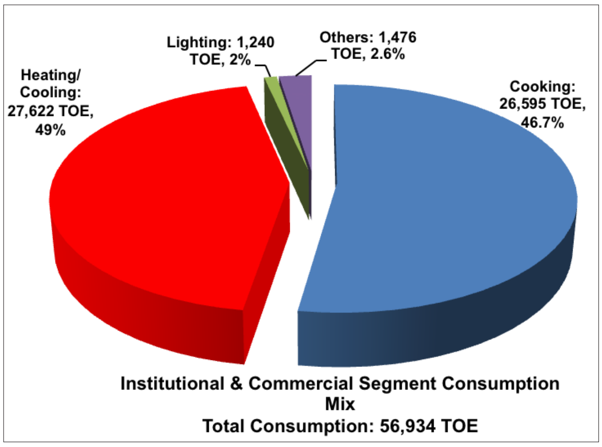


the impact observed is not significantly high as the rural households are still highly dependent on fuelwood. This is due to the easy accessibility, low cost and behavioural stagnancy in favour of fuelwood usage in rural areas.

The main energy use in the Institutional and Commercial segment of Building Sector is heating and cooking, making up more than 95% of the total energy use in the segment. This segment is dominated by the biomass, particularly fuelwood, which comprises of 44,652 TOE (78%). Electricity use has grown by a CAGR of 8.4% over the last decade from 52 GWh in 2005 to 107 GWh in 2014 whereas other fuel components are Kerosene and LPG amounting to 1,465 TOE and 1,593 TOE respectively (Figure 35).
The composition of transport sector fuel mix remains almost the same without much change as compared to 2005. Majority of the sectoral fuel mix is dominated by diesel at 81%, followed by petrol at 16%. These two fuels are the major contributors to the fuel mix in the transport sector amounting 118,197 TOE in the year 2014. Other than petrol and diesel run vehicles, the aviation segment in the transport sector consumes ATF, also known as jet kerosene, amounting to 3,016 TOE (Figure 26).

Introduction of electric vehicles has been a progressive move for the country. With the potential to reduce the dependency on fossil fuels for transport, the introduction of electric vehicles in 2014 has led to electricity being included in the transport sector fuel mix. The sectoral consumption of fuels is depicted in figure 36.

Figure 35: Institutional & Commercial Energy Consumption Split and Fuel Mix for 2014



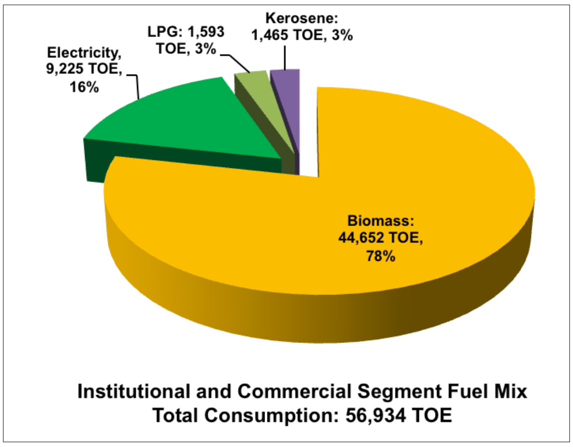
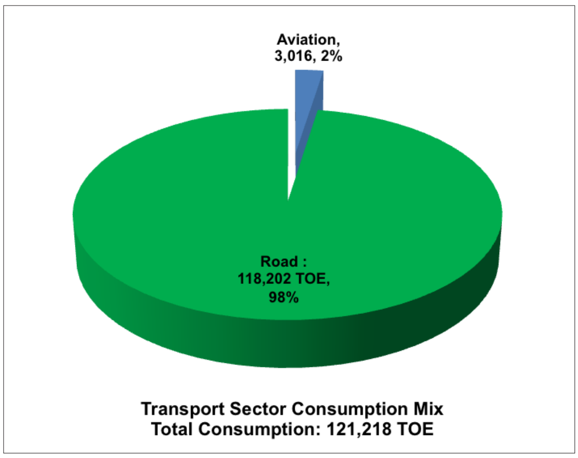


Figure 36: Transport Energy Consumption Split and Fuel Mix for 2014



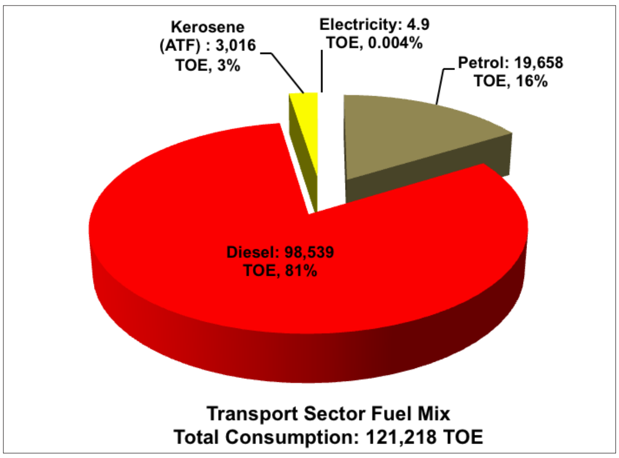


Table 19: Energy Balance in Original Units

ENERGY BALANCE IN ORIGINAL UNITS (2014)

	Major sources of energy consumed in the economy and their classification >>>>	Coal & Derivatives				Electricity				Kerosene			Diesel			Petrol		Liquified Petroleum Gas		Biomass		
		Anthracite	Sub-Bituminous	Other Coal	Coke/Semi-coke of Coal	> 25MW (Hydro)	< 25MW (Hydro)		Solar Home Lighting System	Aviation Turbine Fuel (Jet Kerosene)	Superior Kerosene Oil (Industrial)	Superior Kerosene Oil (Quota)	Diesel Oil	Hi Speed Oil	Light Diesel Oil	Petrol	Speed Oil	LPG (Quota)	Industrial Gas	Bio-Gas	Briquettes	Fuelwood
						On Grid	On Grid	Off Grid	Off Grid													
	Unit >>>>	Tonnes	Tonnes	Tonnes	Tonnes	GWh	GWh	GWh	GWh	Kilolitre	Kilolitre	Kilolitre	Kilolitre	Kilolitre	Kilolitre	Kilolitre	Kilolitre	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes
Energy Supply	Generation/Production	-	121,891.00	-	-	7,130.61	35.19	0.86	0.14	-	-	-	-	-	-	-	-	-	-	898.45	316.15	637,231.66
Energy Supply	Imports	1,875.98	1.56	96,640.05	43,502.63	187.60	-	-	-	3,546.00	21.00	5,673.00	117,273.80	61.00	40.00	31,289.20	30.00	7,029.90	516.61	-	-	-
Energy Supply	Exports	-	26,574.00	6,449.29	2,365.94	5,179.30	-	-	-	-	-	-	2,589.27	-	-	7,190.30	-	-	-	-	-	-
Energy Supply	Total Primary Supply	1,875.98	95,318.56	90,190.76	41,136.69	2,138.91	35.19	0.86	0.14	3,546.00	21.00	5,673.00	114,684.53	61.00	40.00	24,098.90	30.00	7,029.90	516.61	898.45	316.15	637,231.66
Energy Supply	Secondary Generation/Transfer	-	-	-	-	-	-	-	-	-	-	-	-509.64	-	-	-	-	-	-	-	-	-
Energy Supply	Losses	-	-	-	-	80.63		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Energy Supply	Aggregate Supply	1,875.98	95,318.56	90,190.76	41,136.69	2,058.28	35.19	0.86	0.14	3,546.00	21.00	5,673.00	114,174.89	61.00	40.00	24,098.90	30.00	7,029.90	516.61	898.45	316.15	637,231.66

			Major sources of energy consumed in the economy and their classification >>>>	Coal				Electricity				Kerosene			Diesel			Petrol		Liquified Petroleum Gas		Biomass		
				Anthracite	Sub-Bituminous	Other Coal	Coke/Semi-coke of Coal	> 25MW (Hydro)	< 25MW (Hydro)		Solar Home Lighting System	Avaiation Turbine Fuel (Jet Kerosene)	Superior Kerosene Oil (Industrial)	Superior Kerosene Oil (Quota)	Diesel Oil	Hi Speed Oil	Light Diesel Oil	Petrol	Speed Oil	LPG (Quota)	Industrial Gas	Bio-Gas	Briquettes	Fuelwood
								On Grid	On Grid	Off Grid	Off Grid													
			Unit >>>>	Tonnes	Tonnes	Tonnes	Tonnes	GWh	GWh	GWh	GWh	Kilolitre	Kilolitre	Kilolitre	Kilolitre	Kilolitre	Kilolitre	Kilolitre	Kilolitre	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes
Energy Consumption			Total Consumption (Aggregate Demand)	1,875.98	95,318.56	90,190.76	41,136.69	2,058.28	35.19	0.86	0.14	3,546.00	21.00	5,673.00	114,174.89	61.00	40.00	24,098.90	30.00	7,029.90	516.61	898.45	316.15	637,231.66
Energy Consumption	Building Sector		Building Sector Energy Consumption					312.35	5.78	0.86	0.14			5,673.00						7,029.90		898.45	316.15	625,792.46
Energy Consumption	Building Sector	Residential Segment	Residential Segment Total					207.13	3.83	0.76	0.13	-	-	3,401.97	-	-	-	-	-	6,348.62	-	898.45	226.00	494,605.20
Energy Consumption	Building Sector	Residential Segment	Cooking					71.26	1.32	0.26	-	-	-	-	-	-	-	-	-	6,348.62	-	898.45	99.44	274,007.57
Energy Consumption	Building Sector	Residential Segment	Heating/Cooling					124.45	2.30	0.46	-	-	-	-	-	-	-	-	-	-	-	-	126.56	220,597.62
Energy Consumption	Building Sector	Residential Segment	Lighting					9.62	0.18	0.04	0.13	-	-	-	-	-	-	-	-	-	-	-	-	-
Energy Consumption	Building Sector	Residential Segment	Other (Televison, Washing Machines, etc.)					1.80	0.03	0.01	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Energy Consumption	Building Sector	Institutional & Commercial Segment	Institutional & Commercial Segment Total					105.22	1.95	0.10	0.02	-	-	2,271.03	-	-	-		-	681.28	-	-	90.15	119,748.07
Energy Consumption	Building Sector	Institutional & Commercial Segment	Cooking	-	-	-	-	7.41	0.14	0.01	-	-	-	-	-	-	-	-	-	681.28	-	-	49.17	65,309.09
Energy Consumption	Building Sector	Institutional & Commercial Segment	Heating/Cooling	-	-	-	-	80.13	1.48	0.07	-	-	-	-	-	-	-	-	-	-	-	-	38.63	51,314.29
Energy Consumption	Building Sector	Institutional & Commercial Segment	Lighting	-	-	-	-	14.13	0.26	0.01	0.02	-	-	-	-	-	-	-	-	-	-	-	-	-
Energy Consumption	Building Sector	Institutional & Commercial Segment	Other (Construction, Funeral, etc.)	-	-	-	-	3.55	0.07	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-	3,124.69
Energy Consumption	Industry Sector		Industry Sector Energy Consumption	1,875.98	95,318.56	90,190.76	41,136.69	1,564.49	29.41				21.00		2,686.92	61.00	40.00				516.61			11,439.20
Energy Consumption	Industry Sector		High Voltage	1,875.98	31,891.67	-	-	1,467.75	27.59	-	-	-	-	-	143.04	-	-	-	-	-	-	-	-	-
Energy Consumption	Industry Sector		Medium Voltage	-	63,424.91	-	-	88.96	1.67	-	-	-	-	-	2,189.33	-	-	-	-	-	-	-	-	-
Energy Consumption	Industry Sector		Low Voltage	-	-	-	-	7.78	0.15	-	-	-	-	-	354.54	-	-	-	-	-	-	-	-	-
Energy Consumption	Industry Sector		Others	-	1.98	90,190.76	41,136.69	-		-	-	-	-	`	-	-	-	-	-	-	-	-	-	-
Energy Consumption	Transport Sector		Transport Sector Energy Consumption					0.06				3,546.00			110,280.99			24,098.90	30.00					
Energy Consumption	Transport Sector		Aviation	-	-	-	-	-	-	-	-	3,546.00	-	-	-	-	-	-	-	-	-	-	-	-
Energy Consumption	Transport Sector		Road	-	-	-	-	0.06	-	-	-	-	-	-	110,280.99	-	-	24,098.90	30.00	-	-	-	-	-
Energy Consumption			Energy Consumption in other Sectors (Agriculture and Auxilary Consumption)					181.38							1,206.98									

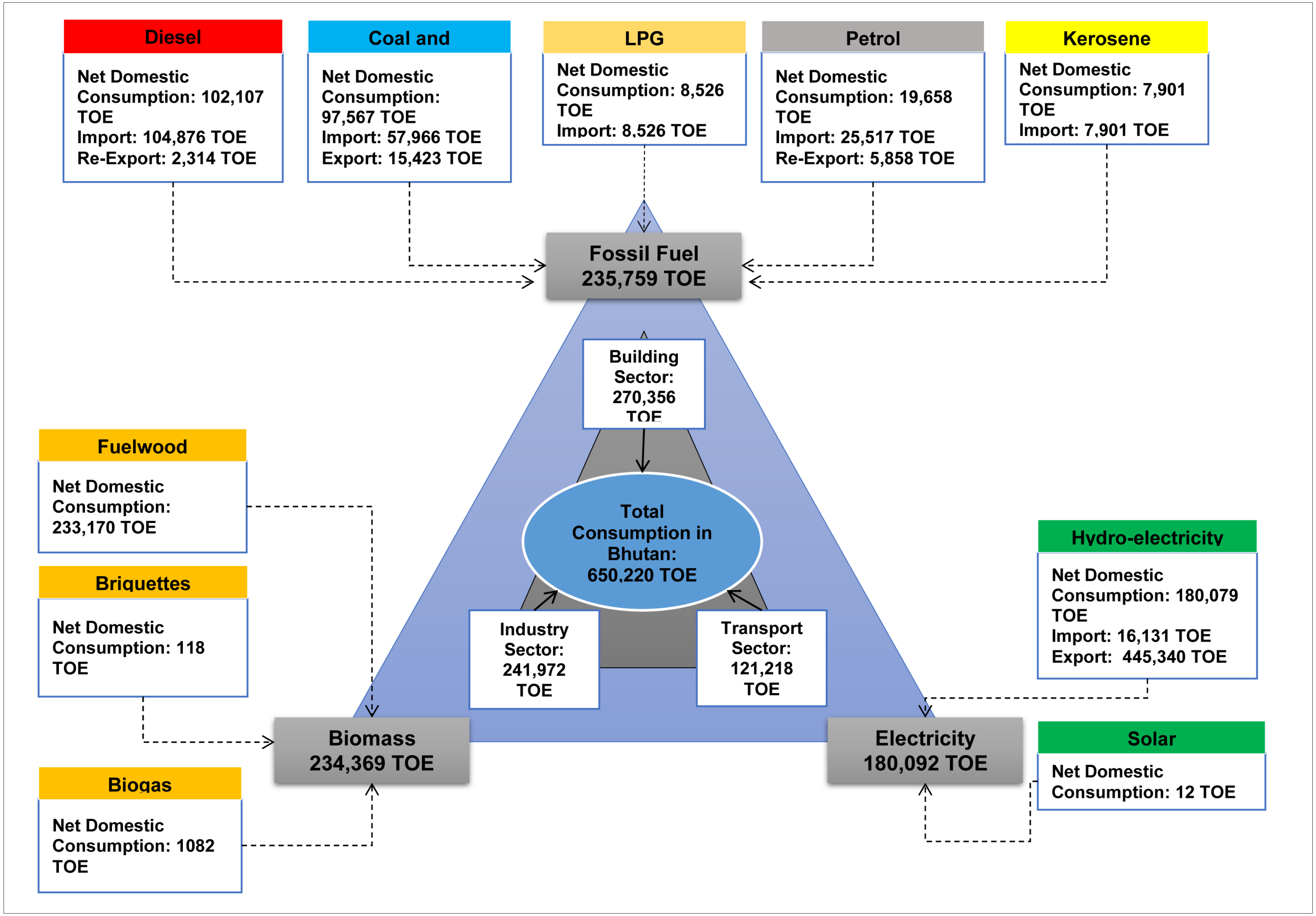
Table 20: Energy Balance in Tonnes of Oil Equivalent

ENERGY BALANCE IN TONNES OF OIL EQUIVALENT (2014)

	Major sources of energy consumed in the economy and their classification >>>>	Coal				Electricity				Kerosene			Diesel			Petrol		Liquefied Petroleum Gas		Biomass		
		Anthracite	Sub-Bituminous	Other Coal	Coke/ Semi Coke of Coal	>25MW	<25MW (Hydro)		Solar Home Lighting System	Aviation Turbine Fuel (Jet Kerosene)	Superior Kerosene Oil (Industrial)	Superior Kerosene Oil (Quota)	Diesel Oil	Hi Speed Oil	Light Diesel Oil	Petrol	Speed Oil	LPG (Quota)	Industrial Gas	Bio-Gas	Briquettes	Fuelwood
						On Grid	On Grid	Off Grid	Off Grid													
	Unit >>>>	TOE	TOE	TOE	TOE	TOE	TOE	TOE	TOE	TOE	TOE	TOE	TOE	TOE	TOE	TOE	TOE	TOE	TOE	TOE	TOE	TOE
Energy Supply	Generation/Production	-	55,023.88	-	-	613,122.22	3,025.68	73.67	12.34	-	-	-	-	-	-	-	-	-	-	1,081.54	117.80	233,170.02
Energy Supply	Imports	1,196.35	0.70	27,467.67	29,301.00	16,130.70	-	-	-	3,016.04	18.01	4,866.52	104,786.78	54.50	34.92	25,492.16	24.44	7,941.97	583.64	-	-	-
Energy Supply	Exports	-	11,996.00	1,833.06	1,593.57	445,339.64	-	-	-	-	-	-	2,313.57	-	-	5,858.13	-	-	-	-	-	-
Energy Supply	Total Primary Supply	1,196.35	43,028.58	25,634.61	27,707.43	183,913.27	3,025.68	73.67	12.34	3,016.04	18.01	4,866.52	102,473.21	54.50	34.92	19,634.03	24.44	7,941.97	583.64	1,081.54	117.80	233,170.02
Energy Supply	Secondary Generation/Transfer	-	-	-	-	-	-	-	-	-	-	-	-455.38	-	-	-	-	-	-	-	-	-
Energy Supply	Losses	-	-	-	-	6,933.04	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Energy Supply	Aggregate Supply	1,196.35	43,028.58	25,634.61	27,707.43	176,980.24	3,025.68	73.67	12.34	3,016.04	18.01	4,866.52	102,017.83	54.50	34.92	19,634.03	24.44	7,941.97	583.64	1,081.54	117.80	233,170.02

	Major sources of energy consumed in the economy and their classification >>>>	Coal				Electricity				Kerosene			Diesel			Petrol		Liquefied Petroleum Gas		Biomass		
		Anthracite	Sub-Bituminous	Other Coal	Coke/ Semi Coke of Coal	>25MW	<25MW (Hydro)		Solar Home Lighting System	Aviation Turbine Fuel (Jet Kerosene)	Superior Kerosene Oil (Industrial)	Superior Kerosene Oil (Quota)	Diesel Oil	Hi Speed Oil	Light Diesel Oil	Petrol	Speed Oil	LPG (Quota)	Industrial Gas	Bio-Gas	Briquettes	Fuelwood
						On Grid	On Grid	Off Grid	Off Grid													
	Unit >>>>	TOE	TOE	TOE	TOE	TOE	TOE	TOE	TOE	TOE	TOE	TOE	TOE	TOE	TOE	TOE	TOE	TOE	TOE	TOE	TOE	TOE
Energy Consumption	Total Consumption (Aggregate Demand)	1,196.35	43,028.58	25,634.61	27,707.43	176,980.24	3,025.68	73.67	12.34	3,016.04	18.01	4,866.52	102,017.83	54.50	34.92	19,634.03	24.44	7,941.97	583.64	1,081.54	117.80	233,170.02
Building Sector	Building Sector Energy Consumption					26,857.32	496.93	73.67	12.34			4,866.52						7,941.97		1,081.54	117.80	228,907.78
Building Sector – Residential Segment	Residential Segment Total	-	-	-	-	17,809.77	329.53	65.29	10.94	-	-	3,401.97	-	-	-	-	-	6,348.62	-	1,081.54	84.21	184,289.70
Building Sector – Residential Segment	Cooking	-	-	-	-	6,127.11	113.37	22.46	-	-	-	-	-	-	-	-	-	6,348.62	-	1,081.54	37.05	102,095.11
Building Sector – Residential Segment	Heating/Cooling	-	-	-	-	10,701.11	198.00	39.23	-	-	-	-	-	-	-	-	-	-	-	-	47.16	82,194.59
Building Sector – Residential Segment	Lighting	-	-	-	-	827.04	15.30	3.03	10.94	-	-	-	-	-	-	-	-	-	-	-	-	-
Building Sector – Residential Segment	Other (Televison, Washing Machines, etc.)	-	-	-	-	154.50	2.86	0.57	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Building Sector – Institutional & Commercial Segment	Institutional & Commercial Segment Total		-	-	-	9,047.56	167.40	8.38	1.40	-	-	1,464.55						1,593.34			33.59	44,618.08
Building Sector – Institutional & Commercial Segment	Cooking	-	-	-	-	636.81	11.78	0.59	-	-	-	-	-	-	-	-	-	1,593.34	-	-	18.32	24,334.14
Building Sector – Institutional & Commercial Segment	Heating/Cooling	-	-	-	-	6,889.79	127.48	6.38	-	-	-	-	-	-	-	-	-	-	-	-	14.39	19,119.68
Building Sector – Institutional & Commercial Segment	Lighting	-	-	-	-	1,215.35	22.49	1.13	1.40	-	-	-	-	-	-	-	-	-	-	-	-	-
Building Sector – Institutional & Commercial Segment	Other (Construction, Funeral, etc.)	-	-	-	-	305.61	5.65	0.28	-	-	-	-	-	-	-	-	-	-	-	-	-	1,164.26
Industry Sector	Industry Sector Energy Consumption	1,196.35	43,028.58	25,634.61	27,707.43	134,521.99	2,528.74				18.01		2,400.82	54.50	34.92				583.64			4,262.24
Industry Sector	High Voltage	1,196.35	14,396.50	-	-	126,203.72	2,372.38	-	-	-	-	-	127.81	-	-	-	-	-	-	-	-	-
Industry Sector	Medium Voltage	-	28,631.19	-	-	7,648.99	143.79	-	-	-	-	-	1,956.22	-	-	-	-	-	-	-	-	-
Industry Sector	Low Voltage	-	-	-	-	669.28	12.58	-	-	-	-	-	316.79	-	-	-	-	-	-	-	-	-
Industry Sector	Others	-	0.89	25,634.61	27,707.43	-	-	-	-	-	-	`	-	-	-	-	-	-	583.64	-	-	-
Transport Sector	Transport Sector Energy Consumption					4.91	-			3,016.04			98,538.55			19,634.03	24.44					
Transport Sector	Aviation	-	-	-	-	-	-	-	-	3,016.04	-	-	-	-	-	-		-	-	-	-	-
Transport Sector	Road	-	-	-	-	4.91	-	-	-	-	-	-	98,538.55	-	-	19,634.03	24.44	-	-	-	-	-
	Energy Consumption in other Sectors (Agriculture and Auxilary Consumption)					15,596.01	-						1,078.46									

Figure 37: Summary of Energy Forms and Flows[14]



14 ATF, is a component of Kerosene, which is completely imported and the consumption recorded for 2014 was 3,016 TOE (3,546 Kilolitres) which constitutes 38% of the total kerosene consumption for the year

6. CONCLUSION AND WAY FORWARD

Bhutan is a carbon neutral and net energy surplus country. However, being a developing country, judicious and efficient use of energy is of major importance for sustainable growth and to maintain the carbon-neutral status. The use of biomass and hydroelectricity is predominant in most sectors except for cooking in the residential segment of the building sector where a large amount of LPG is being used and the transport sector, which runs predominantly on conventional fossil fuels. Given that the country has not yet explored any major fossil fuel resource, with the exception of some coal, the country would need to continue to import fuels such as petrol, diesel, kerosene, ATF and LPG.

Fossil fuel imports are projected to increase (with the expectation of kerosene) over the years, which present future energy security issues to the country. The risk of rising fuel costs is also of particular concern. Real impact of fuel dependence is visible with long line-ups forming at the gas stations when the LPG truck arrives in Thimphu. Limitations of one LPG cylinder exchange per person per month has been imposed. However, there is still sufficient opportunity for Bhutan to substitute fossil fuels with electrical energy (from hydropower) in most sectors. The building and industrial sector is a major consumer of electricity which is heavily subsidized. However, this subsidy should be provided as incentives directly to the consumer if only if they use energy efficiently. A system for monitoring and audits can be designed to check or estimate the pattern of usage of energy which is different for urban and rural segments. Hence separate measures can be designed accordingly. Energy subsidies to targeted consumers must be provided as far down the supply chain as possible so as to encourage efficiencies and prevent subsidy leakages in the system.

Use of renewable energy resources other than large hydropower plants such as solar, wind, small hydropower plants and biogas systems could help diversify the fuel mix and also help Bhutan in its quest to remain a net zero carbon emissions economy. In the Transport Sector, the penetration of electric vehicles is expected to bring about considerable change in the energy balance scenario in future. While there is substantial GHG emissions from conventional vehicles, electric vehicles are emission-free. According to the Alternative Renewable Energy Policy 2013, 9-10% fossil fuel substitution in the Transport Sector will lead to energy savings of 10,000 Kilolitres of Oil Equivalent which is 111,000 MWh in terms of electrical energy. The plausibility of the statement banks upon the target of running 20% of the state owned and 10% of the private vehicle fleet on clean and green fuels by 2025 (ARE Policy, 2013).

Considering the possible long-term impacts of climate change on natural resources, human health, biodiversity and the ecosystem as a whole, the country needs to develop long term strategies to diversify its fuel mix and improve energy security. In the upcoming years with the increasing uptake of energy efficiency interventions, the demand for diesel and other fossil fuels is expected to be substituted by rising demand for electricity, in the industries and more so in the transport sector..

Considering large scale generation of electricity in Bhutan, there is no immediate requirement of solar, wind and other renewable resources. However, Bhutan Water Regulations 2013 recognizes limitations in the hydropower resource, including periodic water shortages in winter and also from non-hydropower uses such as human consumption and agriculture when production is low. These uses compete for water resources in localized areas and create seasonal resource fluctuations that contribute to hydropower plant inefficiencies. Uncertainties in weather projections that are associated with global climate change may also affect future hydropower production. Therefore to sustain uninterrupted electrical services, solar and wind installations would be beneficial, reducing import of electricity in the peak seasons when generation from hydropower becomes restricted.

- The solar resource data show that Bhutan has adequate potential for flat-plate collectors, with annual average values of global horizontal solar radiation ranging from 4.0 to 5.5kWh/m^2-day (4.0 to 5.5 peak sun hours per day) (Shannon Cowlin and Donna Heimiller, 2009).

- The wind resource data show some areas with moderate to excellent potential in several valleys throughout the country, including a few locations near power transmission lines with good-to-excellent resource potential. Because of Bhutan's complex terrain and land cover variation, more data based on ground measurements are required to improve understanding of the wind characteristics, particularly in the valleys. The total restricted theoretical development potential of wind power is estimated at 761 MW (Draft RE Assessment, DRE, 2015).

Renewable energy and its technical understanding is common knowledge to many countries and prove to be a promising solution for energy crisis. However, the penetration of such technologies on a nationwide level is low. Although the technologies are mature enough to be used in place of conventional technologies, the upfront cost of implementation is high (Loiter, 1998). The scenario for renewable energy development in any country is driven by policy and uncertainty of the decision maker because the population is more often than not, heavily dependent on the conventional technologies. Though renewable energy supply seems promising, the challenges are still there in terms of increasing innovation, efficiency and cost reduction. The challenges in renewable energy supply remains to be addressed at policy level.

Given the current developments in the energy sector with very high penetration of electricity and reducing dependency on fuelwood for cooking and heating, Bhutan is already heading towards an efficient scenario: The decline in the usage of kerosene and fuelwood in almost all sectors is a strong indication. With the country gearing up for infrastructural development to support the penetration of electric vehicles and mass rapid transport, the future scenario is expected to witness a higher prominence of electricity usage especially when coupled with energy efficiency interventions.

The fuel mix of the country at present and trend in the future till 2030 will provide a detailed picture of the nation's dependency on various fuels brought to a comparable level. It has been seen that if the economy moves as the same way as it has been over the last decade, the overall fuel mix of the economy will be dominated by electricity with 39% contribution, followed by coal (27%) and diesel (23%). Biomass which has the largest share in the fuel mix, as of 2014, is growing at a CAGR of 0.012%. Considering the current trend of usage of the other fuels, it can be expected that the use of electricity, coal and diesel will dominate the use of biomass in the future. Coal is a cheap and reliable option for the industries. With more than one mine in operation in the country, the usage of coal is expected to increase. However, there is potential for coal consumption to be substituted to a large extent by electricity use due to high electricity access in the country. Moreover, electricity prices have the potential of becoming relatively cheaper in the future as compared to the price of coal which is scarce and not available in high grade. The kerosene demand in the country is not expected to rise in the future. However, there is a significant increase in the demand for Jet Kerosene or ATF in the last decade which will drive the growth of kerosene demand in the future.

Table 21: Assumption for the Business-as-usual vs Energy Efficient Scenario

Fuels	BAU Growth Rate	EE Growth Rate	EE Scenario Conditions
Coal	10.915%	10.14%	► Coal is a cheap and reliable option for the industries and the current trends in usage of coal has shown likelihood to increase in future. However, the use of coal is expected to be substituted with sufficient electricity access, up-gradation in machinery and electricity[15] prices becoming more competitive in future ► Improvement of manufacturing processes in existing industries through investments and adoption of cleaner technology; energy efficiency interventions; and environmental management will drive industries to reduce the consumption of coal and curb the usage at benign levels

15 Relative price of coal against electricity for the same utility/purpose

Electricity	11.9%	14.25%	► Both the INDC of Bhutan, 2015 and the Economic Development Policy, 2010 strongly recommends reduction in usage of fossil fuels and promotion of electric/non-fossil fuel run vehicles ► Electricity use will continue to grow as is apparent in the trend in the recent years. In the future, electricity is expected to substitute not only the industrial processes but also heating and cooking in the building sector. Therefore, in the EE scenario, it is assumed that the electricity will grow at a rate of 14.25% from 2016 to 2030.
Kerosene	-8.7%	-8.7%	► The kerosene demand in the country in the EE scenario is considered to be as less as possible. There is already an import cap which assures restricted import of kerosene.
Aviation Turbine Fuel (ATF)	13.6%	13.6%	► A significant increase in the demand for ATF has been observed in the past decade which will drive the growth of kerosene demand in the future. A 5% savings is predicted for EE scenarios in the case of all petroleum fuels. However, it is further assumed that ATF will not be affected and will continue to grow with the CAGR as derived for the last decade.
Diesel	8.173%	7.42%	► The EE interventions like introduction of EV and MRT in the transport sector can bring about a yearly savings of 10% annually. However, this may not come as soon as 2016 but a gestation phase of 5 years is assumed and year 2020 is considered as the inception of such savings

Petrol	6.334%	5.59%	► The EE interventions like introduction of EV and MRT in the transport sector can bring about a yearly savings of 10% annually. However, this may not come as soon as 2016 but we consider a gestation phase of 5 years is assumed and year 2020 is considered as the inception of such savings
LPG	5.984%	2.0%	► A quota for LPG also exists for the domestic consumption of LPG and hence growth in this sector is expected to be low. ► This form of energy being used for cooking is a more efficient option over and above fuelwood or kerosene used in stoves. ► LPG demand will increase with the increase in the number of households. So, for the EE Scenario projection, the population growth is taken as an indicator for LPG demand growth.
Biomass	0.116%	0.48%	► Biomass use has reduced significantly in the past decade. However, further huge reduction is not expected because a large portion of the rural population does depend on it and will continue to do so as it is the cheapest and easily accessible given the socio-economic and geographical conditions in the rural areas. ► On the other hand, further increase is not justifiable with other cleaner and more efficient options being available. Further, biogas has been a recent development and has a future potential in the rural sectors and thus the growth of biogas has been considered in the projection with 2020 being the period of considerable growth of 5-6% only for domestic biogas plants.

Although there is a significant reflection of growth in cleaner fuel dominating in future, more efficient scenario is possible through interventions at the ground level supported by the Government. Inception of Electric Vehicle is already a reality. Further development can lead to reduction in diesel and petrol dependency in the transport sector. Increase in the penetration and uptake of biogas as a reliable form of cooking energy will reduce dependency on LPG in rural regions and contribute to increase in biomass consumption but the percentage increase in electricity across sectors will be dominant. The probable Energy Efficient scenario has been depicted in figure with 61% of the mix dominated by electricity, getting more prominence than the BAU scenario substituting coal, diesel and biomass by 10%, 9% and 5% respectively in the year 2030.

Figure 38: Future Scenario of Fuel Mix- Business as Usual Scenario

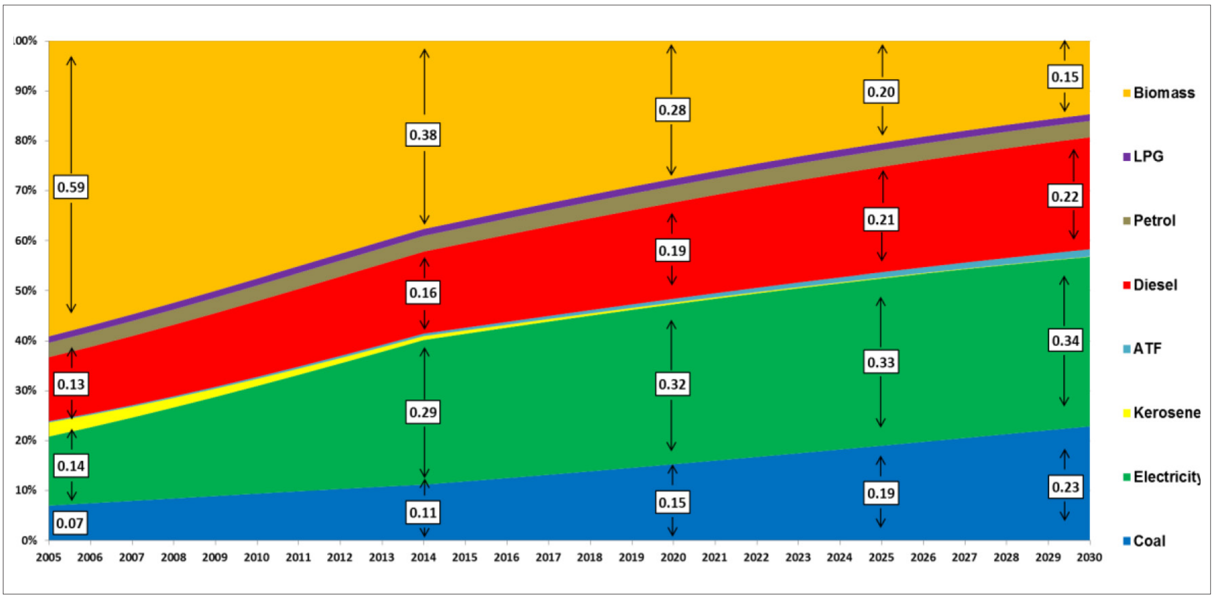
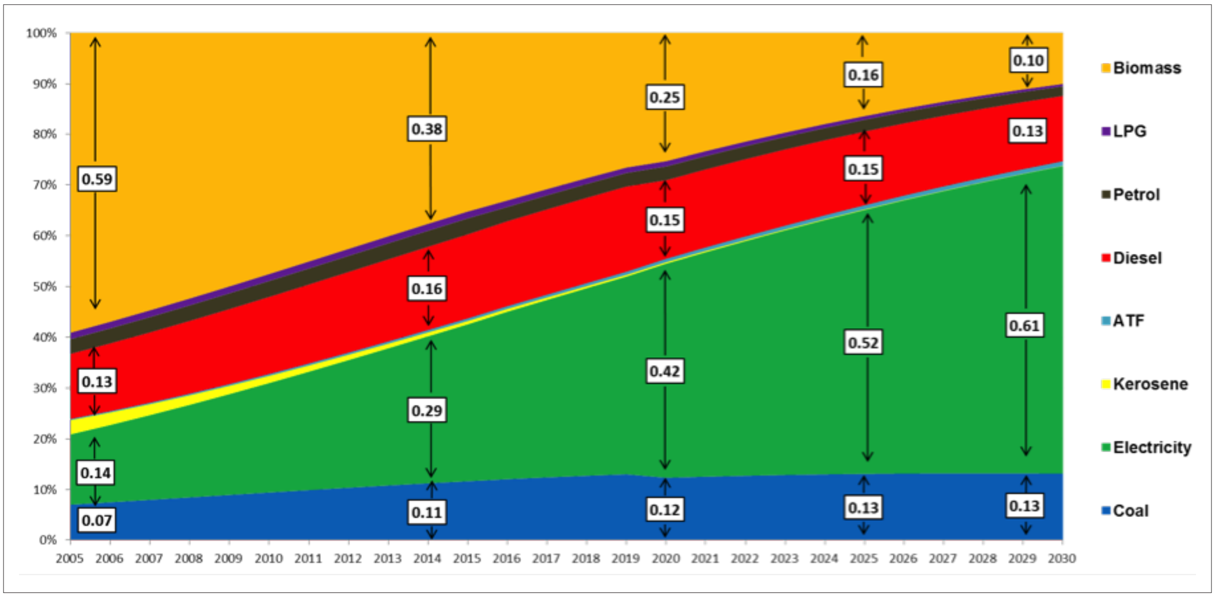


Figure 39: Future Scenario of Fuel Mix- Energy Efficient Scenario



Energy Information System: It is important to set-up an energy information system, which will help the country to set-up a sustainable methodology to establish and regularly feed and update the Energy Data Directory of Bhutan. It becomes a burdensome task to collate information for a long period of time and more often than not, the past record for some critical sectors are not well documented and depends on estimates. Developing an Energy information System will ease the load with exact data feed-in on a timely basis by sector and by fuels. This can help in the data directory to be updated on an annual basis consequently providing more scope to delve into planning with greater information and analysis at disposal. The key features of the Energy Information System can be listed out as:

Collective Responsibility enhancing Efficiency: Although, there should be a nodal department which should have full access to the database and also take onus to update it frequently, the responsibility for updating should be shared by different stakeholders who have first-hand information on the fuel supply and usage. For example, the current database on fuel and energy supply and usage in most sectors are documented and also shared publicly. Moreover, if there are any changes in the subsequent periods, the options for editing remain. This will not only bring about a collective responsibility amongst the various ministries but also reduce the lags in terms of time for collecting the information. The department which is directly involved in maintaining the information of a particular form of energy will be able to provide more astute information, thus increasing the efficiency and quality of the work.

Possibility of Increasing the Information Time Points: The objective of the data directory is to present a robust data for analysing the energy scenarios in the country and consequently strategize policies and programmes for a sustainable development. If different departments do have access to the Energy Information System and can contribute in a regular fashion, data availability can boil down from yearly to even monthly basis. This provides numerous time-points for the planners and policy makers to analyse the trends at a greater depth. In effect, increase in the data time-points leads to more accurate estimates and consequently a more robust analysis.

Intra-departmental Information and Communications: The Energy Information System is likely to be designed in the form of an intra-departmental web portal with limited access to the stakeholders while the Data Directory can be reported on an annual basis. This will help various departments to realize the energy scenarios in the various sectors and report on more concerning issues on energy sector which affect their stake. The information and communication amongst the government departments has the potential to enable better understanding of the national energy scenarios and help to understand the cross-cutting effects of the policies that the various government or non-government stakeholders might be having or might have on the national energy scenarios in the future.

7. APPENDICES

7.1 Appendix: Approach and Methodology

For the estimation of energy consumption in the Industrial, Transport and Building (residential, commercial and institutional) sectors, the study relies mostly on the primary data since extensive survey and detailed audits have been conducted in all the sectors.

Data Gathering
Primary and secondary data were gathered for the major energy consuming sectors. The sectoral data and the derived results on energy consumption data has been briefly discussed below:

Secondary Data Gathering and Consultations

- Hydroelectricity generation, distribution, sale and export data was collected from the Druk Green Power Corporation Limited (DGPC) and the Bhutan Power Corporation limited (BPC)

- Petroleum import data was collected from the POL section, Department of Trade, Ministry of Economic Affairs (MoEA), petroleum product distributors (Bhutan Oil Corporation (BOC), Bhutan Oil Distributor (BOD), Druk Petroleum Corporation Limited (DPCL), Damchen Petroleum Distributors (DPD), Bhutan Industrial Gas (BIG)) and the Department of Revenue and Customs, Ministry of Finance through their annual publication – Bhutan Trade Statistics.

- Data on coal production in the country was collected from the Department of Geology and Mines, Ministry of Economic Affairs (MoEA).

- Data on firewood was collected from the Department of Forests and Park Services, Ministry of Agriculture and Forests (MoAF) and Natural Resources Development Corporation Limited (NRDCL)

- Data on Solar and Wind energy potential mapping and assessments were gathered from the Alternate Energy Division, Department of Renewable Energy, Ministry of Economic Affairs (MoEA).

- Data on waste composition was provided by the Greener Way Waste Management Services and Planning and Policy Department, Ministry of Works and Human Settlement (MoWHS).

Primary Data Gathering
Building Sector:
Energy audits and primary surveys were conducted to gather data from the Building Sector. The buildings identified in each district for energy audit have been phased out for auditing based on the climatic conditions of the district, and assessment during the period of the year when energy consumption in buildings is most varied. Hence, building audits were conducted in two phases: Summer and winter, to understand the consumption patterns in both these situations. Simultaneously, a nationwide survey was conducted through stratified random sampling. In a simple random sample, all members of the population have the same probability of being selected and no weighting of the observations is necessary. In a stratified random sample, all population units are grouped within homogeneous groups and simple random samples are selected within each group. The methodology and sampling techniques was further developed by review of present national representative surveys conducted for the Bhutan Living Standards Survey, 2012: (NSB) and Assessment of Fuel-wood Consumption and Baseline Health Impact Study in Bhutan, 2014 (SRBE). . Therefore, a comprehensive primary survey of 1875 residential households and 75 institutional and commercial buildings across 20 Dzongkhags was carried out to accurately estimate the

energy consumption in the Building Sector.

Primary Survey and Estimation of Resources and Supply:
a. Building Sector
The building sector in Bhutan is famous for its traditional architecture and extensive use of wood for its construction. The types of buildings may be identified based on category of use, building construction technology or materials used. This varies from one region to other depending on the type of climatic zone the particular region falls under.

- Urban Buildings: The urban buildings are of a larger scale, and use of modern construction materials like glass and steel is widely seen, whereas the rural structures adhere to use of local traditional materials and are generally of a smaller scale.

- Rural Buildings: In rural areas, the traditional Sa-Khem houses are prevalent and a range of variations (especially with respect to building materials) can be observed. The urban and sub-urban housing stock is dominated by reinforced-concrete (RCC) frame buildings (with infill walls) up to 6 stories high.

A common feature of all types of construction in Bhutan is the arrangement of an attic that is mostly left open. The light roof construction (mainly made of timber, in few cases made of steel tubes, or CGI) rests upon posts made of timber, masonry or RCC. Common features of a large percentage of vernacular building typologies are sloping roofs (because of high probability of heavy snowfall), open attics (for storage and air circulation purposes), and large openings in exterior walls, especially upper floors (to allow for natural lighting).

1. **Residential segment:** The main end-uses that contribute towards energy consumption in the residential sector are cooking, space heating, lighting, and household appliances, such as room-heaters, television, refrigerators, fans, etc. A comprehensive primary survey of 1750 households across 20 Dzongkhags was carried out to accurately estimate the energy consumption in the residential sector. Secondary sources of information includes Bhutan Power Corporation's – Power data Handbook – 2014, Bhutan Living standard Survey conducted in 2012, Bhutan Statistical Yearbook from 2004 to 2014 and Baseline Study of Fuels -2013 done by GIF and the Government of Bhutan.

2. **Commercial and Institutional segment:** Energy used for commercial activities, such as in shops and hotels; in institutions such as hospitals, schools, religious institutes, and government offices; and for municipal services, was estimated using primary and secondary data. Secondary data on energy consumption were available from the Bhutan Power Corporation's – Power data Handbook – 2013, Bhutan Living Standard Survey conducted in 2012 and Baseline Study of Fuels -2013 done by GIF and the Government of Bhutan. .Primary data were collected for 75 Institutional units as required for deriving the total consumption of the population. Commercial figures are derived from initial building audits and secondary fuel usage data reported by BPC and DoFPS.

Survey Coverage in Institutions: It was ensured that at least four institutions were surveyed in each Dzongkhag which includes

- Monastery sample in each Dzongkhag
- One boarding school each in each Dzongkhag
- One hospital each in each Dzongkhag
- One army cantonment in whichever Dzongkhag has one
- One college in whichever Dzongkhag

A questionnaire cum verification type of survey style had been followed in the methodology. In the questionnaire category, the respondents were asked to provide answers to a structured sequence of short 'close-ended' questions. However, with regards to energy consumption, the customary practice of asking questions alone is not sufficient in terms of deriving quantitative aspects of energy consumption. The field surveyors therefore engaged the sampled households and institutions in the measurement of fuels like firewood, kerosene, LPG, etc. for a typical day (24-hour usage). This is the verification category and entails the enumerator to allocate a certain amount of fuel which the household or institution would think as a typical day's consumption.

The buildings identified in each district for energy audit have been phased out for auditing based on the climatic conditions of the district, and assessment of the period of the year when energy consumption in buildings is highest. Districts like Bumthang, Thimphu, Paro to name a few have cold winters, and December to February is primarily the duration when these districts make maximum use of space heating appliances and equipment like heaters, Bukhari etc. However, districts like Gelephu have summers with relatively much higher temperatures due to which they witness use of fans, and air conditioners to some extent too, which is when the space cooling appliances are used most. Hence, building audits were conducted in two phases, to understand the peak consumption patterns in both these situations.

The sampling methodology for this primary residential and institutional survey is stratified random sampling. In a simple random sample, all members of the population have the same probability of being selected and no weighting of the observations is necessary. In a stratified random sample, all population units are grouped within homogeneous groups and simple random samples are selected within each group. This method allows computing estimates for each of the strata with a specified level of precision while population estimates can also be estimated by properly weighting individual observations. The sampling weights take care of the varying probabilities of selection across different strata. The strata for selected for this sampling methodology are the Dzongkhag (geographical spread), urban and rural sectors (size) and accessibility (road connectivity). The sample survey frame is derived from the most recent universe of all eligible candidates as maintained by the National Statistical Bureau and in this case the BLSS 2012.

The methodology and sampling techniques was further developed by review of present national representative surveys conducted for the Bhutan Living Standards Survey, 2012: (NSB) and Assessment of Fuel-wood Consumption and Baseline Health Impact Study in Bhutan, 2014 (SRBE). Upon final approval by the DRE and the National Statistical Bureau, EY had deduced the following sampling methodology.

A few important definitions have been listed to explain the computation that follows.

- *Confidence Interval:* This term is frequently used in inferential statistics and it basically measures the probability that a population parameter will fall between two set values. These set values define the range within which the estimate value has the highest probability of occurrence. The confidence interval can take any number of probabilities, with the most common being 95% or 99%. In other words, a confidence interval is the probability that a value will fall between an upper and lower bound of a probability distribution.

- *Z-Score:* A Z-Score is the estimated mean of the population. It is a statistical relationship to the mean in a group of scores. A Z-score of 0 means the score is the same as the mean. A Z-score can also be positive or negative, indicating whether it is above or below the mean and by how many standard deviations.

- *Margin of Error:* The margin of error is a statistic expressing the amount of random sampling error in a survey's results. It asserts a likelihood (not a certainty) that the result from a sample is close to the number one would get if the whole population had been queried. The likelihood of a result being "within the margin of error" is itself a probability, commonly 95%, though other values are sometimes used. The larger the margin of error, the less confidence one should have that the survey's reported results are close to the true figures; that is, the figures for the whole population. Margin of error applies whenever a population is incompletely sampled.

To maintain a confidence level of about 95%, we have a Z-score of 1.96 according to the standard normal distribution. However, we need to have a Margin of Error for the data, which is how much the sample data will vary from the estimated average. Due to unavailability of initial ground data, we had to assume a margin of error. We assumed that the margin will be 3.5%.

Confidence level	95%
Z-score	1.96
Assuming a margin of error (MOE)	3.5%

Since the distribution of data is not available, to maintain a conservative estimate of variance, we take probability that all the data will lie within the Margin of Error (P) as 50% and 50% will not. Therefore, the variance of sample data will be (.50 * .50) = .25, which is the product of P and (1-P).

Estimated population % to fall within MOE (p)	50%
Estimated population % to not fall within MOE (1-p)	50%
Variance = {(P)*(1-P)}, by definition	25%

Assumption Prior to Sampling:

- Population is homogeneous, considering electrification status approximating 100%; as electrification impacts energy demand and utilization patterns
- Thus, total sample size (by sample calculator available online) at 95% confidence level, 3% margin of error:1,058 households

Sample Size

Sample size calculators available on line usually employ the following formula:

$$\mathrm{ss} = \frac{\mathrm{z}^2.\mathrm{p}.(1-\mathrm{p})}{\mathrm{c}^2}$$

Where,

$z = z - \mathrm{value};\ 1.96\ for\ 95\%\ CL$

$\mathrm{p} = \text{percentage of picking a choice} = 0.5, \text{worst case}$

$\mathrm{c} = \text{confidence interval, eg: } 0.03 = \pm 3$

Design Effect: Taken as 1.8

Non-Response Rate: Taken as 10%

General Assumption:
(a) The population as fairly homogeneous owing to almost 100% electrification rate, as electrification impacts energy demand and consumption patterns
(b) Survey outcomes to be nation-wide representative as deemed by Energy data directory

Determined Sample Size:
(a) Rural → 1383 households
(b) Urban →712 households
(c) Institutions → at least 4 from each Dzongkhag → 80 institutions
Total for primary energy survey = 2175 samples

b. Industry Sector

The energy consumption data was collected from agencies such as the Bhutan Power Corporation Limited, Department of Industries, and the industries themselves and further verified by audits conducted by certified Energy Auditors in 39 industrial units which included all large industries and Chhukha hydropower plant (to study and analyse the energy performance of a typical hydropower plant station). The audited figures helped to understand the characteristics of fuel usage and consumption of various fuels in different industries.

c.Transport Sector

The transport sector in Bhutan is emerging as a major energy-consuming sector, which primarily depends on fossil or petroleum-based fuels. The vehicle population

Table 22: List of Industries – Segregated on the Basis of Voltage Consumption

Category – High Voltage Industries		
No	**Name of Industry**	**Location**
1	Bhutan Carbide & Chemicals Ltd	Pasakha
2	Bhutan Concast Pvt. Ltd	
3	Bhutan Ferro Alloys Ltd	
4	Bhutan Silicon Metals Private Ltd	
5	Druk Ferro Alloys Ltd	
6	Druk Wang Alloys Ltd	
7	Lhaki Steels and Rolling	
8	Pelden Enterprises Pvt Ltd	
9	Saint Gobain Ceramics	
10	SKW Tashi Metals& Alloys	
11	Ugen Ferro Alloys Pvt Ltd	
12	Penden Cement Authority	Gomtu
Category – Medium Voltage Industries		
No	**Name of Industry**	**Location**
1	Bhutan Alloys & Steel Castings	Pasakha
2	Bhutan Rolling Mills Ltd	
3	Druk Cement	
4	Kenpa Pvt Ltd	
5	Quality Gases Pvt Ltd.	
6	Rabten Wires	
7	RSA Marbles Pvt Ltd.	
8	Tashi Beverages Ltd	
9	Zimdra Foods	
10	Bhutan Brewery Pvt Ltd	Phuentsholing
11	Bhutan Milk & Agro Pvt Ltd	
12	Karma Feeds	
13	RSA PolyproductsPvt Ltd	
14	Yarab Pvt. Ltd.	
15	Bhutan Polymers	Gomtu
16	Lhaki Cements	
17	Bhutan Crushing Unit	Pugli
18	Bhutan Himalayan Waters	
19	Chundu Dolomites	
20	Jigme Industries Pvt Ltd	
Category – Low Voltage Industries		
No	**Name of Industry**	**Location**
1	Bhutan Bitumen	Pasakha
2	Bhutan Board Products Ltd	
3	Bhutan Packaging	Phuentsholing
4	Bhutan Polythene	
5	Drangchu Beverages	
6	Jigme Mining Corporation	Pugli
7	Penden Mining	

Table 23: Major Fuel Consumed and their Classification

The Major Fuels

Coal and Dertivatives	Electricity	Diesel	Kerosene	Petrol	Liquefied Petroleum Gas	Biomass
All three types of coal are recorded to be consumed in the country- anthracite, bituminous, sub-bituminous and lignite (other coal). The only coal mine is located at Rishore; Samdrup Jongkhar where the coal produced is bituminous/sub-bituminous type. Other than coal, its derivatives like coke and semi-coke of coal is also used in the industries as reducing agents.	Electricity is mostly generated from hydro-electricity plants of greater than 25MW size (large). Other than the large hydro, small, micro, mini and pico scale plants are also in operation which are either decentralized or connected to the grid. Diesel-fueled generators are also used mainly in agriculture and other auxiliary consumption. Solar use has also come in to fore in 2014 with wind not trailing behind much.	Diesel is used for transport, generation of electricity and also in the industries as fuel (Hi Speed Diesel (HSD)). The majority consumption is attributed to transport; however the dependence of the industries on HSD and Light Diesel Oil (LDO) has been increasing over time.	Kerosene in various forms is used across the sectors. The households have quota for using kerosene, which is the Superior Kerosene Oil (SKO). SKO is also used in the Industries but that usage has reduced significantly over the last decade. The transport sector uses kerosene in the form of Jet Kerosene, termed as Aviation Turbine Fuel (ATF)	Petrol is used only for transport. Other than the usual petrol available, Hi Speed petrol is used by a few vehicles which need compliance with the higher efficiency standards of the vehicle engine.	Liquefied petroleum Gas (LPG) is mostly used for cooking in the commercial Building Sector. There is quota for the usage of household LPG. However, LPG is also used in the industries as a cheaper substitute for acetylene which is used mainly for cutting.	In this study, the biomass is segregated into three categories: Firewood, Biogas and Briquettes. Biomass in the form of fuelwood cater to the majority of the residential energy demands, such as cooking and space heating, especially in the rural areas. Fuelwood is also used by some industries that use woodchips and briquettes for heating. Timber used for construction is not considered as fuel for the purpose of this study

data was collected from the RSTA (Road Safety and Transport Authority) and the ongoing study by the EY for the Energy Efficiency interventions in the Transport sector. Petroleum fuel import data was collected from the Department of Trade, petroleum product distributors, and also from the Department of Revenue and Customs. The audits were divided into two segments –The Vehicle Audits and the Road inventory survey. To further update the figures and fill in the gaps in the data, the study- Technical Support to the Low Emission Capacity Building (LECB) Programme on Decision Support Tool for the development of NAMAs in Bhutan was referred.

The vehicle audits were carried out to understand the energy consumption by different types of vehicles in Bhutan. The Survey covered various aspects which may be listed as follows:

- Type of fuel used, brand and model, engine capacity (CC), year of manufacturing, fuel efficiency, odometer reading, capital and maintenance cost, pollution control certificate, occupancy in case of passenger modes, wiliness to shift to EV and barriers etc. were recorded.
- The modes of transport audited were 2-Wheeler, SUV, car, taxi, bus, tractor, truck, Power Tiller and Earth Moving Equipment owners by interviewing their drivers
- The cities covered in the interview were Damphu, Gelephu, Pasakha, Phuentsholing, Samdrup Jongkar, Thimphu, Trashigang-Moshi, Trongsa and Paro.

The stratified sampling strategy was used to decide the sample size distribution. Based on the desegregated vehicle registration data, 1% of all vehicle types were covered in the survey. Annual InfoComm and Transport Statistical Bulletin, 2014 estimates that the vehicle population in Bhutan to be approximately 70,000 in the given year.

The road inventory survey was carried out to understand the impact of road surface, terrain and other spatial factors on the energy consumption. The areas covered in the survey were roads connecting Damphu, Gelephu, Pasakha, Phuentsholing, Samdrup Jongkar, Thimphu, Trashigang-Moshi, Trongsa and Paro- the roads within these urban areas. For the purpose of the road inventory audit a car and a SUV were hired to go around the nation and point based audits were carried out. There were total of 94 locations across Bhutan where road inventory audit was carried out.

7.2 Appendix: Summary of detailed energy audit in 39 Industries and one Hydropower Plant

1. Bhutan Concast Pvt. Ltd.

Bhutan Concast Pvt. Ltd is a producer of Mild-Steel

Figure 40: Transport Survey Locations

Billets that goes in the manufacture of TMT bars, Steel Rods and such similar products in different metal-based industries. The market for the product extends to India also. The factory was commissioned in the year 2007 in the industrial estate of Pasakha, Bhutan and is in regular operation ever since. The factory utilises electrical energy for all its processes that includes thermal energy need also, drawn from the Bhutan Power Corporation Limited (BPC) under a HV service connection. The average monthly energy consumption based on the data of 2013 & 2014 for electricity is 3,950 MWh.

2. Bhutan Ferro Alloys Ltd.

Bhutan Ferro Alloys Ltd is one of the leading Ferro Alloy manufacturers in Bhutan. The industry is located in Pasakha industrial estate in Southern Bhutan. The industry uses only electrical energy for its process operations. On an average, the factory consumes 23,427 MWh of electricity in a month. Of this, 95% is consumed by furnace and the rest by the auxiliaries.

3. Bhutan Carbide & Chemicals Ltd.

Bhutan Carbide & Chemicals Ltd was conceived as a joint Venture between the Royal Government of Bhutan and Tashi Commercial Corporation, keeping in mind the abundant availability of hydel power, indigenous raw material and a ready market for its products. The industry uses only electrical energy for its process operations drawn from BPC under HV connection. On an average, the factory consumes 172.72 GWh of electricity in a year.

4. Bhutan Silicon Metals Private Ltd.

Bhutan Silicon Metals Private Ltd is one of the leading Silicon Metal (Si) manufacturers in Bhutan. The industry is located in Pasakha industrial estate in Southern Bhutan. The plant had started production in January 2014. Of the 12 months in 2014, normal production occurred only during 5 months. The average monthly production was arrived at based on the production of 5 months which is 425 tons/month. The industry uses only electricity for its process operations, which is procured from BPC.On an average, during the normal production period, the monthly electricity consumption is 7,466 MWh. Of this, 90 % is consumed by the furnace and the rest by the auxiliaries.

5. Druk Ferro Alloys Ltd.

Druk Ferro Alloys Ltd is one of the leading Ferro Alloy manufacturers in Bhutan. The industry is located in Pasakha industrial estate in Southern Bhutan. The industry uses only electrical energy for its process operations, which is procured from BPC. On an average, the factory consumes 9,661 MWh of electricity in a month. Of this, 95% is consumed by furnace and the rest by auxiliaries.

6. Druk Wang Alloys Ltd.

Druk Wang Alloys Ltd is one of the prominent ferro alloy manufacturers in Bhutan. The factory is located in the Pasakha industrial estate in Southern Bhutan. The factory uses only electrical energy, which is sourced from BPC. On an average, the factory consumes 9,930 MWh of electricity in a month. Of this, 94% is consumed by the furnace and the rest by the auxiliaries.

7. Lhaki Steels and Rolling Pvt. Ltd.

Lhaki Steels and Rolling Pvt. Ltd is a producer of Mild Steel Billets which is used to manufacture TMT bars, steel rods and other products in different metal-based industries. This factory is the principal supplier of MS Billets to its sister concern, Bhutan Rolling Mills Ltd., located in the same industrial estate of Pasakha. Despite being commissioned in the year 2008 as a part of the renowned Lhaki Group of Industries, the factory had undergone a major shut down and resumed its operation only from January 2014 onwards. This essentially means that data for only 12 months were available for analysis. The factory utilises electrical energy for all its processes which is drawn from BPC under a HV service connection. The average monthly energy consumption based on the data of 2014 for electricity is 4,490 MWh.

8. Bhutan Rolling Mills Ltd.

Bhutan Rolling Mills Ltd is a manufacturer of thermos-mechanically treated (TMT) bars of grades Fe 415 and Fe 500. The electricity is drawn from BPC that categorizes this factory under the MV service connection. In addition, the factory consumes High Speed Diesel (HSD) and Furnace Oil (FO) for its furnace operation. Thus, both electrical and thermal energy are needed for the process operation. The average monthly power consumption has been established as 251,552 kWh. The average monthly HSD consumption is more than 58kL and that of FO is 51kL.

9. Pelden Enterprises Pvt Ltd.

Pelden Enterprises Pvt. Ltd. is one of the leading Ferro Alloy manufacturers in Bhutan. The industry is located in Pasakha industrial estate in Southern Bhutan. The total production of Ferro Silicon in the year

2014 by the factory is about 13,651 tons. The industry uses only electrical energy for its process operations, which is procured from BPC. On an average, the factory consumes 10,022 MWh of electricity in a month. Of this, 91% is consumed by two furnaces and the rest by the auxiliaries.

10. Saint Gobain Ceramics Materials (Bhutan) Pvt. Ltd.

Saint Gobain Ceramics Materials (Bhutan) Pvt. Ltd. is a sole manufacturer of the unique product Silicon Carbide (SiC) in Bhutan. Silicon Carbide finds most of its application in the manufacturing of different grades of abrasives, grinding wheel surface, etc. The factory was commissioned in the year 2008 in the industrial estate of Pasakha. It supplies most of its products to the markets of India. The factory needs electrical energy for all its process operations.Electricity is sourced from BPC through a HV service connection. The average monthly energy consumption based on the available data for 2013 and 2014 for electricity is 6,367 MWh.

11. SKW Tashi Metals & Alloys

SKW Tashi Metals & Alloys is the only manufacturer of Calcium Silicon and Calcium Silicon Cored wire in Bhutan. The industry is located in Pasakha industrial estate in Southern Bhutan. The industry uses only electrical energy for its process operations, which is procured from the Bhutan Power Corporation Limited (BPC). On an average, the factory consumes 6,296 MWh of electricity in a given month.

12. Ugen Ferro Alloys Pvt Ltd.

Ugen Ferro Alloys Pvt Ltd is one of the leading Ferro Alloy manufacturers in Bhutan. The industry is located in Pasakha industrial estate in Southern Bhutan. The average annual production of Ferro Silicon by the factory is 13,655 tons. On an average, the factory consumes 10,380 MWh of electricity in a month. Of this, 96% is consumed by furnace and the rest by the auxiliaries.

13. Penden Cement Authority Ltd.

Penden Cement Authority Ltd. is one of the leading cement manufacturers in Bhutan. The factory is located in Samtse district in Western Bhutan. The average cement production was worked out to be 30,270 tons/month. The factory uses both thermal and electrical energy for its process operations. The thermal energy requirements are met by coal burning and HSD that are procured domestically as well as from India whereas the electricity is drawn from BPC.

14. Druk Cement Co. Pvt. Ltd.

Druk Cement Co. Pvt. Ltd is the sole manufacturer of Ordinary Portland Cement (OPC) in the industrial estate of Pasakha. The factory was commissioned in the year 1992. Electricity is drawn from BPC that categorizes this factory under the MV service connection. The average monthly energy consumption based on the available data for 2013 and 2014 for electricity is 48 MWh.

15. Kenpa Pvt. Ltd

Kenpa Pvt Ltd is a producer of Refined Edible Oil. The raw material of the factory is semi refined oil imported from India. The factory utilises electrical energy for all its processes (any thermal energy need also met by electricity) drawn from BPC under a MV service connection. The average monthly energy consumption based on the data of 2013 and 2014 for electricity is 11,033 kWh.

16. Quality Gases Pvt Ltd.

Quality Gases Pvt Ltd. is a major manufacturer of Oxygen and Nitrogen gas in Bhutan. The factory is located in Pasakha Industrial Estate, Chhukha Dzongkhag. The factory uses only electrical energy, which is purchased from BPC. There is no requirement of thermal energy in the factory for any of its processes. On an average, factory produces 118kL of Oxygen and 104kL of Nitrogen every month.

17. Rabten Wires Industry

Rabten Wires Industry is a manufacturer of Wire Nails, Barbed Wires and Binding Wires. The factory, despite being in operation for only a couple of years, has already carved out a niche market for itself in the country. It caters mostly to domestic market and reaches out to the Indian market as well to a limited extent. The electricity is drawn from BPC. The annual energy consumption based on the available data of 2014 for electricity is 105,200 kWh.

18. RSA Marbles Pvt Ltd.

RSA Marbles Pvt Ltd., located in the Pasakha Industrial Area in the Chhukha Dzongkhag is one of the leading importers of marbles in the country. The factory having a processing capacity of 12,000 tonnes per year, and produces around 6,800 tonnes of finished goods every year. The company, on an average, consumes 114,350 kWh of electricity annually. The company does not need thermal energy for its operations.

19. Tashi Beverages Ltd.

Tashi Beverages Ltd Phuentsholing, Bhutan is a franchisee for Coca-Cola. It caters to the local market and a limited quantity is exported to India across the border. Being a process industry, the electrical and thermal energy are used in substantial quantities. While the electrical needs are met by drawing power from BPC, the thermal energy requirement is met by burning High Speed Diesel (HSD) in boiler. On an average, the factory consumes 175,583kWh of electricity and 10.67kL of HSD in a given month.

20. Zimdra Foods Pvt Ltd.

Zimdra Foods Pvt Ltd. has its factory in Toribari, Pasakha in Southern Bhutan. The production varies with the season and demand. The overall production of the plant in 2014 is 663.1kL of flavoured juice and 19.5kL of toned milk. The industry uses both thermal energy and electrical energy for its process operations. The thermal energy requirement is met by burning High Speed Diesel (HSD) in boiler. The electrical energy is procured from BPC. On an average, the factory consumes 15.6kL of HSD and 148,606 kWh of electricity in a given month.

21. Bhutan Brewery Pvt Ltd.

Bhutan Brewery Pvt Ltd is the only manufacturer of beer in Bhutan. It manufactures beer in 650 ml bottles under the brand name “Druk”. The factory, having a production capacity of 20,555 kL per year is located in the Pasakha Industrial Estate, Chhukha Dzongkhag. Being a process industry, the electrical and thermal energy are used in substantial amount. While the electrical needs are met by drawing power from BPC, the thermal energy requirement is met by burning High Speed Diesel (HSD) in a boiler. On an average, the factory produces 1,713kL of beer every month.

22. Bhutan Milk & Agro Pvt Ltd.

Bhutan Milk & Agro Pvt Ltd., Phuentsholing, Bhutan produces 3 categories of products, namely, milk, fruit juice and mineral water. The factory’s operating period is 5,000 hours / year for mineral water production. Being a process industry, both electrical energy and thermal energy are consumed in substantial quantities in the process operation. Electricity is drawn from BPC and thermal energy is extracted by burning High Speed Diesel (HSD) is an oil fired boiler of 2 TPH of steam generation capacity. The energy consumption due to electricity and HSD is 1.9 GWh and 234.4 kL respectively for the 3-year period.

23. Karma Feeds Pvt Ltd.

Karma Feeds Pvt Ltd manufactures feeds for poultry, cattle, pig and fish. All these utilities are powered by electricity and therefore electrical energy share accounts to nearly 45% of total energy usage of the plant. Thermal energy is needed for steam generation. The steam is used for wetting the crushed feed prior to pelletization.

24. Lhaki Cements Pvt Ltd.

Lhaki Cements Pvt Ltd. is the one of the major manufacturers of cement in Bhutan. The average cement production was computed to be around 13,000 to 14,000 tonnes per month. Being a cement manufacturing industry, thermal and electrical energy are needed in substantial quantities. Electricity is drawn from BPC while the thermal energy requirements are met by burning coal in the Rotary Kiln. Coal is mainly imported from India. Based on the data of the year 2014, major cost outflow is due to Coal (about 80%).

25. Bhutan Polymers Company Ltd.

Bhutan Polymers Company Ltd. is the sole manufacturer of Polypropylene fabrics and bags in the country. This factory was commissioned in the year 1997 as a sister concern of the Jigme Group of Industries. It caters solely to the demands of all the nearby industries in Gomtu and that in the adjacent Pugli region. The factory is solely dependent on electrical energy for its entire process operation. Electricity is drawn from BPC under a MV category service connection. The average monthly electricity consumption based on the data of 2013 & 2014 is 137,262 kWh.

26. Bhutan Crushing Unit

Bhutan Crushing Unit is a major Dolomite Powder processing unit of Pugli area which is located along the western border of Bhutan. The industry consumes only electrical energy for all its processes. Electricity is drawn from BPC through a MV category service connection. The average monthly electricity consumption is 84,788kWh.

27. Yarab Pvt. Ltd.

Yarab Pvt. Ltd. is a manufacturer of Electrical Wires and PVC pipes. The manufacturing site is located in Phuentsholing Industrial Area, Bhutan. The plant uses only electrical energy for its various manufacturing operations and is sourced from BPC. The contracted demand is 400kW for producing the cable, wires & pipes. On an average, the factory consumes 33,000 kWh of electricity in a given month.

28. RSA Poly products Pvt Ltd.
RSA Poly products Pvt Ltd. is a prominent polybag manufacturer in Bhutan. The industry is located in Phuentsholing Industrial Area. The polybag manufacture calls for use of electrical energy only which is drawn from BPC. The industry falls under the MV category with a contracted demand of 650 kW. On an average the factory consumes 124,794 kWh in a month.

29. Bhutan Himalayan Waters Pvt Ltd.
Bhutan Himalayan Waters Pvt Ltd. is the only mineral water plant in the region of Pugli. This plant is located closer to Gomtu. This plant was established as a part of the Bhutan Pharmaceuticals Pvt. Ltd. to meet the mineral water requirement of it. However, it had eventually found its own demand in the domestic markets and also in the bordering Indian state of West Bengal. Electricity is drawn from BPC which categorizes it as a MV consumer owing to its combined service connection with the Bhutan Pharmaceuticals Pvt. Ltd. The average monthly electricity consumption based on the data for 2014 is 4,835 kWh.

30. Chundu Dolomites Powdering Plant
Chundu Dolomites Powdering Plant was established in the year 1999 as a part of the Chhundu Enterprises to cater to the markets of the neighbouring countries, mainly Nepal, Bangladesh & India. The factory uses electrical energy for its entire process operation which is drawn from BPC under a MV category service connection. The average monthly electricity consumption based on the data of 2013 & 2014 is 60,124 kWh.

31. Jigme Industries Pvt Ltd.
Jigme Industries Pvt. Ltd. is the oldest low silica dolomite powdering plant in the industrial area of Pugli which is strategically located bordering with India. This factory was commissioned in the year 2005 as a sister concern of the Jigme Group of Industries. It had been procured from its predecessor with 15 years of prior operation. It caters solely to the markets of Nepal and India. The dolomite powder has various uses such as a soil neutralizer in tea estates, as pesticides, in fisheries for cultivation, etc. The factory is dependent on electrical energy for its entire process operation which is drawn from BPC under a MV category service connection. The average monthly electricity consumption based on the data of 2013 & 2014 is 153,440 kWh.

32. Bhutan Bitumen Industries Pvt Ltd.
Bhutan Bitumen Industries Pvt Ltd. was commissioned in the year 2009 which processes / makes raw bitumen into an emulsion form that is readily usable with the stone chips. The average monthly electricity consumption based on the data of 2013 & 2014 was 615 kWh. These numbers are quite low due to the lesser period of operation of the plant in a month per year. The average monthly fuel consumption for 2013 & 2014 is 390 litres.

33. Bhutan Board Products Ltd.
Bhutan Board Products Ltd. is a Royal Government of Bhutan undertaking set up established in 1982. At present, the factory employs around 30 to 35 people. The factory in Pasakha produces around 1,130 sets of furniture every month. These furniture are sold domestically (15%) and also across the border in India (85%).The Factory has two service connections from BPC. The factory operates for 2,400 hours per year and on an average it consumes 0.168 million kWh annually.

34. Bhutan Packaging
Bhutan Packaging is one of the prominent cardboard box manufacturers in Bhutan, established under the Tashi Commercial Corporation in the Year 2004. The factory operates for about 2,400 hours per year and on an average consumes 28,700 kWh in a given month.

35. Bhutan Polythene Company Ltd.
Bhutan Polythene Company Limited is the sole manufacturer of HDPE pipes in Bhutan and is one of the reputed and oldest contributors in the industrial development of the country. The factory was commissioned in the year 1986. It is presently located in the industrial estate of Phuentsholing, Bhutan, and supplies HDPE pipes both within the country as well as across the border. The factory uses electrical energy for all its process operations. Electricity is drawn from BPC that categorizes this factory under the LV service connection. The average monthly electricity consumption based on the data for 2013 & 2014 is 57,014 kWh.

36. Drangchu Beverages Ltd.
Drangchu Beverages Ltd., Phuentsholing, Bhutan is a franchisee for PepsiCo. It caters to the local market and a limited quantity is sold in India across the border. Being a process industry, the electrical and thermal energy are used in substantial quantities.. While the electrical needs are met by drawing power from BPC, the thermal energy requirement is met by burning High Speed Diesel (HSD) in boilers. On an av-

erage, the factory consumes 26,248 kWh of electricity and 11.7kL of HSD in a given month.

37. Jigme Mining Corporation Ltd.
Jigme Mining Corporation Limited is an established dolomite mine in the Phuntshopelri region which is located in the heart of the dolomite rich hills of Pugli. is Mining Corporation was founded as a part of the Jigme Group of Industries to meet the dolomite stone requirement of its sister concern Jigme Industries Pvt. Ltd. Electricity for process operation is drawn from BPC which categorizes it as a bulk consumer of the LV service connection. The industry also runs on a parallel mechanical line of operation whereby the entire process is carried out with diesel as the source of energy. The average monthly energy consumption, based on the data for 2013 and 2014 for electricity, is 44,666 kWh.

38. Penden Mining Corporation Ltd.
Penden Mining Corporation Limited is one of the oldest limestone mines located in the heart of the limestone rich hills of Pugli. Electricity is drawn from BPC which categorizes this industry under the LV service connection. The average monthly energy consumption, based on the data of 2012, 2013 and 2014 for electricity is 56,095 kWh.

39. Bhutan Alloys and Steel Casting Ltd.
Bhutan Alloys Steel Casting is the sole manufacturer of grinding steel balls in the industrial estate of Pasakha. It is a major supplier of the grinding steel balls to the cement industries in Bhutan and reaches out the Indian markets as well. The factory depends on electrical energy for all its process operations. Electricity is drawn from BPC under MV service connection. The average monthly energy consumption, based on the available data for 2013 and 2014 for electricity, is 29,491 kWh.

Table 24: Energy Consumption Summary by the 39 Audited Industries

Category – High Voltage Industries				
No	**Name of Industry**	**Electricity (GWh)**	**Diesel (kl)**	**Coal (MT)**
1	Bhutan Carbide & Chemicals Ltd	172.717	0	0
2	Bhutan Concast Pvt. Ltd	49.19281	0	0
3	Bhutan Ferro Alloys Ltd	262.8641	0	0
4	Bhutan Silicon Metals Private Ltd	41.3388	0	0
5	Druk Ferro Alloys Ltd	121.14	0	0
6	Druk Wang Alloys Ltd	121.3416	0	0
7	Lhaki Steels and Rolling	53.876	0	0
8	Pelden Enterprises Pvt Ltd	120.8215	0	0
9	Saint Gobain Ceramics	75.9971	0	0
10	SKW Tashi Metals& Alloys	79.2633	0	0
11	Ugen Ferro Alloys Pvt Ltd	126.219	0	0
12	Penden Cement Authority	48.323	122.35	40,692.00

Category – Medium Voltage Industries				
No	**Name of Industry**	**Electricity (GWh)**	**Diesel (kl)**	**Coal (MT)**
1	Bhutan Alloys & Steel Castings	0.3791	0	0
2	Bhutan Rolling Mills Ltd.	3.0583	0	0
3	Druk Cement	0.49035	0	0
4	Kenpa Pvt. Ltd.	0.137	0	0
5	Quality Gases Pvt Ltd.	4.5109	0	0
6	Rabten Wires	0.1052	0	0
7	RSA Marbles Pvt. Ltd.	0.1144	0	0
8	Tashi Beverages Ltd.	2.2739	124.08	0
9	Zimdra Foods	1.7833	187.82	0
10	Bhutan Brewery Pvt. Ltd.	3.8261	655.75	0
11	Bhutan Milk & Agro Pvt. Ltd.	0.7316	87.89933	0
12	Karma Feeds	0.4391	55.5765	0
13	RSA Polyproducts Pvt. Ltd.	1.5817	0	0
14	Yarab Pvt. Ltd.	0.4604	0	0
15	Bhutan Polymers	1.61079	0	0
16	Lhaki Cements	20.892	0	21,456.00
17	Bhutan Crushing Unit	1.0175	0	0
18	Bhutan Himalayan Waters	0.053187	0	0
19	Chundu Dolomites	0.721485	0	0
20	Jigme Industries Pvt. Ltd.	1.81007	0	0

Category – Low Voltage (Bulk) Industries				
No	**Name of Industry**	**Electricity (GWh)**	**Diesel (kl)**	**Coal (MT)**
1	Bhutan Bitumen	0.005591	5.866	0
2	Bhutan Board Products Ltd	0.4331	0	0
3	Bhutan Packaging	0.3444	0	0
4	Bhutan Polythene	0.6954	0	0
5	Drangchu Beverages	0.32531	131.503	0
6	Jigme Mining Corporation	0.561769	0	0
7	Penden Mining	0.7069	0	0

Table 25: Energy Consumption Summary by the 1 Audited Hydropower Plant

	Hydroelectricity Plant	Electricity (GWh)	Diesel (kl)	Coal (MT)
1.	Chhukha Hydropower Plant	5.92	0	0

(Source: Analysis on Primary survey and audit results)

7.3 Appendix: Conversion Factors Used

Table 26: Conversion Factors, Densities and Net Calorific Values

Unit	Abbreviation	Terajoules
Tonnes of Oil Equivalent	TOE	0.041868
Terajoules	TJ	1
Megawatt-Hour	MWh	0.0036
Kilowatt-Hour	kWh	0.0000036
Kilocalorie	kcal	0.00000000419
Joule	J	0.000000000001
Gigawatt-Hour	GWh	3.6
Densities	**Values**	**Units**
ATF (Jet Kerosene)	807.5	kg/m3
Diesel (Diesel Oil)	870	kg/m3
Kerosene	820.1	kg/m3
Petrol (Motor Gasoline)	770	kg/m3
LDO	850	kg/m3

Fuel	Basic Units	Net Calorific Values[16] per basic unit	
		Terajoules	Tonnes of Oil Equivalent
ATF (Jet Kerosene)	kl	0.03561	0.8505
Coal (Anthracite)	MT	0.02670	0.6377
Coal (Sub-Bituminous)	MT	0.01890	0.4514
Other Coal (Lignite)	MT	0.01190	0.2842
Coke of Coal	MT	0.02820	0.6735
Diesel (Gas Diesel Oil)	kl	0.03741	0.8935
Electricity	GWh	3.60000	85.9845
Wood (Fuelwood and Briquette)	MT	0.01560	0.3726
Kerosene	kl	0.03592	0.8578
LPG	MT	0.04730	1.1297
Petrol (Motor Gasoline)	kl	0.03411	0.8147
Biogas	MT	0.05040	1.2038
Light Diesel Oil (LDO)	kl	0.03655	0.8730

16 *The 2006 IPCC Guidelines for National Greenhouse Gas Inventories lists out the internationally acknowledged, Net Calorific Values for the given fuels*

Table 27: Conversion Numbers Used for different forms of Fuelwood

Product	Measurement Unit	Conversion factor in m3
Tree	Nos	1.3
Shinglap	Nos	2
Sawn wood	Cft	0.028
Log	Cft	0.028
Chams	Nos	1.1
Offcut	M3	1
Hakaries	Cft	0.028
Bakal	Tl	6
Firewood	HL	0.09
Firewood	TL	8
Firewood	M3	1
Poles	Nos	0.067
Flag post	Nos	0.047
Fence post	Nos	0.035
Tsim	Nos	0.067
Dangchung	Nos	0.067
Firewood	HL	0.09

(Source: Department of Forests and Park Services, Ministry of Agriculture and Forests)

7.4 Appendix: List of Relevant Tables and References

Table 28: Length of Transmission Line (in Kilometres)

#	Line	400kv	200kv		132kv	66kv			
		400kv D/C	200kv S/C	200kv D/C	132kv S/C	66kv S/C	66kv D/C	66kv Q/C	UG
1	Tala - Khogla	24.615							
2	Tala - Malbase - Pugli	49.528							
3	CHP-Gedu-Indian border			35.78					
4	CHP-Gedu-Malbase		29.841						
5	CHP-Semtokha		54.01						
6	Semtokha-Rurichhu		44.9						
7	Malbase-Border (Birpara)		4.075						
8	Malbase Singhigaon		1.706						
9	Malbase Singhigaon		2.607						
10	Malbase Multi circuit							3.405	
11	Malbase-Samtse			40.55					
12	Samtse-Sibso						26.96		
13	Samtse-Gomtu						14.85		
14	Chhukha-Gedu					20.4			
15	Gedu-Phuentsholing					16.7			
16	Phuentsholing-Malbase					8.986			
17	Phuentsholing-Gomtu					26.9			
18	Kurichhu-Kilikhar				10.06				
19	Kilikhar-Kanglung				29.7				
20	Kilikhar-Tangmachhu(Lhuntse)				42.8				
21	Kurichhu-nangkor				31.08				
22	Nangkor-Deothang				23.3				
23	Deothang-Motanga				10.5				

24	**Motanga - India (border)**				1.5				
25	**Nangkor-Nganglam**				33.8				
26	**Nganglam-Tintibi**				83.3				
27	**Gelephu-Tintibi**				45.7				
28	**Gelephu-Indian Border**				0.1				
29	**Tintibi - Yurmoo**				32.6				
30	**Yurmoo - Bumthang**					34.9			
31	**Yurmoo - Trongsa**					20.9			
32	**Chhukha-Chumdo**					37			
33	**Chumdo-Khasadrapchu**					4.78			
34	**Khasadrapchu-Olakha**					11.7			1
35	**Chumdo-Paro**					24			
36	**Chumdo-Haa**					33.4			
37	**Tie-line watsa**					0.5			
38	**Semtokha-Olakha**					1.7			
39	**Khasadrapchu - Jemina**						5.96		
40	**Semtokha - Lobeysa**					24.43			
41	**Hebesa-Rurichhu**					3.08			
42	**Lobeysa-Rurichhu**					20.3			
43	**Semtokha-Dechencholing**					11.45			
44	**Rurichhu - Tsirang**		46.6						
45	**Tsirang-Jigmeling**			30.57					
46	**Tsirang-Dagachu Port head**			20.2					
47	**Jigmeling- Pelrithang(Lodrai)**			10.4					
48	**Tshendengang-Dagapela**			4.4					
49	**Pasakha Industrial Area**								5
	Total	**74**	**184**	**142**	**345**	**301**	**48**	**3.4**	**6**

*(Source: BPC Power Data Handbook -2014. *D/C stands for double circuit, S/C stands for single circuit and Q/C stands for Quadruple Circuit)*

The amount of coal production, export and production has been given in the following table:

Table 29: Export, Domestic use and production of Coal (in MT)

Year	Export	Domestic Use	Production
2005	48,377	36,902	85,279
2006	65,545	32,420	97,965
2007	75,366	29,895	1,05,261
2008	80,976	42,728	1,23,704
2009	27,076	21,469	48,545
2010	58,819	28,997	87,816
2011	33521	75354	1,08,876
2012	46,608	52,123	98,731
2013	5,202	72,542	98,731
2014	26,574	95,317	121,891
2015	5,403	79,762	85,164
***For the year 2015, the dispatch is till the month of October.			
Coal Data (converted to energy units : Terajoules)			
Year	**Export**	**Domestic Use**	**Production**
2005	1,875	1,430	3,305
2006	2,541	1,257	3,797
2007	2,921	1,159	4,080
2008	3,139	1,656	4,795
2009	1,049	832	1,882
2010	2,280	1,124	3,404
2011	1,299	2,921	4,220
2012	1,807	2,020	3,827
2013	202	2,812	3,827
2014	1,030	3,694	4,724

(Source: Developed on consultation with Department of Geology and Mines, Ministry of Economic Affairs, Converted with reference: IPCC Guidelines for National Greenhouse Gas Inventories)

The consumption of coal by the industries in 2014 is listed below:

Table 30: Existing Import Tariff on Vehicles

Vehicle's Engine Capacity and Country of Origin	Existing Tax Rates (%)			
	CD	ST	GT	Total
Less than 1500CC (imported from India)	0	45	10	55
Less than 1500CC (imported from third countries)	45	45	10	100
1500cc – 1799cc	50	50	15	115
1799cc – 2500cc	50	50	20	120
2500cc – 3000cc	50	50	25	125
More than 3000cc	100	50	30	180

(Source: Department of Revenue and Customs)

Table 31: Number of Solar Beneficiaries across Bhutan, 2015

Sl No	Name of Dzongkhags	Total No of Solar Beneficiaries	Total No of Sets
1	Bumthang	13	47
2	Chhukha	15	15
3	Dagana	61	66
4	Gasa	192	198
5	Haa	230	238
6	Lhuntse	32	45
7	Monggar	185	222
8	Paro	89	118
9	Pema Gatshel	2	2
10	Punakha	17	21
11	Samdrup Jongkhar	142	146
12	Samtse	115	125
13	Sarpang	70	72
14	Trashigang	136	137
15	Trashiyangtse	28	37
16	Thimphu	111	122
17	Trongsa	70	78
18	Tsirang	79	79
19	Wangdue Phodrang	87	90
20	Zhemgang	457	534

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