Energy Efficiency Roadmap
(Draft Report)

Department of Renewable Energy
Ministry of Economic Affairs
Royal Government of Bhutan

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Acknowledgement

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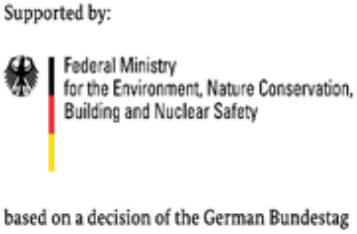

List of Acronyms

ABI	Association of Bhutanese Industries
BAU	Business As Usual
BCCI	Bhutan Chamber of Commerce and Industries
BEE	Business with Energy Efficiency
BEA	Bhutan Electricity Authority
BPC	Bhutan Power Corporation Limited
BSB	Bhutan Standards Bureau
CEA	Central Electricity Authority
CET	Constant Elasticity of Transformation
CGE	Computational General Equilibrium
CM	Combined Margin
CPI	Consumer price index
CO_2e	Carbon Dioxide Equivalent
DCSI	Department of Cottage and Small Industry, MoEA
DES	Department of Engineering Services, MoWHS
DHS	Department of Human Settlement, MoWHS
DoI	Department of Industry, MoEA
DoT	Department of Trade, MoEA
DRC	Department of Revenue and Customs, MoF
DRE	Department of Renewable Energy, MoEA
DSM	Demand Side management
EDD	Energy Data Directory
EDP	Economic Development Policy
EE	Energy Efficiency
EE&C	Energy Efficiency and Conservation
EMIS	Energy Management & Information System
EPS	Expanded Polystyrene
EY	Ernst & Young
FTL	Fluorescent tube light
GCF	Green Climate Finance
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GNHC	Gross National Happiness Commission
IFC	International Finance Corporation
NDC	Nationally Determined Contribution
HV	High Voltage
LV	Low Voltage
LED	Light emitting diode
LES	Linear expenditure system
MEPS	Minimum Energy Performance Standards
MoF	Ministry of Finance
MoIC	Ministry of Information and Communications, Bhutan

MoWHS	Ministry of Works and Human Settlements
MRV	Measurement, Reporting and Verification
MV	Medium Voltage
NAMA	Nationally appropriate mitigation action
NECS	National Environment Commission Secretariat
NA	Nodal Agency
RGoB	Royal Government of Bhutan
SAM	Social Accountability Matrix
S&L	Standards & Labelling
UNDP	United Nations Development Program
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organization
VFD	Variable Frequency Drive

List of Units

'000	Thousand
GWh	Gigawatt hour
kW	Kilowatt
kWh	Kilowatt hour
MW	Megawatt
Nu	Ngultrum
TOE	Tonnes of oil equivalent
tCO_2e	Ton of Carbon di-oxide equivalent

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Executive Summary

Energy Efficiency (EE) in the country offers a great opportunity to enhance economic benefits by saving losses, increased domestic savings, reducing import expenditures on fossil fuels and electricity during peak demand. In addition, EE also helps in enhancing the energy security and contributing to self-reliance by enhancing the national revenue through the export of surplus electricity. The importance of Energy Efficiency and Conservation (EE&C) measures is reflected in the country's Nationally Determined Contribution (NDC)[1] and United Nations Sustainable Development Goals (SDGs) as one of the mitigation tools for greenhouse gas reduction and to remain carbon neutral at all times. However, to achieve the same, the Royal Government of Bhutan (RGoB) must adhere to a systematic structured approach which will guide to develop and implement the EE interventions in the energy extensive sectors and help in strengthening coordination and synergies among the relevant stakeholders.

The EE roadmap defines the rationale for energy efficiency and its purpose of enhancing the country's energy security through the potential energy savings from the energy consuming sectors. The roadmap also establishes the impact of energy efficiency on country's GHG emission in line with the country's NDC targets with about 0.59 Million tCO_2e emission reduction potential from implementation of EE&C measures.

The roadmap has elaborated the key interventions required to achieve the energy saving target of 0.206 million tons of oil equivalent for 15 years and a broad level financial resources required for each realistic and achievable interventions.

The interventions are organized sector wise and over three time horizons viz. short term (0-5 years), medium term (6-10 years) and long term (>10 years) for which the detailed interventions are focused in the Chapters 6-8. The roadmap suggests all interventions to be preceded by a proper feasibility study, clear institutional roles and responsibilities of the agencies, budget requirement, identification of financial source and international collaboration.

The roadmap further elaborates on the importance of a proper monitoring and evaluation tool to be designed during the preparatory phase. It would ensure a real time feedback mechanism for on-line course correction if necessary. As a way forward, the roadmap suggests further digitization of the program and its alignment with the five yearly planning exercise.

[1] Royal Government of Bhutan NDC 2015, UNFCCC

1. Introduction

Bhutan continued to experience acceleration in average annual growth rate of GDP to 8.53% from 5.9% in the 1990s. The average annual growth rate in the 1980s was 7.4%, which decreased to 5.9% in the 1990s, but increased again to 8.53% in the first decade of the present century[2]. The economy is expected to grow at an average of 11.1% from 2017-19[3]. The country witnessed increase in domestic energy consumption due to expansion of rural electrification programme and associated increase in GHG emission.

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[4]. Though emission from energy sector seems small (12.5% of GHG sequestration potential), the growth rate has been significant.

As per country's NDC, RGoB intends to remain carbon neutral and would make efforts to maintain current levels of forest cover (~70%) having sequestration potential of around 6.3 million tons of GHG. To remain carbon neutral, growing emissions from economic development will need to be mitigated by pursuing low emission development pathways across energy consuming sectors through promotion of energy demand side management.

The RGoB had identified energy efficiency and conservation measures as one of the key mitigation tools for GHG reduction, based on recommendations from several studies[5] conducted on energy saving potentials across all the energy consuming sectors. Subsequently, a draft EE&C policy has been formulated to achieve this potential.

Sustained pursuit of green growth entails systematic focus on energy efficient productive activities across different sectors like industry, transport, building, and appliances. The overall economy will be further improved through EE&C measures by reduced energy intensity, higher revenue earning through additional electricity export emerging from energy efficiency and possible revenues from participation in international climate finance mechanism.

In 2014, the country consumed around 650,220 Tonnes of Oil Equivalent (ToE) of energy. The key energy consuming sectors include Building (residential, institutional and commercial), Industry and Transport. The energy supply was primarily in the form of electricity, fossil fuels

[2] EDP 2016

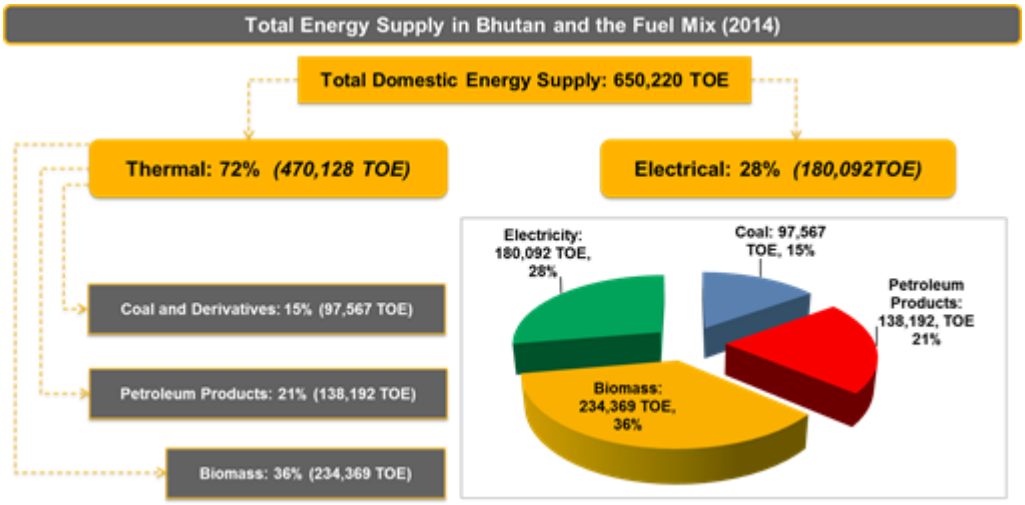
[3] Global Economic Prospects 2017-World Bank

[4] Bhutan INDC September 2015

[5] Bhutan EDD 2015, Bhutan Building Energy Efficiency, Industry Audit Report, Appliances Audit Report, Technical Specifications for Energy Efficient Appliances

and biomass. The maximum energy consumption is noted in the Building and Industry sectors with around 78.8% of the total energy consumption. The Building sector consumed 270,356 ToE while the Industry sector consumed 241,992 ToE. The Transport sector noted 18.64% share in the energy consumption (121,218 TOE) while the remaining 2.56% energy was consumed in agricultural and auxiliary activities[6].

Figure 1. Energy Supply and Fuel Mix (2014)



Therefore, it is imperative to develop the EE roadmap to be implemented by various agencies as well as non-governmental stakeholders. The roadmap will also act as the guiding tool for implementation of the draft EE&C Policy[7] and enabling integration into the 12th Five Year Plan (July 2018- June 2023) and subsequent five year plans. This roadmap will also form the basis for the national process to review progress in implementation of EE&C measures. The EE roadmap is focused only on Building, Appliance and Industry sectors at national, household and industrial levels.

[6] Bhutan EDD 2015

[7] Expected to be approved within 2017-2018

2. Rationale for Energy Efficiency

Energy has specific importance in the country's economy. Revenue generated from export of clean energy to India accounts for third largest share of GDP after Agriculture, Livestock & Forestry and Construction sector[8]. While electricity sales have been one of the significant revenue earners, expenditure for fossil fuels have been growing significant as shown in Figure 2[9].

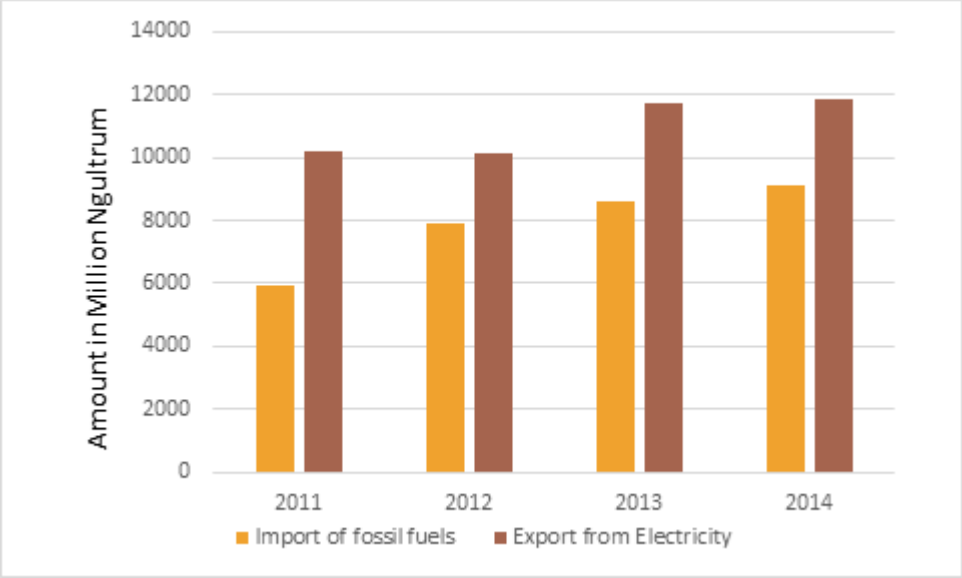


Figure 2. Trend in the Export of electricity and Import of Fossil fuels

In 2014, the country exported around 5,179 million kWh annually of surplus electricity, the contribution of which comes to around Nu. 10,698 million at Nu. 2.07 per kWh of electricity export tariff[10]. In the same year, the country imported Nu. 8,432.66 Million worth of petroleum products[11].

Over the last decade (2005-14), a steady increase in domestic electricity consumption is observed, which is affecting the nation's income from sale of electricity as shown in the Figure 3. The more the domestic consumption, the lesser is the potential for export revenue by selling electricity.

[8] National Accounts Statistics, NSB; Percentage share of GDP by Economic Activity at current prices (2011-2015)

[9] Statistical Year Book 2015-NSB

[10] National Statistics Bureau

[11] Developed from data provided by the POL Section, Department of Trade, MoEA, Bhutan

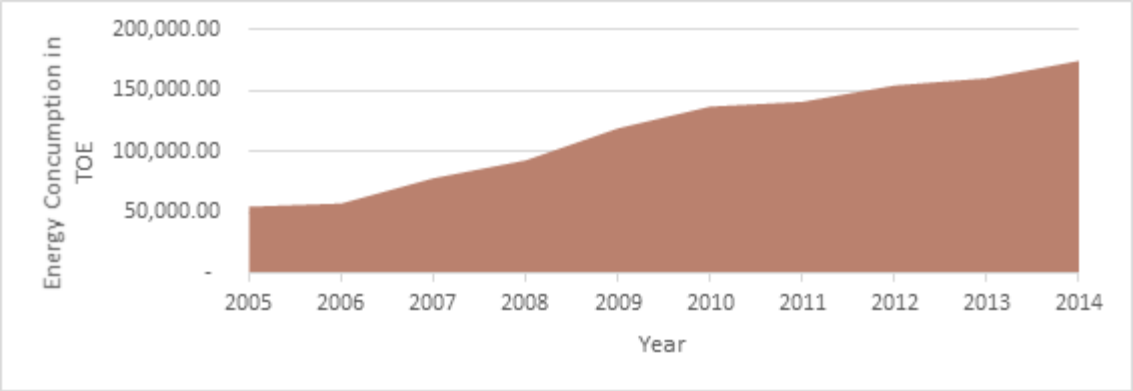


Figure 3: Energy consumption pattern for electricity (Bhutan EDD 2015)

The EE&C measures entail multiple benefits such as domestic savings, reduction in import of fossil fuels and additional revenue generation. The energy savings potential in electricity consumption, averaged over the 15 years projected period, in the industry, building and appliance sectors is about 155 million kWh annually which amounts to an additional revenue of about Nu. 320 million per annum. The EE&C measures will contribute to job creation in energy consuming sectors, making EE&C an important contribution to RGoB's green growth strategy and enhance energy security of the country. The roadmap is a part of ongoing effort to elaborate Bhutan's commitment to reduce emission from the energy-consuming sector and provides clarity on the energy efficiency and emission reduction targets, implementation plans and associated resource needs. It provides a sound technical basis for formulating investment plans in the sectors.

The roadmap will contribute to the fulfilment of the upcoming obligation arising out of the Paris Agreement under the UNFCCC. It elaborates Bhutan's commitment to reduce emission from the energy-consuming sector and provides clarity on the energy efficiency and emission reduction targets, implementation plans and associated resource needs.

The pursuit of EE&C measures aligns with RGoB's priority in the implementation of United Nations' Sustainable Development Goals. Reduced energy intensity is expected to contribute towards climate action through reduction in GHG emissions, while also promoting sustainable environment through lesser environmental pollution.

In the Industrial sector, energy efficient production processes and technologies will improve productivity, profitability and competitiveness by lowering operating costs, enhancing skills and disseminating knowledge and best practices. Energy efficiency measures in industries will help in enhancing national economy, technology transfer and establishing value chains for energy-efficient goods and services.

In the Building sector, the EE&C measures will help in reducing fuel wood consumption leading to maintaining of carbon sequestration capacity.

In the Appliance sector, EE&C measures will help in improving the energy performance of the appliances through systematic efforts of lowering the average wattage of appliances by replacing the current stock with energy efficient appliances.

3. Purpose of EE Roadmap

The purpose of the EE roadmap are:

1. A guide towards formulation and implementation of EE&C measures in the energy consuming sectors.
2. Strengthen coordination and synergies among relevant stakeholders on the implementation of EE&C measures.
3. Mobilise resources for implementation of EE&C measures.
4. Institute Monitoring, Reporting & Evaluation systems of the implementation of EE&C measures.

The expected outcomes of the implementation of the roadmap are as follows:

At National level:

- ➔ Any potential energy savings in the form of electricity will lead to an increase in RGoB's export revenue and thus will positively affect its balance of trade.
- ➔ Reduced energy consumption can lower the RGoB's fiscal burden on energy subsidies and re-allocate resources for developmental activities.
- ➔ Reduce global GHG emission by substituting energy demand which otherwise would need to be met from thermal power plants.

At an Industrial level:

- ➔ Energy efficiency can allow the country's industries to improve productivity and competitiveness by reducing operating costs and environmental pollution.

At a Household level:

- ➔ Economic impact analysis reveals that energy efficiency induces a long-term positive impact on the household income in an economy.

4. Energy Efficiency Targets

The target for energy efficiency is set for 15 years, focusing on Buildings and Appliance and Industry sectors (Table 1). This target is determined based on the technical studies and detailed energy audit carried out in the energy consuming sectors. While the respective agencies for each sector will carry out the streamlining of the EE&C measures through development of codes, standards, energy auditing, etc., the targets reflected in the table below will be achieved with involvement of institutions and private sectors in all the three sectors. The target will be reviewed and adjusted after 5 years, following evaluations of implementation, operation and impacts of EE&C measures in the country.

Table 1: Energy Efficiency Target

Sector	Short Term (0-5 years) savings in TOE	Medium Term (6-10 years) savings in TOE	Long Term (> 10 years) savings in TOE	Total Savings in TOE
Building	21,705.30	138.02	182.52	**22,025.84**
Appliance	49,432.84	49,432.84	49,432.84	**148,298.51**
Industry	11,877.92	11,877.92	11,877.92	**35,633.76**

5. Expected Energy Saving potentials

With the implementation of EE&C measures over short, mid and long term, the energy consumption can be curtailed through a cumulative energy saving of 1.4 Million TOE. In the process, the GHG emission reduction of approximately 5.8 million tCO_2e can be achieved over the same period. The analysis indicates that the energy consumption and simultaneously the GHG emission in building, appliances and industry sectors are expected to grow within 15 years as shown in figure 4.

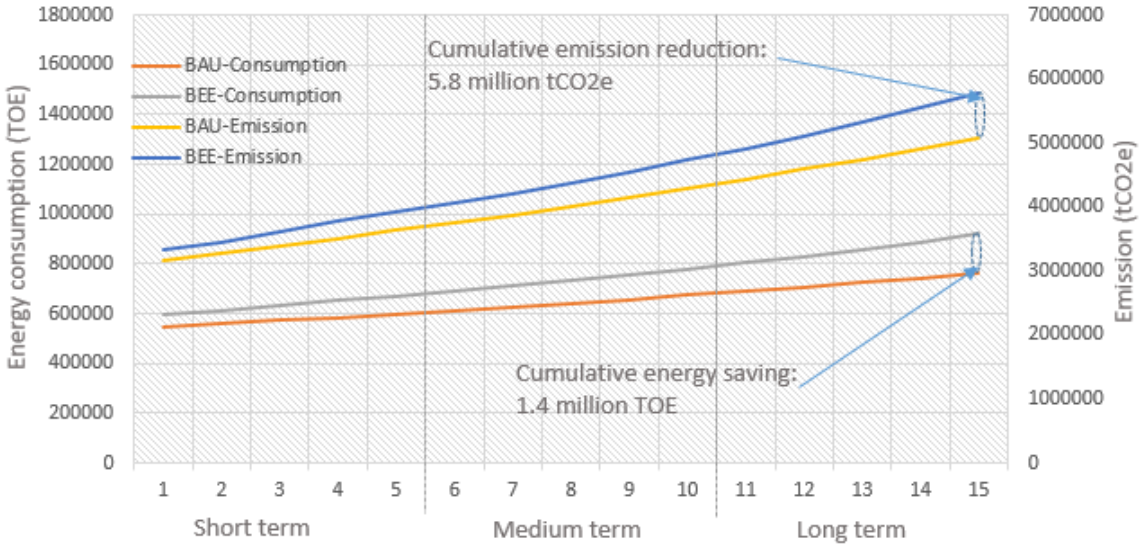


Figure 4: BAU & BEE Scenario for all sectors

The BAU and BEE scenario is derived from the macro-economic modelling taking into consideration of the highest penetration of EE&C measures. From Figure 4, the energy consumption and simultaneously the GHG emission in building, appliances and industry sectors are expected to grow within 15 years.

The following assumptions are considered while calculating the emission reduction potential and the abatement cost for implementing energy efficiency intervention proposed in the roadmap.

- The energy saved from the interventions from Building, Industry and Appliance sectors are assumed to be exported to the neighboring country, India.
- While calculating the abatement cost (Nu./tCO_2e), the grid emission factor (0.96 tCO_2e/MWh) of India has been taken.
- The carbon credits from the interventions are shared between Bhutan and India due to the shared electricity grid.
- The BAU and BEE scenario is derived from the macro-economic modelling taking into consideration of the highest penetration of EE&C measures.

6. Energy Efficiency Interventions in Building Sector

Introduction

In 2014, the building sector consumed 42% of the total energy in the country[12]. The dominance of biomass in the form of fuel wood is high with 87% biomass consumption in residential building and 78% in institutional and commercial buildings. The huge consumption of biomass is mainly for heating and cooking. The findings from the energy audits indicate that building envelope plays an important role in preventing heat loss from a building in a cold climate and the reverse in a warmer climate. Presence of cracks or gaps in masonry joining, lack of sufficient insulation, inefficient building materials, and inappropriate orientation contributes for inefficient energy performance of the building.

Brief description of interventions

Energy performance of buildings can be improved through a systematic effort of establishing database to develop the energy efficiency codes and developing auditing and reporting guideline as shown in Table 2.

Table 2: Building Sector Interventions

Short term (0-5 years)	
Establishment of Database towards EE Building Codes development	A database of energy efficiency parameters in context to Bhutan shall be established through intensive studies of various building typologies in Bhutan.
Medium Term (6-10 Yrs.)	
Develop Building Energy Efficiency Codes	Roll out for full Certification of EE programs and ensure uptake of energy efficient buildings in the country.
Develop and implement Energy Audit and Reporting Guidelines	Mandate periodic energy audits and reporting of energy performance of energy intensive buildings, as defined in the energy efficiency building codes.
Long Term (over 10 years)	
Implementation of EE Buildings	Local builders to adopt appropriate design, building material and construction practices.

[12] Bhutan EDD 2015

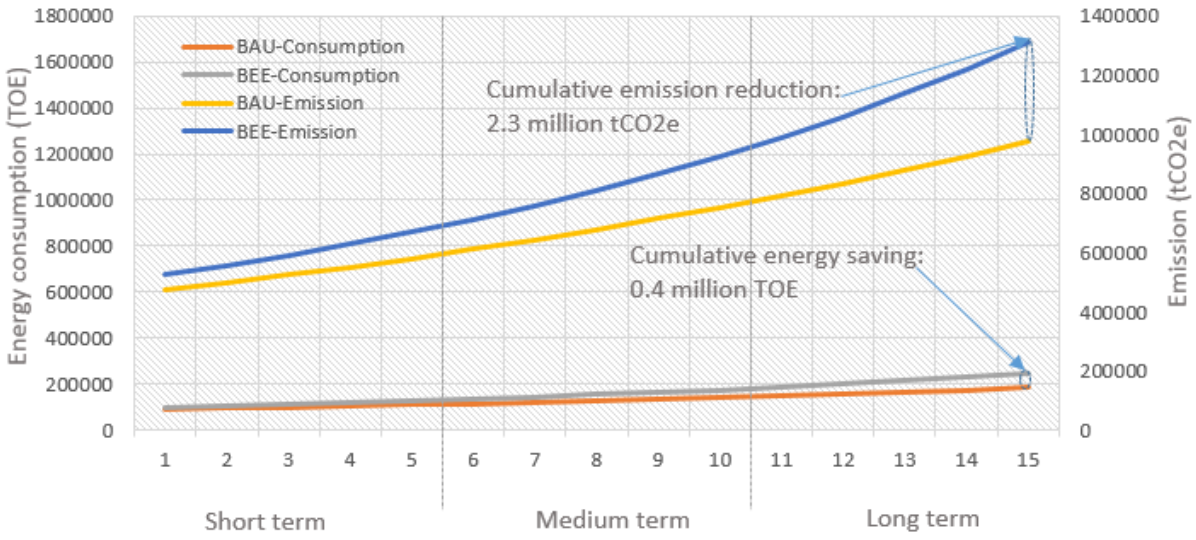
Standards/Codes	
Certification of EE buildings	Once the value chain components are ready the certification process can be rolled out for full implementation and would ensure efficient buildings in the country.

Table 3: Estimated Energy Savings and Investment Requirement – Building sector

Aspect	Value
Energy savings (TOE)*	22,026
Investment (Million Ngultrum)	49.98
Investment per unit of energy savings (Million Nu. per TOE)	0.0003
Emission Reduction Potential (tCO_2e)	144,197
Abatement Cost (Nu./tCO_2E)	48,603

The audits carried out in 2014 recommends various EE&C measures in the building sector which are detailed in Table 11 of this report. However, to realize targets as mentioned in the above Table 3, it is important to first have the building codes and auditing guidelines in place. The piloting of the interventions in few residential, institutional and commercial buildings will be carried out after the development of the codes and guidelines.

Figure 5: BAU & BEE Scenario- Building sector



The implementation of highest EE&C penetration in the building sector is expected to have cumulative energy consumption savings of 0.4 Million TOE and GHG emission reductions of 2.3 Million tCO2e over a period of 15 years provided there is highest penetration of EE&C

measures. However, with the selected interventions in the roadmap the expected energy savings amounts to 22,025.84 TOE with emission reduction potential of 144,197.12 tCO_2e (Table 3). The energy consumption and GHG emission in the Building sector is expected to grow from the base year till 15 years (Figure 5) due to faster pace of urban development, construction of larger buildings and recreational facilities.

7. Energy Efficiency Interventions in Appliance sector

Introduction

Energy performance of appliances is improved by replacing existing appliances at the end of their life span with more energy efficient ones and by creating awareness programs. The energy performance standards can be adopted to the similar benchmarks as set in Thailand and India (the two primary sources of import of appliances) and discourage the users in buying non-labelled appliances or in-efficient appliances.

Brief Description of Interventions

The audit for appliance sector was carried out in 201 households across the country for all levels of income. It was found out that most of the commonly used appliances were imported from India and Thailand where EE Standards and Labeling (S&L) are already in place. Since Bhutan doesn't have manufacturing units, the need for harmonization of standards with the exporting countries is recommended. While the adoption of standards for appliances can be targeted in the long term, it is essential to develop and adopt S&L scheme as stated in the Table 4 below.

Table 4: Appliance Sector Interventions

Short term (0-5 years)	
Develop and adopt S&L Scheme	DRE in consultation with BSB will develop the S&L scheme for energy intensive appliances imported in the country
Incorporate EE&C aspects in the Public Procurement System	The EE&C aspects recommendation to be incorporated in the Public Procurement System.
Incorporate EE appliance in Bhutan Trade Classifications	Once the S&L scheme and specifications are ready, it should be incorporated into the trade classification system for effective monitoring and enforcement.
Medium Term (6-10 years)	
Voluntary implementation of S&L scheme	In this first 5 years, S&L for 5 appliances will be implemented and carried out as voluntary measure in the medium term too along with development of S&L scheme for rest of the appliances.
Long Term (over 10 years)	

Strengthening of Electrical testing Laboratory	To support certification of appliances for higher efficiency with collaboration with BSB and technical colleges in the country
Mandatory implementation of S&L scheme	The mandatory implementation of S&L scheme for the appliances will be carried out after the 10 years to prohibit the import of inefficient appliances.

Table 5: Appliances Sector Energy Savings and Investment – Appliance sector

Aspect	Value
Energy savings (TOE)	148,298
Investment (Million Ngultrum)	4719.82
Investment per unit of energy savings (Million Nu. per TOE)	0.1325
Emission Reduction Potential (tCO_2e)	142,366
Marginal Abatement Cost (Nu./tCo_2e)	5,316,695

The energy saving potential of 148,298.51 TOE over a period of 15 years will be achieved with S&L scheme developed for 15 energy consuming appliances. The participation of the retailers in the country will play a crucial role in achieving the target. While the import projection of the appliances was taken for 15 years, an adjustment factor of 23% has been taken into consideration mainly as a startup implementation.

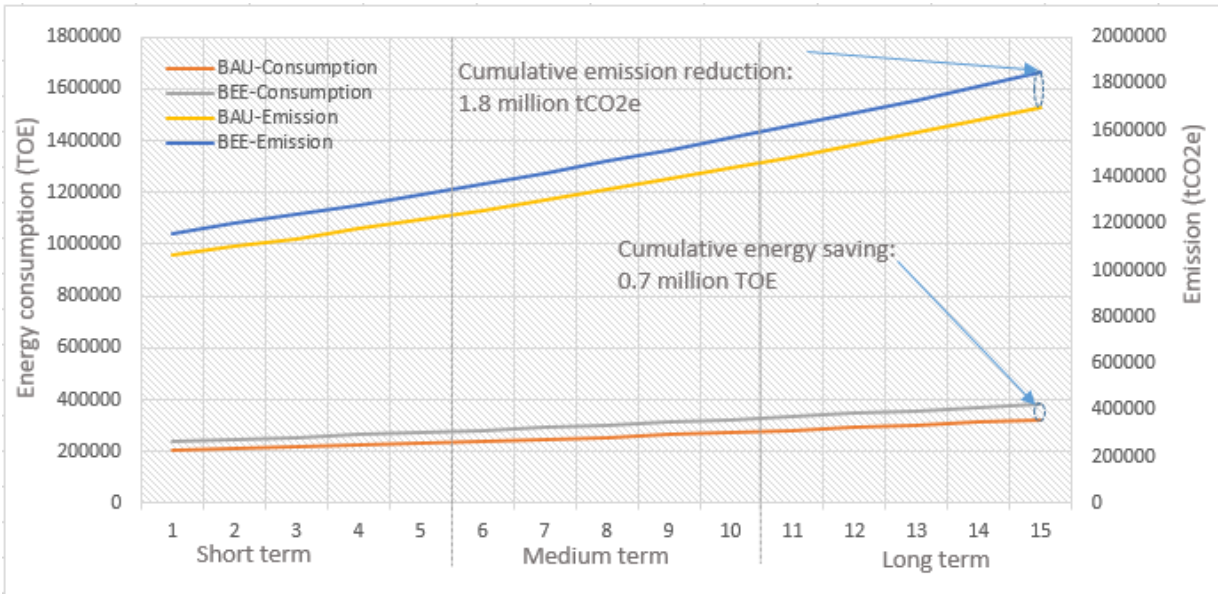


Figure 6: BAU & BEE Scenario- Appliance sector

The energy saving potential and associated GHG reduction potential indicates the savings from opting for efficient appliances and prevents the country from becoming a dumping yard for inefficient appliances .The forecast from the figure 6 in the BAU scenario and with the highest penetration of EE&C measures shows that the energy consuming appliances would result in a cumulative energy savings of 0.7 Million TOE over a period of 15 years. However, with the selected interventions in the roadmap, the expected energy savings amounts to 148,298.51 TOE with emission reduction potential of 142,366.57 tCO_2e (Table 7).

8. Energy Efficiency Interventions in Industry Sector (Production & Manufacturing)

Introduction

The Industry Sector, with a total consumption of 241,972 TOE in the year 2014, has the most diverse fuel mix. High voltage industries are the major consumers of energy, consuming around 78% of the total energy in the sector. The heavy industries also have a diverse fuel consumption mix, while the medium and Cottage and Small industries (CSI) are mainly dependent on electricity as the main fuel[13].

Brief description of Interventions

The energy audits revealed that maximum savings potential are in boilers and furnaces followed by motors and fans through energy efficiency retrofits and technology changes focusing on both small-scale, low-cost retrofit measures as well capital intensive large-scale projects. The Table 6 shows the interventions that will need to be carried out by various agencies in order to implement the recommendations from the studies.

Table 6: Industry Sector Interventions

Short term (0-5 years)	
Develop & Maintain EE quality circle	Quality Circle establishment actively gathers information about losses in the areas of operation, and also gathers best practices across the globe the solutions for the losses.
Design Industrial park as per the industrial ecology or Eco-industrial park design guidelines to be formulated	Systematic zoning of area for industrial development to harness the maximum potential from waster to heat/energy in the area.
Develop Energy Management and Information Systems (EMIS)	Initiate Energy Management and Information Systems (EMIS) for consistent and reliable data.
Medium Term (6-10 years)	

[13] Bhutan EDD 2015

Develop Energy Efficiency Codes for Industries	The codes will be an input to the development of Energy Audit and Reporting Guidelines
Develop and implement Energy Audit and Reporting Guidelines	In this period EMIS systems being at place, energy audit guidelines must be implemented to achieve results.
Establish the Motor rewinding centre	Motor re-winding centre can be opened in any of the industrial zone that can repair, test and certify the motors so the efficiency and motor life can be improved. During the first two years, the feasibility for the rewinding system needs to be finalized and the centre can come up in the 3rd year, if feasible.
Implement EE upgrades in Industries	As per audit recommendations, EE upgrades will be implemented following initial awareness and auditing programs
Implementation of Energy Management and Information Systems	EMIS to be implemented for energy information system and monitoring EE&C measures
Long Term (over 10 years)	
Certification of Industries for energy management systems and standard	Once the information system is in place, the certification process can ensure sustainability of continuous improvement process

The table 7 below gives a cumulative impact from the industry sector with Energy Savings of 35,633.76 TOE with implementation of various EE&C measures as mentioned in action plan:

Table 7: Estimated Energy Savings and Investment – Industry sector

Aspect	Value
Energy savings (TOE)	35,634
Investment (Million Ngultrum)	90.92
Investment per unit of energy savings (Nu. per TOE)	0.0004
Emission Reduction Potential (tCO_2e)	228,487
Marginal Abatement Cost (Nu./tCO_2e)	22,395

While the detailed audits were carried out for 40 industries including one hydropower plant in 2014, the recommendations of the interventions from the studies will be implemented in other industries too. However, the energy auditing and reporting guidelines will exhibit the energy saving potential in all the industries prior to the implementation.

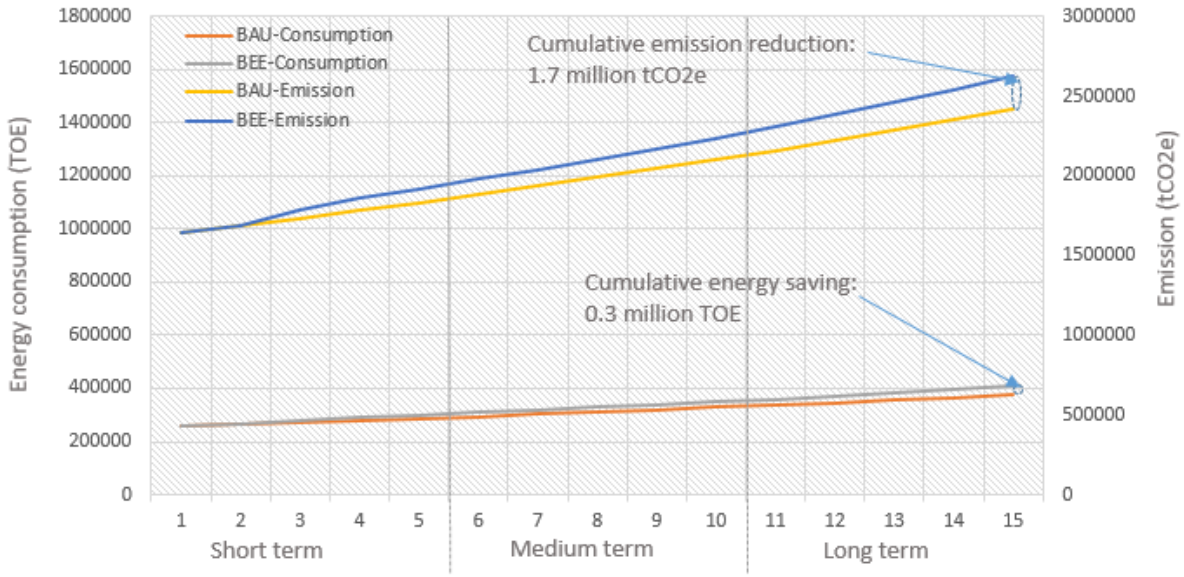


Figure 7: BAU & BEE Scenario- Industry sector

Implementation of extensive EE&C measures is expected to achieve a cumulative energy savings of 0.3 Million TOE through lower energy demand and reducing energy intensity. The same measures are expected to generate cumulative GHG emission reduction of 1.7 Million tCO2e, thus helping in the reduction of carbon footprints in the industrial sector of the country. However, with the selected interventions in the roadmap the expected energy savings amounts to 35,633.76 TOE with emission reduction potential of 228,487.42 tCO_2e (Table 5). This comes despite the fact that energy consumption and GHG emission trends in industrial sector are expected to rise within 15 years (Figure 5).

9. Means of implementation to achieve EE&C intervention

Effective implementation of the proposed energy saving measures in building, appliances and industry sectors will depend of the availability of resources and capacity building. Adequate means of implementation is crucial for realizing the energy efficiency targets. These are termed as crosscutting needs and support and are presented in the Table 8:

Table 8: Cross Sector Interventions

Financial	1. Fiscal incentives for EE equipment, plants, machineries, appliances and buildings as per NEPA 2007 and EDP 2016 2. Resource mobilization for EE&C measures from both national & international sources including climate finance, bi-lateral, multi-lateral development partners & market and non-market mechanisms under Paris Agreement
Capacity Building	1. Capacity Building Needs Assessment to map existing capacities, identify gaps and challenges 2. Institutional development & strengthening 3. Skills development & capacity enhancement of stakeholders for implementation & monitoring of EE&C measures
Technology Transfer	1. Technology Needs Assessment to identify the technology need, gaps and challenges 2. Technology Match Making & Best practices

10. Institutional Arrangements

EE&C implementation is a cross-sectoral activities and will require support from various agencies at any point in time. The institutional arrangement outlines the roles and responsibilities of relevant agencies in the promotion and implementation of EE&C measures. The Table 9 presents the sector-wise key stakeholders for implementation of EE&C measures in the country.

Table 9: Key Stakeholders for Implementation of EE Roadmap

Sector	Lead Agency	Collaborating agencies
Building	➢ Ministry of Works and Human Settlements ➢ Bhutan Standards Bureau	➢ Department of Renewable Energy ➢ Thromdes (Municipalities) ➢ National Housing & Development Corporation Limited ➢ Private sectors
Appliances	➢ Department of Renewable Energy ➢ Bhutan Standards Bureau	➢ Department of Trade, MoEA ➢ Private sectors ➢ Bhutan Chamber of Commerce and Industry
Industry	➢ Department of Renewable Energy ➢ Department of Industry, MoEA ➢ Department of Cottage and Small Industry, MoEA	➢ Bhutan Electricity Authority ➢ Bhutan Power Corporation Limited ➢ Bhutan Chamber of Commerce and Industries ➢ Bhutan Standards Bureau ➢ Association of Bhutanese Industries
Cross-cutting	➢ Ministry of Finance ➢ Gross National Happiness Commission ➢ National Environment Commission	➢ Financial Institutions ➢ Royal University of Bhutan

10.1. Department of Renewable Energy (DRE)

The Department of Renewable Energy (DRE) under the Ministry of Economic Affairs (MoEA) will be the nodal agency for implementation of the actions laid down in the EE Roadmap. DRE will promote, facilitate and coordinate EE&C measures in the country.

10.2 Ministry of Finance (MoF)

The MoF shall give due consideration to the proposals for EE&C financing instruments recommended by DRE and seek approvals for fiscal incentives from the Parliament and incorporate EE&C aspects in the Public Procurement system.

The DRC in collaboration with the DoT, MoEA and other relevant agencies, shall strive to monitor the import and sale of energy efficient appliances and equipment including sub-standard energy efficient appliances and equipment in the Country.

10.3 National Environment Commission Secretariat (NEC)

The NEC shall collaborate with the DRE for consolidating all relevant information to prepare the country's position on climate change mitigation related to EE&C measures and facilitate the flow of climate finance through NAMA, NDCs, and emerging international mechanisms.

10.4 Gross National Happiness Commission

The GNHC shall periodically review the implementation status and effectiveness of EE&C measures at a national level to ensure its alignment with the overall national development objectives based on the progress report of action plan submitted by DRE.

10.5 Department of Trade (DoT), MoEA and Department of Revenue and Customs (DRC), MoF

The DoT in collaboration with the Department of Revenue & Customs (DRC), MoF and other relevant agencies, shall monitor the import and sale of energy efficient appliances and equipment including sub-standard energy efficient appliances and equipment in the Country.

10.6 Bhutan Standards Bureau (BSB)

The BSB shall certify the energy performance of energy efficient appliances as well as other sectors included in this roadmap wherever appropriate as per relevant national standards or such other directives issued by a competent authority.

10.7 Ministry of Works and Human Settlements (MoWHS)

The DoES under the MoWHS shall develop the energy efficiency building codes in close coordination with DRE for both new building constructions and retrofits in existing buildings.

The DoES, under the MoWHS, shall coordinate with DRE to conduct targeted outreach and awareness on EE&C measures for building sectors to promote uptake of energy efficient construction technologies and practices.

The DoHS, under the MoWHS, shall use the provision of the EE&C Policy as an input for integrated and green urban planning.

10.8 Department of Industry (DoI) and Department of Cottage and Small Industries (DCSI)

The DCSI shall work in close coordination with the DRE, BCCI and ABI to promote and implement EE&C measures in the small and cottage industries.

10.9 Bhutan Electricity Authority (BEA)

The BEA shall explore to re-categorize HV, MV and LV industries, from time to time, based on actual power consumption/connected load. BEA in consultation with DRE may design a price signal, as appropriate, for facilitating EE&C measures in industries.

The BEA will study in consultation with the DRE and other stakeholders, applicable tariff instruments, which can incentivize EE&C, demand response or demand side management, as and when appropriate. The EE&C policy shall be used as an input for design and/or amendment of the Domestic Electricity Tariff Policy.

The BEA, in collaboration with the Bhutan Power Corporation Limited, shall ensure that the transformer sizing and distribution system design is optimum for consumers for energy efficient operation.

10.10 Bhutan Chamber of Commerce and Industries (BCCI) and Association of Bhutanese Industries (ABI)

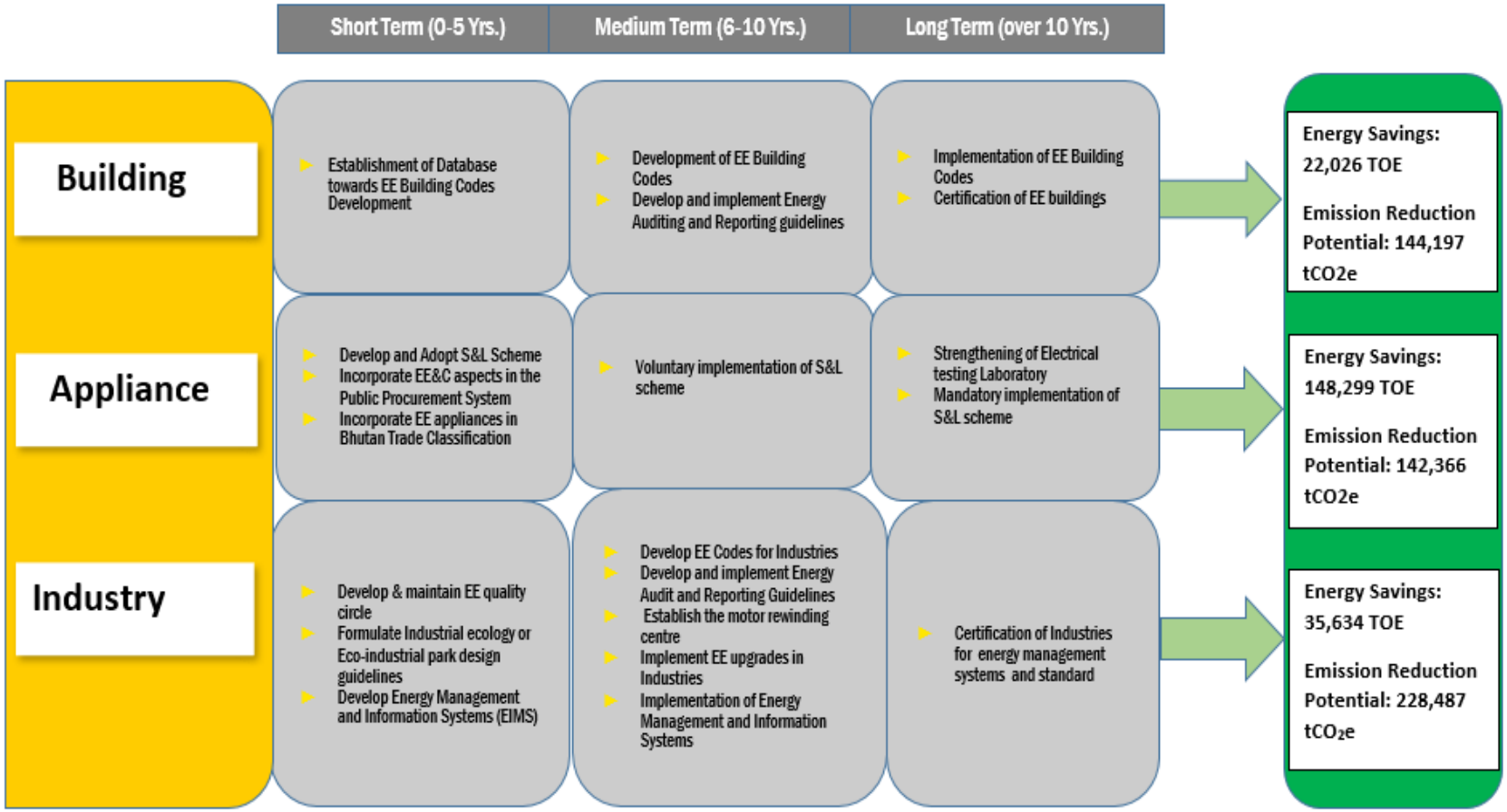
The BCCI and ABI shall also provide periodic inputs and industry insights to the RGoB on industrial EE&C measures.

11. Energy Efficiency Roadmap

11.1 EE Roadmap

The Figure 8 shows the summary of the EE measures to be taken up by various agencies over the period of 15 years.

Figure 8: EE roadmap framework



11.2 Detailed roadmap framework

The table gives shows the interventions that will be carried out by various agencies to achieve the said energy saving potentials

Table 10: Interventions by various agencies

Sl. No.	Intervention	Time line	Lead Agency	Collaborating agency/ies	Budget Estimate (Million Nu.)	Outcome
BUILDING SECTOR						
1	Establishment of Database towards EE Building Codes development	Short Term (0-5 years)	DES, MoWHS	DRE	8.00	A database of energy efficiency parameters in context to Bhutan established through intensive studies of various building typologies in Bhutan.
2	Develop Building Energy Efficiency Codes	Medium Term (6-10 years)	DES, MoWHS	DRE, Thromdes, BSB	22.00	Roll out for full Certification of EE programs and ensure uptake of energy efficient buildings in the country.
3	Develop and implement Energy Audit and Reporting Guidelines	Medium Term (6-10 years)	DRE	DES, MoWHS	5.50	Mandate periodic energy audits and reporting of energy performance of energy intensive buildings, as defined in the energy efficiency building codes.
4	Implementation of EE Building Codes	Long Term (>10 years)	DES, MoWHS	Private/ Government building owners	0.10	Local builders to adopt appropriate design, building material and construction practices.
5	Certification of EE buildings	Long Term (>10 years)	BSB	DES, MoWHS & DRE	3.00	Ensure energy efficient building practice
APPLIANCE SECTOR						
1	Develop and adopt S&L Scheme	Short Term (0-5 years)	DRE	BSB, ADB (TA)	4.13	Implementation of S&L scheme for 5 appliances
2	Incorporate EE&C aspects in the Public Procurement System	Short Term (0-5 years)	DRE	GPMD, MoF	0.10	Reduce in the import of inefficient appliances
3	Incorporate EE appliance in Bhutan Trade Classifications	Short Term (0-5 years)	DRE	DRC, MoF	0.10	Reduce in the import of inefficient appliances

4	Voluntary implementation of S&L scheme	Medium Term (6-10 years)	DRE	BSB, DoT, DRC	0.15	Encourage retailers to import energy efficient appliances
5	Strengthening of Electrical testing Laboratory	Long Term (>10 years)	BSB	DRE and technical colleges	5.00	In house testing of the appliances imported from other countries
7	Mandatory implementation of S&L scheme	Long Term (>10 years)	DRE	BSB, DoT, DRC	0.15	Prohibition of inefficient appliances import
INDUSTRY SECTOR						
1	Develop & Maintain EE quality circle	Short Term (0-5 years)	DRE	DoI, BCCI, ABI	1.00	Adopting best practices and streamlining decisions
2	Design Industrial park along as per the industrial ecology or Eco-industrial park design guidelines to be formulated	Short Term (0-5 years)	DoI		5.12	Harness waste to heat/energy potential.
3	Develop Energy Management and Information Systems (EMIS)	Short Term (0-5 years)	DoI	DRE, DIT, MoIC	8.10	EMIS developed for energy information system and monitoring EE&C measures
4	Develop Energy Efficiency Codes for Industries	Medium Term (6-10 years)			8.60	EE&C codes developed to streamline EE&C measures for the industries
5	Develop and implement Energy Audit and Reporting Guidelines	Medium Term (6-10 years)	DRE	DoI	5.50	Mandate periodic energy audits and reporting of energy performance of the industries
6	Establish the Motor rewinding centre	Medium Term (6-10 years)	DRE	DoI, BPC	3.00	Establish independent centre with due collaboration with BPC or use the existing centre at Begana Maintenance centre under BPC
7	Implement EE upgrades in Industries and EMIS	Medium Term (6-10 years)	DRE	DoI, BCCI, ABI	3.00	Increased productivity of the industries with less energy consumption
8	Certification of Industries for energy management systems	Long Term (>10 years)	BSB	DRE, DoI, BCCI, ABI	1.00	Encouraging industries to implement EE&C measures

	and standard					

11.3 Detailed Roadmap for each Sectors

The following Tables 11, 12 & 13 highlight on the detailed EE interventions/activities to be implemented in the respective energy consuming sectors.

Table 11 : Detailed Roadmap for EE Interventions-Building Sector

Action Item	Output	Outcome	Budget (in Million Nu.)	Emission Reduction potential (tCO_2e)	Abatement Cost (Nu./tCO_2e)	Energy Savings (in ToE)
Distribution of 600,000 LED lighting bulbs	Installation of LEDs in all types of buildings	Increased penetration of energy efficient lighting.	42	142,135	295	27,042
Installation of 1 inch glass wool insulation in 185 institutional and commercial buildings	Installation of glass wool insulation on north facing walls of the buildings	Increased penetration of energy efficient building insulation practices	2.93	323	3,370	62
Promotion of Rat trap wall in 45 new commercial and institutional buildings	Wall construction using rat trap method of brick bonding	Increased penetration of energy efficient wall construction	0.58	208	8,406	40

		practices				
Promotion of Rat trap wall in 50 new residential buildings	Wall construction using rat trap method of brick bonding	Increased penetration of energy efficient wall construction practices	0.65	147	13,189	28
Promote installation of double glazed windows in 300 buildings	Installation of double glazing on windows	Increased penetration of energy efficient glazing practices	6.28	843	22,358	160
Promote usage of 1 inch EPS insulation on roof for 75 institutional and commercial buildings in summer districts	Installation of Extruded polystyrene insulation on roofs of institutional and commercial buildings	Increased penetration of energy efficient building roof insulation practices	0.18	542	985	103

Note: The details of the intervention options may be subject to change as per the finalization of the 12th FYP

Table 12: Detailed Roadmap for EE Interventions-Appliance Sector									
Sl. No	**Appliance for S&L scheme**	**Output**	**Outcome**	**Indicators for monitoring**	**Total import by 2030**	**Estimated Budget (Million Nu.)**	**Emission Reduction (tCO2e)**	**Abatement cost (Nu/tCO2e)**	**Energy Saving Potential TOE**
1	Rice cooker	Increased usage of energy efficient appliances	Savings in electricity consumption for consumers using more efficient appliances	Import data of energy efficient appliances	44,092	88.18	1,826	48,299	1,902
2	Water Boiler				41,732	93.90	2,785	33,710	2,901
3	Electric heater				23,585	129.72	9,496	13,660	9,892
4	Refrigerator				139,580	2791.59	104,956	26,598	109,330
5	Storage water boiler				92,794	927.94	20,441	45,395	21,293
6	Washing Machine				22,131	287.71	93	3,102,968	97
7	Television				17,468	138.00	593	232,787	618
8	Fans				33,181	49.77	976	50,980	1,017
9	Air Conditioner				257	12.86	11	1,125,069	12
10	Microwave Oven				19,204	115.22	212	543,981	221
11	Curry Cooker				42,464	84.93	976	86,990	1,017

Table 13: Detailed Roadmap for EE Interventions-Industry Sector						
Action Item	**Output**	**Outcome**	**Budget (in Million Nu.)**	**Emission Reduction potential (tCO_2e)**	**Abatement Cost (Nu./tCO_2e)**	**Energy Savings (in ToE)**
Replacement of V-Belt with Flat-Belt Drives	Uptake of energy efficient techniques	Savings in terms of energy and resources, capacity building, on job training,	2.56	5,809	440	906
Improvement of power factor in motors through addition of capacitor banks			3.16	8,592	368	1,340
Downsize and Usage of Energy Efficient Motors			4.22	4,240	994	661
Replacement of outdated pumps with right sized energy efficient pumps for blade cooling			0.12	72	1,661	11
Replacement of 40W FTLs with 36W FTLs			0.40	627	633	98
Installation of servo stabiliser in the lighting distribution board and optimization of operating voltage			1.36	1,146	1,182	179
Installation of VFD to the high			1.48			

power cooling water circulation pumps				4,285	345	668
Enhancement of operating power factor of utilities			1.22	5,057	242	789
Downsize and use of auto star-delta-star starters to the identified motors	Uptake of energy efficient techniques	Savings in terms of energy and resources, capacity building, on job training,	0.96	1,662	575	259
Replacement of identified lesser efficient blowers with more energy efficient ones			0.26	666	383	104
Installation of VFD in ID fans			12.15	18,663	651	2,911
Replacement of bottom cooling fans of centrifugal type with axial type			0.37	1,584	234	247
Improvement of insulation in rotary kilns in cement factories outer surface			3.20	19,535	164	3,047
Revamping of coal burner systems for efficient combustion of coal inside kilns			30.00	81,269	369	12,674
Replacement of lesser efficient fans with high efficiency fans of apt. size			0.80	1,181	677	184

Replacement of steam heating by electrical heating in bottle warming technique in beverage industry	Uptake of energy efficient techniques	Savings in terms of energy and resources, capacity building, on job training,	0.10	10	9,620	2
Improvement of insulation in oil fired boilers			0.04	95	421	15
Replacement of high watt HPMV with low watt HPMV			1.32	1,670	790	260
Replacement of high watt HPSVL with low watt HPSVL			0.22	348	625	54
Ranking of air compressors based on performance and replacement of inefficient ones with efficient ones			0.30	323	930	50
Replacement of standard motors with energy efficient motors			23.23	22,774	1,020	3,552
Others			3.48	48,882	71	7,623

8. Preparatory Activities

In order to implement the EE Roadmap, the following preparatory activities needs to be conducted beforehand:

8.1 Sectoral Program Design Master Document

Under this Activity, DRE in consultation with all the relevant stakeholders prepares the Program Design document of each action identified in the Roadmap. The Program Design document covers the description of the action, steps of execution, clear roles & responsibilities of the stakeholders, resource (budget/ manpower) allocation and update the mandate of the stakeholders (if required)

8.2 Funding arrangement for the implementation of the Roadmap

Based on the Program Design Documents, GNHC/DRE or concerned RGoB agency will initiate the discussion with bi-lateral/multilateral agencies such as UNDP, UNIDO, the World Bank, ADB and other development partners for funding to implement the actions identified in the EE Roadmap. In addition to this, RGoB agencies can also explore the funding from local/international financial institutions such as International Finance Corporation (IFC) for implementing EE upgrades in Industry and Building sector.

8.3 International Collaboration

In order to implement the following actions of the EE Roadmap, the collaboration with India/Thailand/etc. is required.

- Establish the motor rewinding centre
- To establish value chain of energy efficient building material
- Develop and Adopt S&L Scheme
- Knowledge sharing and exchange for EE Quality Circle for industry and building sector

GNHC/DRE or concerned RGoB agency should initiate the high-level dialogue with other countries' governments or relevant government agencies for above-mentioned actions.

8.4 Institutional strengthening in other relevant departments

It is essential to strengthen the capacity of counterpart departments/ministries (BSB, DRC, DoT, DoI, DCSI, BCCI, MoWHS, RUB etc.) for the implementation of this EE Roadmap. To strengthen the capacity of these departments/ministries, the following activities need to be performed:

- Identify a few dedicated resources/ persons in these departments/ministries for the implementation of EE Roadmap

- Train the identified staff through capacity building development programs (workshops/ seminar/ trainings)
- Establish proper collaboration with inter-departments/ministries for implementing policy related actions, such as development of EE Building Code, EE Codes for Industries, S&L scheme, tax rebates program, Energy Information and Management Systems, etc.

8.5 DRE institutional strengthening - creation of an EE&C division

This activity would be the backbone for implementing the EE Roadmap the country. Under this activity, DRE's institutional strengthening would be required by creating an EE&C division with adequate resources, IT infrastructure, web portal as a knowledge hub, etc. The EE&C division should play a lead role in successful implementation and execution of the EE Roadmap with the required support from all the relevant stakeholders.

8.6 Negotiations with MoF on fiscal incentives/tax rebates

To promote EE upgrades in industry and adoption of higher efficient appliances, fiscal incentives/ tax rebates would be the key driver in the Bhutanese economy. As per the draft EE&C policy, a provision tax rebates on energy efficient equipment in Industry and tax rebates to offset the higher price of the labelled appliances is proposed. To develop the strategy for implementing of these actions, DRE should initiate discussion with Ministry of Finance (MoF) with other relevant stakeholders (DRC, DoI, BSB, etc.).

9. Monitoring Framework

Monitoring of the EE Roadmap is an important process which helps in measuring the progress and success of the Roadmap. A robust monitoring framework increases the transparency and credibility of the Roadmap on the outcome of energy efficiency investments. This credibility can increase the confidence of the probable investors to fund the energy efficiency projects.

The monitoring framework should ensure that the targets of EE Roadmap are measureable, verifiable and clearly define the data needs for monitoring and evaluation, measure the real achievements against planned and provide feedbacks for correction if there are deficiencies in performances. Therefore, it is very essential to develop the monitoring framework based on the indicators to assess the effectiveness of actions identified in the EE Roadmap.

The Table 14 explains the robust monitoring framework proposed to assess the impact of identified action items.

i. Development of program-specific evaluation projects to support the verification of program performance
ii. Development of research projects necessary to support future planning processes (e.g., potential studies, updates)
iii. Development of projects to support policy oversight and quality control (e.g. financial and managerial audits)
iv. Transition planning to make sure the projects currently being managed by utility program managers are smoothly integrated with future studies, and
v. Ensuring that there are budget and staff resources to support these studies.

Finally, the roadmap addresses the development of MRV protocols. A process and schedule is proposed for developing ”content” protocols early on that relate to what types of studies need to be completed and how they can be used to update the performance basis of programs. The second set of protocols relate to providing guidance on how to conduct different kinds of evaluations and what types of information must be reported to ensure quality control.

Strategic objectives will be measured with set of strategic key performance indicators (SKPIs) that has clear targets

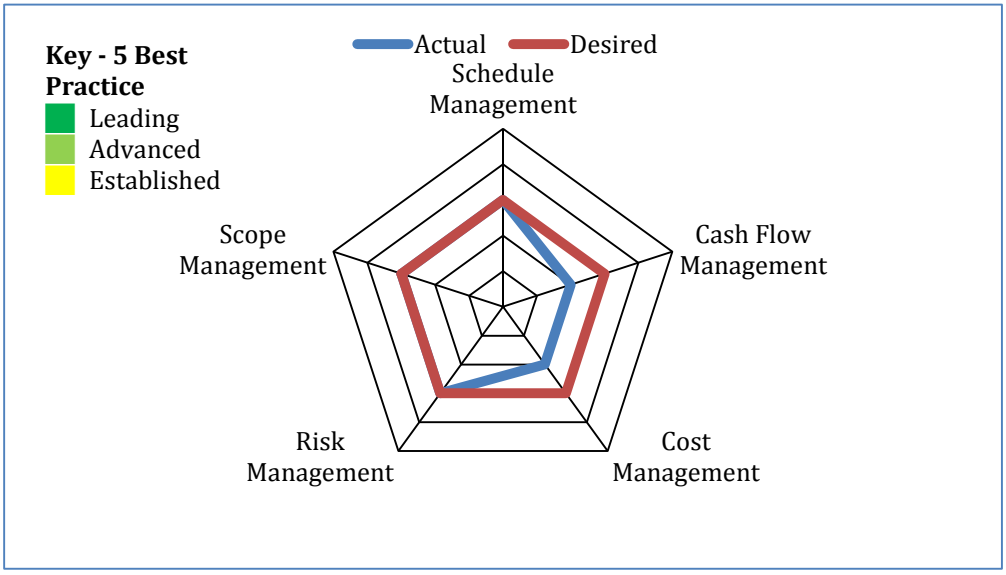
Table 14: Draft Monitoring Framework

Sector	Description of Action	Type of action (Policy/EE Interventions)	Type of Indicators	Reporting Agency	Frequency of reporting

a. Use of evaluation tools – Multi-criteria Comparative Analysis

For assessing the performance of programs in different regions/countries along a series of performance indicators, a simple multi-criteria comparative analysis tool and graphic representation that conveys a message in a simple and appealing manner is proposed. Any EE program would have multiple criteria other than energy savings. Specifically we need to evaluate Efficiency, effectiveness and relevance for any program periodically. For multiple aspects of a program this tool depicts relative performance and represented graphically so that ay departure and particularly well/worse performing aspects can be monitored.

Figure 9: Multi-criteria Comparative Analysis

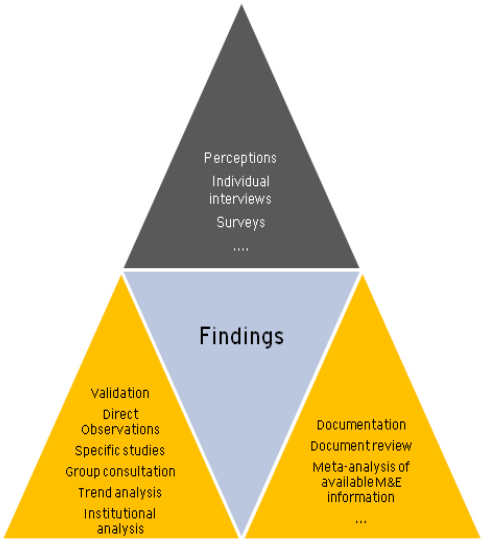


b. Use of evaluation tools – Triangulation Matrix

Triangulation is often used to indicate when more than two methods are used in a study with a view to double (or triple) check the results. Basically, triangulation is based on the assumption

that a study finding is more solid if different methods lead to the same result. In research, triangulation is a powerful technique that facilitates validation of data through cross verification from more than two sources. If applied rigorously, triangulation helps reducing a common risk in evaluations, the risk of being anecdotic in the identification of evaluation findings.

Figure 10: Triangulation Matrix



Use of Triangulation Matrix for evaluation of effectiveness of testing facilities		
Type of Method	**Method**	**Source of information**
Perception	Surveys and interview with stakeholders, i.e. policy makers, IAMEs	Involved stakeholders
Validation	Direct Observation	Field visit to testing facilities
Documentation	Meta Analysis of laboratories test reports and raw data.	Testing laboratories

10. The Way Forward

Various studies and ground level audits carried out by DRE had sufficiently proven the potential of energy savings and its likely positive impacts on the country's economy, environment and contribution to international climate change efforts. Key stakeholders had been consulted on the subject since last five years and the subject gained momentum. It's now the time for action on the ground to reap benefits.

Under the next steps, for each target sector, a more detailed program design of the identified actions will be required to better articulate how each priority is to be implemented. Program design development should draw upon existing activity as a starting point and build in the lessons of successful approaches from other developing countries. Sourcing of low cost capital/grants depend on the quality program design and adequate international collaboration. A lot of action is required in immediate future to approve program designs and securing attractive finances/grants to kick start implementation. Several interventions in the roadmap can be initiated with public participation and imparting right information on EE&C measures and institutional strengthening & capacity building of the stakeholders can be initiated immediately.

This roadmap will enable RGOB to integrate into the development of the 12th Five Year Plan & the subsequent Five Year Plans with increased focus on the EE and its interventions. The followings should be achieved with the implementation of the EE&C measures as indicated in the EE Roadmap.

- Consumers should be better informed and therefore online energy information and monitoring system can be implemented
- Innovative financing tools should be implemented to support consumers' investments.
- The quality of energy-inefficient equipment and services should be controlled.
- Behaviour should be addressed as much as technologies, relying on information and communications technologies (ICTs).
- Monitoring achievements is necessary to evaluate the real impact of energy-efficiency policies.
- International and regional cooperation should be enhanced given its broad geographical coverage and the correlation between indicators and policy.

The RGoB has to endorse and approve the EE Roadmap as a national document to be implemented by the relevant agencies to enhance the energy security of the country and mitigate the GHG emissions.

Annexure-1

Approach and Methodology

As a starting point for developing a future-looking statement of priority activities in energy efficiency, various technical studies and energy audits were completed considering current progress and future opportunities. In broad terms, the proposed process to develop a roadmap generally involves the following:

- Review of the existing policies, plans and mandates, adjusting for developments since those plans were made;
- Integrating current activity with new opportunities, in light of the recent reviews and studies: this includes discussion of the justification for targets with reference to the RGoB energy context, integration of existing and new actions, and enablers and options for reaching them; and
- Setting out targets and recommended actions by sector and creating actionable, measurable milestones for the short, medium and long term.
- Consultation meetings with relevant stakeholders on the actionable plans under their respective sectors

The figure below presents the overall roadmap development process.

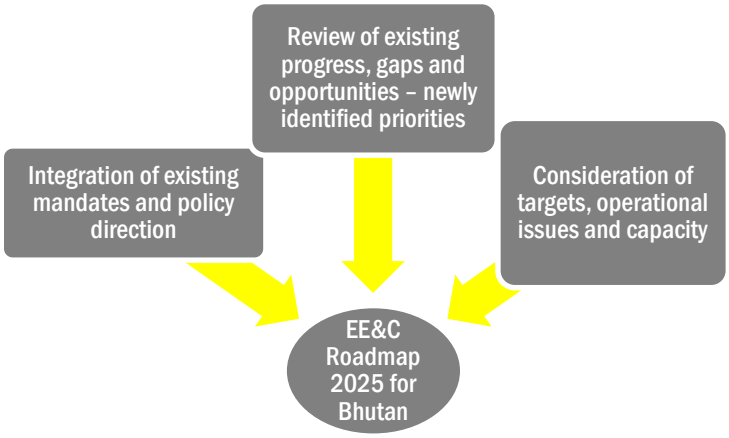


Figure 11: EE Roadmap Development Process (Source: EY Analysis)

The methodology adopted to develop the roadmap is focused on development and dissemination of a holistic modeling framework, which would consist of a country-level analysis, sectoral analysis (bottom-up approach) and analysis of rules and regulations that impact energy efficiency

and climate change. This structured approach minimizes time, cost and risk while achieving the business and financial objectives defined for the initiative.

Key Assumptions

Key assumption for BAU energy consumption projection that are used for potential Energy savings and emission savings calculations using CGE modelling

The following are the key assumptions to establish the general equilibrium of the economy, for the components discussed in the Social Accountability Matrix (SAM) and set to equilibrium to assess the impact of the energy efficiency interventions.

- Producers are assumed to maximize profits and to operate in perfectly competitive markets.
- Households maximize utility subject to income and prices, and the household demand for commodities is modelled through the linear expenditure system (LES). Household income comprises of income derived from labour and capital and transfers from the government and the rest of the world. Households also save part of their income and pay taxes to the government. Savings rate is also fixed.
- Government expenditure is on the consumption of goods and services, transfers to households and subsidies. Government income is from taxes (direct and indirect), and rest of the world. Indirect taxes include production tax, and import and export tariffs. Government savings, which is the difference between government expenditure and income is determined residually.
- Imperfect substitution between domestic goods and foreign goods is allowed for in CGE models. In other words, producers/consumers are free to sell or consume goods from the domestic or foreign market based on relative prices.
- The Armington function is used to capture the substitution possibilities between domestic and imported goods. The import demand function, derived from the Armington function, specifies the value of imports based on the ratio of domestic and import prices.
- The Constant Elasticity of Transformation (CET) function is used to capture substitution possibilities between domestic and foreign sales. The export supply function, derived from the CET function, specifies the value of exports based on the ratio of domestic prices to export prices. The elasticity of substitution determines the relative ease of substitution between domestic and foreign goods in response to changes in relative prices.
- Markets for all goods and services clear through adjustment in prices. The consumer price index (CPI) is chosen as the numeracies and is therefore fixed.
- The model follows a savings-driven closure, that is, aggregate savings is fixed. The saving-investment balance is maintained through adjustment in aggregate investment.
- The model assumes foreign savings to be fixed and the real exchange rate to be flexible. Government consumption and savings is fixed within a period.

BAU energy consumption as per CGE model that has been used.

Table 15: Projection of BAU energy consumption using CGE modelling

Baseline Energy Consumption (EC) TOE			
Year	**Building Sector**	**Appliance Sector**	**Industry Sector**
2016	89,932	209,216	255,733
2017	94,698	216,330	262,894
2018	99,717	223,685	270,255
2019	105,002	231,290	277,822
2020	110,568	239,154	285,601
2021	116,428	247,285	293,598
2022	122,598	255,693	301,819
2023	129,096	264,387	310,269
2024	135,938	273,376	318,957
2025	143,143	282,671	327,888
2026	150,729	292,281	337,069
2027	158,718	302,219	346,507
2028	167,130	312,494	356,209
2029	175,988	323,119	366,183
2030	185,315	202,337	376,436

Annexure-2

Emission Reduction through EE&C Measures

In this section, baseline emission refers to the business as usual energy consumption as mentioned in table 1 and reference emission refers to the energy saving potential identified through results of energy audits and stakeholder consultations under energy plus project. Policy target emission refers to the energy saving under draft EE&C policy target multiplied by respective emission factor. While the units for emission is Tons of CO2e (carbon di oxide equivalent), energy units and emission factors are in ToE and TonCO2e/ToE respectively.

Estimation of emission from energy efficiency interventions follow the following formula.

Baseline emission = baseline energy consumption x emission factor for respective energy
Reference emission = reference energy saving x emission factor for respective energy
Policy target emission = policy target energy saving x emission factor for respective energy

a. Estimation of Emission Reduction

To quantify the GHG emission reduction due to EE interventions, following steps have been followed:

Step 1: Estimation of baseline emission factor for building (inclusive of appliance) sector and industry sector high level Energy projection for RGoB

Step 2: Projection of business as usual energy demand for respective sector and thereby BAU emission projection

Step 3: Projection of energy savings potential and thereby emission savings potential by each sector

Step 4: Impact of energy savings target considered under draft policy and this roadmap document

For the purpose of estimating the emission reduction, following steps are followed:

1) Overall emission factor for industry and building sector have been estimated by summing up the TOE consumption of fossil fuels and biomass. Emission from Biomass has been considered as any emission reduction would affect the overall emission reduction and contribute to use RGoB's carbon sink to absorb equivalent GHG from atmosphere.
2) The emission factors for the energy sources are the default values taken from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2: Energy Chapter 2: Stationary Combustion.
3) For domestic electricity consumption, emission factor is technically nil. However, for energy efficiency case, the emission factor of India has been referenced from the CO_2 Baseline Database for the Indian Power Sector User Guide Version 11.0 published in April 2016 by

the Central Electricity Authority (CEA), Ministry of Power, Government of India. For Combined Margin (CM), the weighted average emission factor is 0.96 tCO_2/MWh. Therefore, overall emission factor seems higher and therefore would defer from national Inventory significantly.

4) Only Building (including appliances) and industry sector was considered with emissions from use of kerosene, coal, LPG, diesel, electricity and biomass.
5) For approximation, overall emission considered above is divided by overall ToE energy consumption and used to estimate emission reduction from energy efficiency activity. It is understood that in actual sector-wise, and emission source-wise estimation would provide accurate emission factor and the process followed here would be high level approximation only and can be used to understand the trend and must not be seen as absolute values.
6) Baseline Energy Consumption: This is the energy consumption had there been no energy efficiency interventions in any sector. Baseline energy consumption has been the result of macroeconomic modelling (Using Computational general equilibrium (CGE) models) with base values from 2005 to 2015. GDP projection has been considered in consultation with GNHC and the same has been adopted. For the same purpose, country's input/output has been referred from RGoB Trade statistics from the year 2005. The model has been calibrated for real data in 2013-15 and the same had been projected for 15 years.
7) Energy Efficient (EE) Energy Consumption: This is the energy consumption when identified energy efficient interventions are taking place as per the energy audit reports. The interventions in industry sector considered for payback period within three years in most cases. The potential would go much further in case cheaper finances can be availed (to bring down payback period) or cleaner production methods applied. However, a lot of additional savings would emerge from awareness, building code and more efficient industrial practices. Only average 6-7% of energy saving potentials has been considered within economic payback period. Energy Savings is the difference between baseline and energy efficient scenario.

Elaboration of Steps

Step 1: Estimation of baseline emission factor for building (inclusive of appliance) sector and industry sector high level Energy projection for RGoB

To assess the baseline energy consumption, the overall energy consumption data from RGoB Energy Data Directory 2015 under energy plus project has been considered. The following energy balance information has been referred and the related energy consumption has been used for emission estimation.

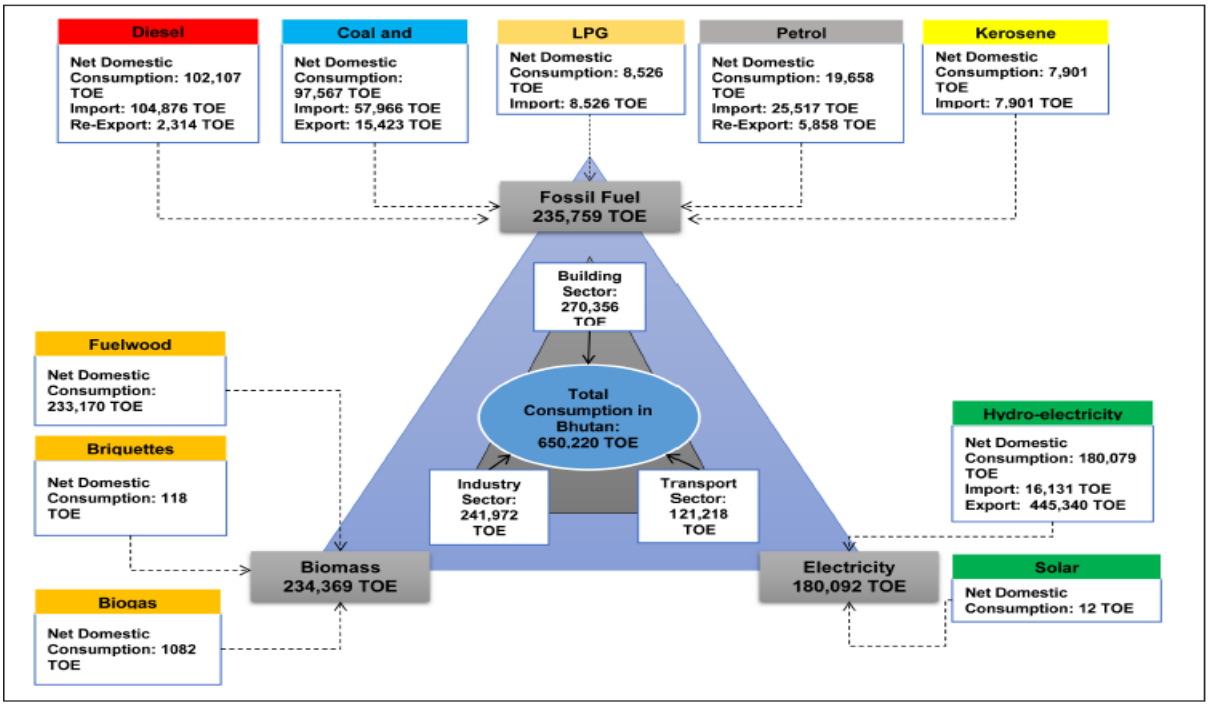


Figure 12: Energy forms and flows[14]

Emission factor Calculation (methods elaborated under section 6.2):

Table 16: Emission calculation – Building & Appliance Sector (2014)

	Biomass (ToE)	**Kerosene (ToE)**	**LPG (ToE)**	**Electricity (ToE)**	**Diesel (ToE)**	**Coal (ToE)**
Institutional	44,652	1,465	1,593	9,225		
Residential	185,455	3,402	6,349	18,216		
Overall Building sector	230,107	4,867	7,942	27,441		
Emission factor unit	(tCO2e/TJ)	(tCO2e/TJ)	(tCO2e/TJ)	tCO2e/MWh	(tCO2e/TJ)	(tCO2e/TJ)
Emission factor (on Dry basis)	112	71.9	63.1	0.96	74.1	96.1
Building sector consumption (ToE)	230,107	4,867	7,942	27,441		
Building Sector emission(tCO2e)	1,079,073	14,652	20,983	306,318		
Building Sector Total Energy Consumption	270,357					

[14] Bhutan EDD 2015

(ToE)	
Building Sector total Emission (tCO2e)	1,421,025
Building Sector emission Factor (tCO2e/ToE)	**5.25**

Step 2: Projection of business as usual energy demand for respective sector and thereby BAU emission projection

Energy efficiency measures calls for lower energy consumption compared to baseline. In previous chapter 4.1.1 (table 1) the baseline energy projection has been made considering the GDP values in consultation with GNHC and 11th five year plan. GDP and energy consumption values were calibrated for the period 2010- 2014 and projection have been made

Step 3: Projection of energy savings potential and thereby emission savings potential by each sector

Energy efficiency interventions are considered for industry sector for three years of payback period or below and implementable as per individual industry consultation. For building and appliance sector relevant stakeholders were consulted and few pilot projects, EE building code and S&L program have been considered. Effect of these energy interventions are considered for energy saving potential and policy target. The investment value for the same are at average market price as per EY understanding and as per stakeholder consultation. In few cases like that of double glazed glass and insulation price variation occurs and varies significantly between manufacturer or traders.

Table 17: Energy Savings, Consumption and Expenditure Projections – Building & Appliance Sector

Year	Energy savings potential (ES) TOE	Baseline Energy Consumption (EC) TOE	Baseline Emission (tCO2e)	Emission reduction potential (tCO2e)
1	9,766	292,269	1,536,197	51,330
2	11,172	303,915	1,597,409	58,721
3	12,781	316,047	1,661,178	67,177
4	14,621	328,687	1,727,616	7,6851
5	16,727	341,858	1,796,841	87,917

6	19,135	355,582	1,868,976	100,577
7	21,891	369,884	1,944,148	115,060
8	25,043	384,789	2,022,492	131,629
9	28,649	400,325	2,104,150	150,584
10	32,775	416,518	2,189,266	172,268
11	37,494	433,400	2,277,996	197,074
12	42,894	450,999	2,370,501	225,453
13	49,070	469,349	2,466,949	257,918
14	56,136	488,482	2,567,515	295,058
15	64,220	508,434	2,672,386	337,547
Cumulative emission (tCO2e)				4,157,960

Step 4: Impact of energy savings target considered under draft policy and this roadmap document

These energy savings are further multiplied with respective emission factors to arrive at emission reduction profile for interventions as energy saving potential or as emission reduction potential from policy target**.**

As evident from above table, the BAU emission from building and appliance sector is estimated to experience an average 7% growth over a span of 15 years. The draft EE policy target has been estimated to bring effect from 2018, if implemented and can bring about savings in the order of around 1% of baseline emission which grows up gradually. However, the building code would trigger a larger emission reduction potential in terms of reducing infiltration which is around 35% of consumption on heating and cooling and improved insulation.

Table 18: Emission calculation – Industry Sector

	Biomass (ToE)	**Kerosene (ToE)**	**LPG (ToE)**	**Electricity (ToE)**	**Diesel (ToE)**	**Coal (ToE)**
Industry Sector	4262	18	584	137071	2490	97567
Emission factor unit	(tCO2e/TJ)	(tCO2e/TJ)	(tCO2e/TJ)	tCO2e/MWh	(tCO2e/TJ)	(tCO2e/TJ)
Emission factor (on Dry basis)	112	71.9	63.1	0.96	74.1	96.1
Industry sector consumption (ToE)	4262	18	584	137071	2490	97567
Industry Sector emission(tCO2e)	19986	54	1543	1530095	7725	392581
Industry Sector total Energy Consumption (ToE)	241992					
Industry Sector total Emission (tCO2e)	1551678					
Industry Sector emission Factor (tCO2e/ToE)	**6.41**					

Table 19: Energy Savings, Consumption and Expenditure Projections – Industry Sector

Year	**Energy savings (ES) TOE**	**Baseline Energy Consumption (EC) TOE**	**Baseline Emission (tCO2e)**	**Emission reduction potential (tCO2e)**
1	0	255,733	1,639,788	0
2	0	262,894	1,685,703	0
3	9,000	270,255	1,732,902	57,709
4	12,334	277,822	178,1424	79,087
5	13,469	285,601	1,831,303	86,365
6	14,708	293,598	1,882,580	94,310
7	16,061	301,819	1,935,292	102,987
8	17,539	310,269	1,989,480	112,462

9	19,153	318,957	2,045,186	122,808
10	20,915	327,888	2,102,451	134,106
11	22,839	337,069	2,161,320	146,444
12	24,940	346,507	2,221,836	159,917
13	27,234	356,209	2,284,048	174,629
14	29,740	366,183	2,348,002	190,695
15	32,476	376,436	2,413,746	208,239
Cumulative emission (tCO2e)				1,669,758

For industry sector, the BAU emission is estimated to experience an average 6% growth over a span of 15 years. The emission reduction potential on a conservative scale only through intervention in limited appliance standard and pilot initiatives in building retrofit ranges from 4.5 % in the 1st year of implementation to around 11% at end of 15th year. The draft EE policy target has been estimated to bring effect from 2018, if implemented and can bring about savings in the order of around 1.2% of baseline emission which grows up gradually. Under the policy target, only projects with a three year payback have been considered. The level of emission can reduce further with higher level of investment in process up-gradation. However, benefit calculation for those would be done considering other business considerations too.

However above figures reveal that the emission reduction potential in industry is around 1.6 million tons for 15 years and that of building and appliance sector being around 4.2 million tons for the same time period. This is significant as it means a virtual increase in carbon sequestration capacity compared to present level.

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