Energy Efficiency Roadmap

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

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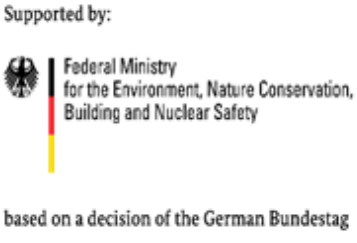

List of Acronyms

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
EPS	Expanded Polystyrene
EY	Ernst & Young
FEMS	Factory Energy Management System
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

Implementation of Energy Efficiency (EE) measures in the country offers a great opportunity to enhance economic benefits by saving losses, increased domestic savings, reducing expenditures incurred on the import of fossil fuels and electricity during lean seasons. In addition, EE measures will also help enhance the energy security and in realization of the self-reliance goal 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 to remain carbon neutral at all times. However, to achieve these goals, the Royal Government of Bhutan (RGoB) must adhere to a systematic structured approach which will guide in the development and implementation of the EE interventions in the energy intensive sectors and for strengthening coordination and synergies among the relevant stakeholders.

This EE roadmap defines the rationale for energy efficiency and outlines the potential energy savings through deployment of EE measures in the energy consuming sectors which will help enhance the country's energy security. 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. Additionally, the action plans will contribute towards the NDC mitigation measures by enhancing demand side management through promotion of EE in appliances, buildings and industrial processes and technologies. It will also be a guiding tool for implementation of low emission strategies in urban and rural settlements through construction of green building, sustainable and efficient construction methods and smart cities in the future.

The roadmap has elaborated the key interventions required to achieve the energy saving target of 0.2 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 outlined in 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

[1]Royal Government of Bhutan NDC 2015, UNFCCC

digitization of the program and its alignment with the five-year planning exercise. The action plans reflected under this roadmap will engage various stakeholders ranging from government sectors to Non-Governmental Organization in order to realize the targets.

1. Introduction

Bhutan's GDP growth rate in constant (2000) prices has averaged around 7.36% between 2005 and 2017 and the annual growth of GDP per capita has averaged around 9.043% from 2006 to 2017[2]. The economy is expected to grow at an average of 11.1% from 2017-19[3]. The country witnessed an increase in domestic energy consumption mainly due to expansion of rural electrification programme, increasing in the number of households and due to establishment of new industries.

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 is 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 final EE&C policy has been formulated and approved by the RGoB in August 2019 to achieve these potentials.

Sustained pursuit of green growth entails systematic focus on energy efficient productive activities across different sectors like industry, transport, buildings, and appliances. The overall economy will be further improved through EE&C measures by reduced energy intensity, more revenue through export of additional electricity realized from the adoption of 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),

[2]National Accounts Statistics 2017, National Statistics Bureau

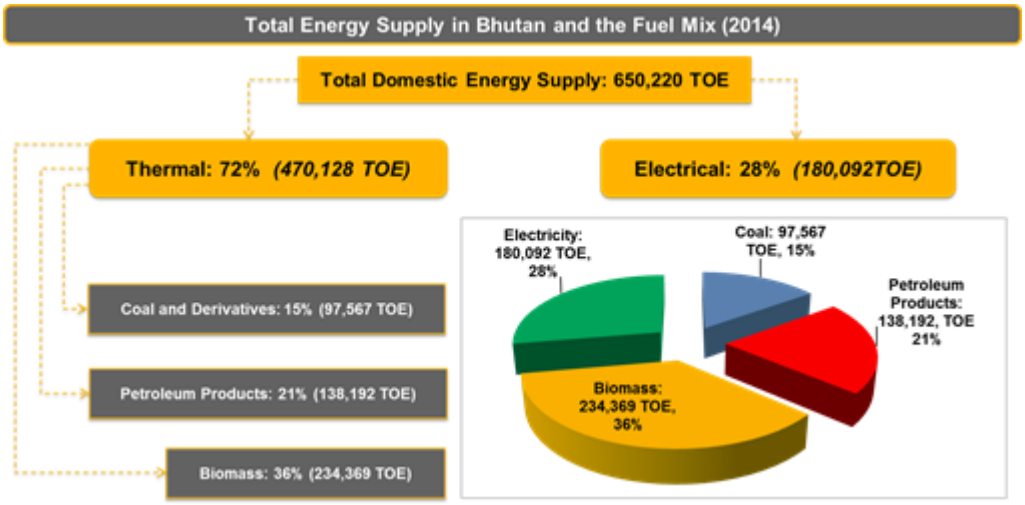
[3]Global Economic Prospects 2017-World Bank

[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

Industry and Transport. The energy supply was primarily in the form of electricity, fossil fuels 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 42% of the total energy while the Industry sector consumed 37%. The Transport sector consumed 19% share in the energy consumption while the remaining of 3% 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 EE&C Policy 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

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[7]. While electricity sales have been one of the significant revenue earners, expenditure for petroleum products have been growing significant as shown in Figure 2.

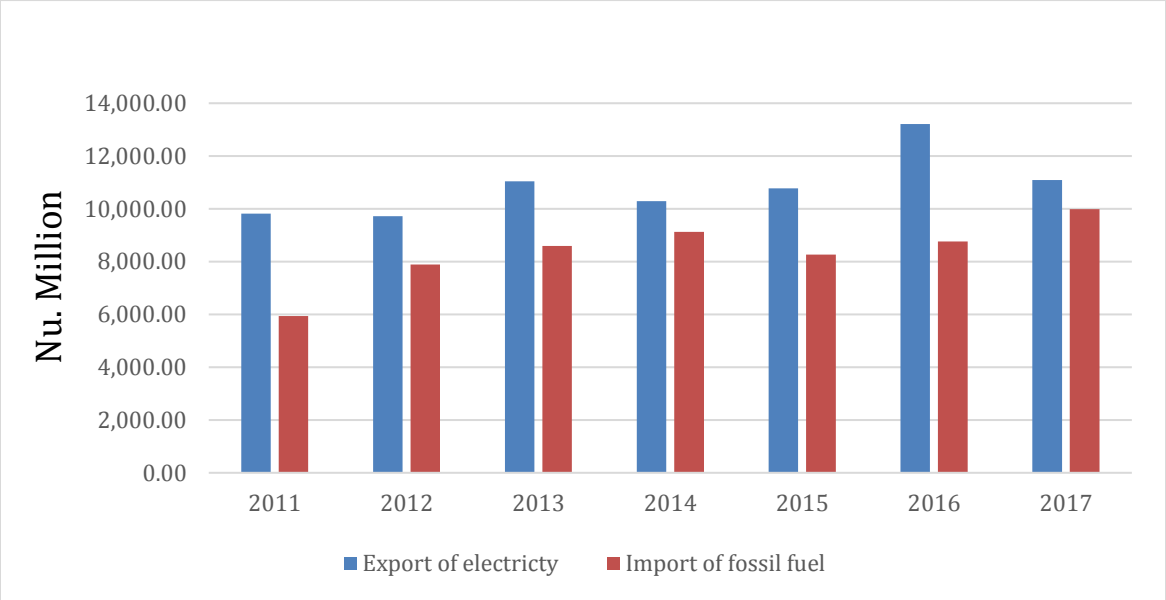


Figure 2. Trend in the Export of electricity and Import of petroleum products

In 2017, the country earned Nu. 12.37 billion with the sale of electricity and in the same year, the country imported Nu. 8.97 billion worth of petroleum products[8].

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 revenue from the export of electricity.

[7] National Accounts Statistics, NSB;
[8] Statistical Year Book 2015 & 2018, NSB

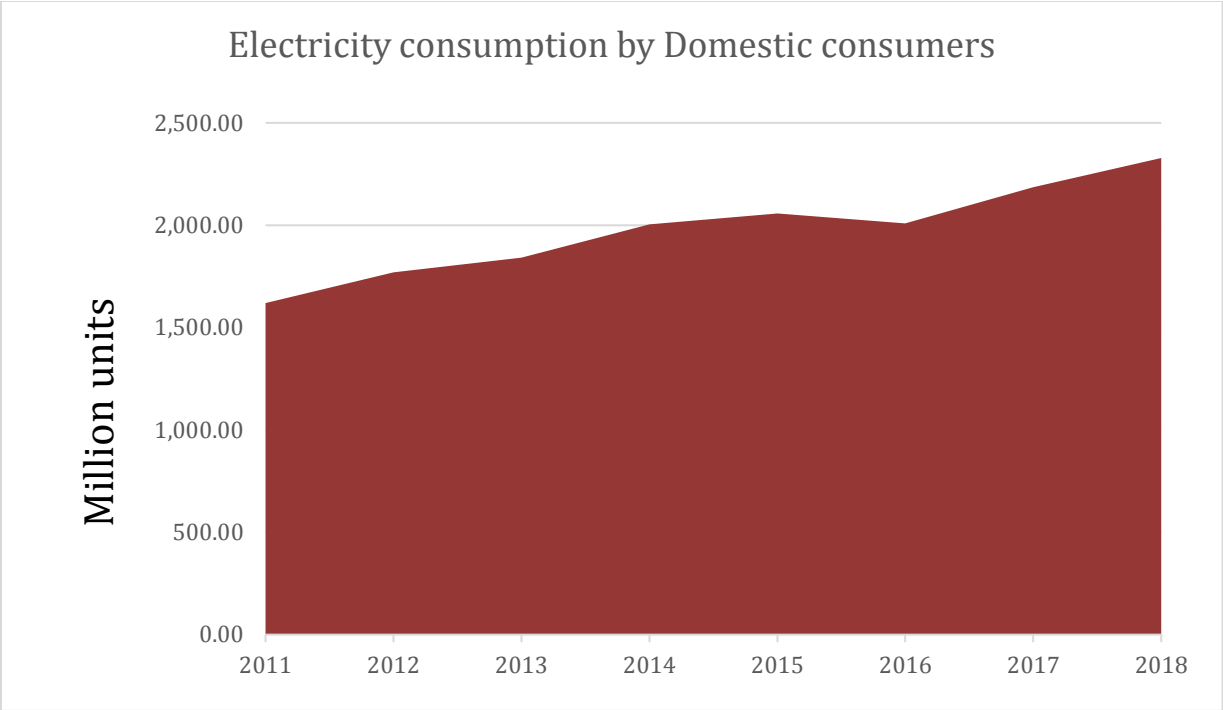


Figure 3: Energy consumption pattern for electricity (BPC Power data book 2018)

The EE&C measures offer numerous 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' period, in the industry, building and appliance sectors is projected as around 155 million kWh annually which translates to an additional revenue of about Nu. 338 million per annum at current average export tariff rate of Nu.2.17/unit. 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 in enhancing energy security of the country. The roadmap will contribute to the fulfillment of the upcoming obligation arising out of the Paris Agreement under the UNFCCC to remain carbon neutral and pursue low emission development to achieve the ambitious global targets of climate change post 2020. It elaborates Bhutan's commitment to reduce emissions 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 to implement the EE measures in the sectors.

The pursuit of EE&C measures aligns with RGoB's priority in the implementation of United Nations' Sustainable Development Goals not only limiting to SDG 7 (Energy). 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 energy intensive 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, encourage the use of EE construction materials, promote EE appliances for effective energy consumption and encourage timely monitoring of energy consumption through energy audits and installation of energy management systems.

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 purposes of the EE roadmap are:

1. A guide towards formulation and implementation of EE&C measures in the energy intensive sectors.
2. Strengthen coordination and synergies among relevant stakeholders on the implementation of EE&C measures.
3. Mobilize resources for implementation of EE&C measures.
4. Institute Monitoring, Reporting& Evaluation systems of the implementation of EE&C measures.
5. Contribute to meet the global commitment under the NDC targets and SDGs with the implementation of the 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 revenue and thus will positively affect its balance of trade.
- ➔ Reduced energy consumption can lower the RGoB's fiscal burden on energy subsidies and the savings from the reduced subsidies can be reallocated for other developmental activities.
- ➔ Contribute towards reducing global GHG emissions through lowering he energy intensity for the various economic activities.

At an Industrial level:

- ➔ Improve productivity and competitiveness by reducing operating costs and environmental pollution.

At a Household level:

- ➔ Energy savings and enhancement of household income.
- ➔ Employment opportunity
- ➔ Added advantage to women who handles the household chores.

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 of practice, energy auditing, energy management systems etc. EE targets can be achieved with enhanced collaboration among the relevant agencies. The target will be reviewed and adjusted 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	16,712.97	138.02	182.52	**17,033.51**
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. Energy Saving potentials

With the implementation of EE&C measures over short, medium and long term, the energy consumption can be curtailed through a cumulative energy saving of 1.4 million ToE. In the process, a cumulative GHG emission reduction of approximately 1.8 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.

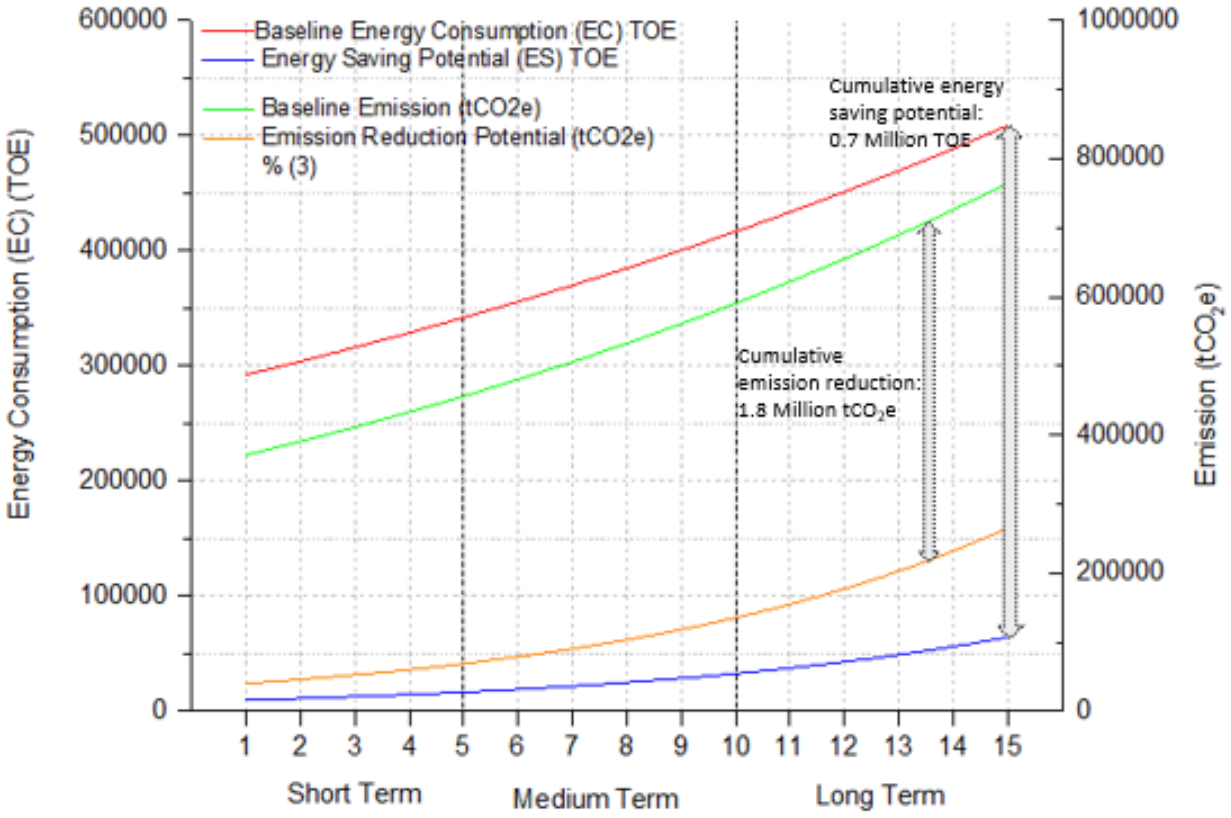


Figure 4: BAU & BEE Scenario for all sectors

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 electricity saved from the interventions from Building, Industry and Appliance sectors are assumed to meet the growing domestic demand due to the industrial growth and for other developmental activities or exported.

- Emission from electricity is considered zero since Bhutan does not have grid emission factor and energy generation from hydropower plants are considered clean and zero emission.
- 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[9]. 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 of practice and auditing & reporting guideline as shown in Table 2.

Table 2: Building Sector Interventions

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

[9] Bhutan EDD 2015

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)*	17,033.51
Investment (Million Ngultrum)	51.43
Investment per unit of energy savings (Million Nu. per TOE)	0.0003
Emission Reduction Potential (tCO_2e)	87,383.99
Abatement Cost (Nu. /tCO_2E)	87,458.53

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 develop EE building codes of practice or amend the existing building code to include EE aspects and develop energy auditing guidelines.

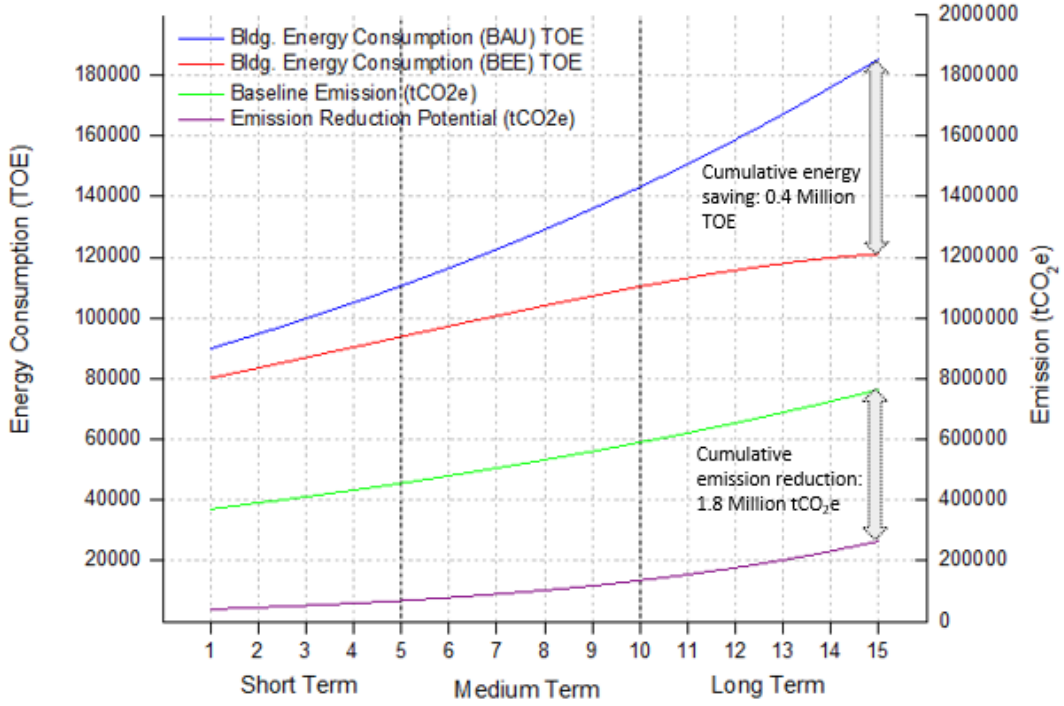


Figure 5: BAU & BEE Scenario- Building sector

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 1.8 Million tCO2e over a period of 15 years. However, with the selected EE interventions the

expected energy savings amounts to 17,033.51 TOE with emission reduction potential of 87,383.99 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 inefficient appliances with energy efficient ones through certification of EE appliances, adoption of EE standards and introduction of the Minimum Energy Performance Standards (MEPS). 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 implementation of S&L scheme can be targeted in the long term, it is essential to develop and adopt S&L scheme as stated in the Table 4 below. There is also a need to transform the market towards EE through a mix of tax and duty exemptions, introduction of rebate scheme for EE appliances and rigorous promotion and information sharing.

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.
Medium Term (6-10 years)	
Incorporate EE appliance list in Bhutan Trade Classifications	Incorporation of the EE specifications (S&L scheme report) into the trade classification system for effective monitoring and enforcement.
Implementation of S&L scheme	In this first 5 years, S&L for 5 appliances will be implemented
Long Term (over 10 years)	

Strengthening of Electrical testing Laboratory	To support certification of appliances for EE appliances in collaboration with BSB and technical colleges.
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)	1,086
Investment per unit of energy savings (Million Nu. per TOE)	0.1325
Emission Reduction Potential (tCO_2e)	0
Marginal Abatement Cost (Nu. /tCo_2e)	0

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 and potential manufacturers 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.

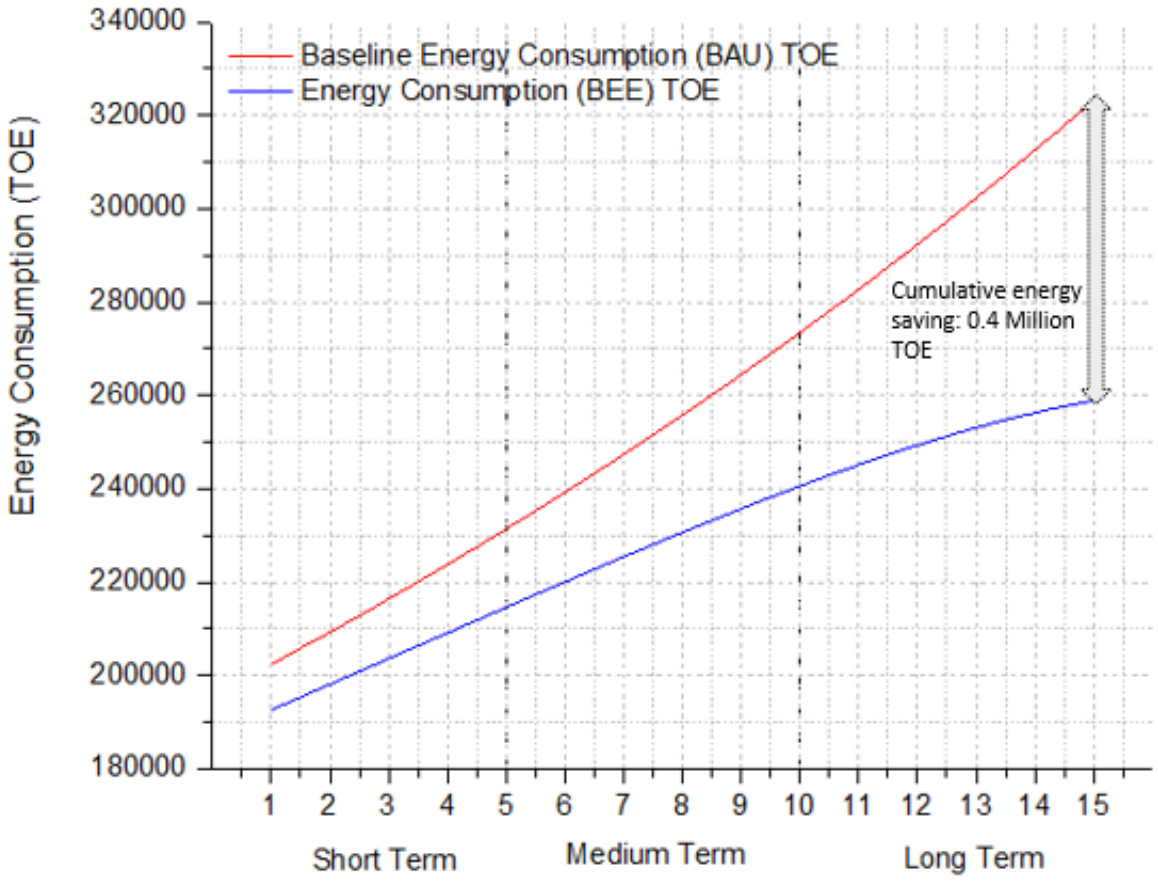


Figure 6: BAU & BEE Scenario- Appliance sector

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 which also creates the issue of E-waste management in the country. 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 (Table 7). With the interventions carried out in the appliance sector, there is a potential of 142,336 tCO_2e of emission reduction using the grid emission factor of India.

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

Introduction

The Industry Sector, with energy consumption of 37% (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[10].

Brief description of Interventions

The energy audits revealed that maximum savings potential is 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 as 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.
Factory Energy Management System (FEMS)	Promote the use of FEMS
Develop Energy Efficiency codes of Practice	The codes will set the technical specifications for EE equipment
Develop Energy Auditing and Reporting Guidelines	The guidelines will help in monitoring the energy consumption
Medium Term (6-10 years)	

[10] Bhutan EDD 2015

Implement EE upgrades in Industries	As per audit recommendations, EE upgrades will be implemented following initial awareness and auditing programs
Long Term (over 10 years)	
EE Certification of Industries	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)	3,178.21
Marginal Abatement Cost (Nu. /tCO_2e)	1,609,995

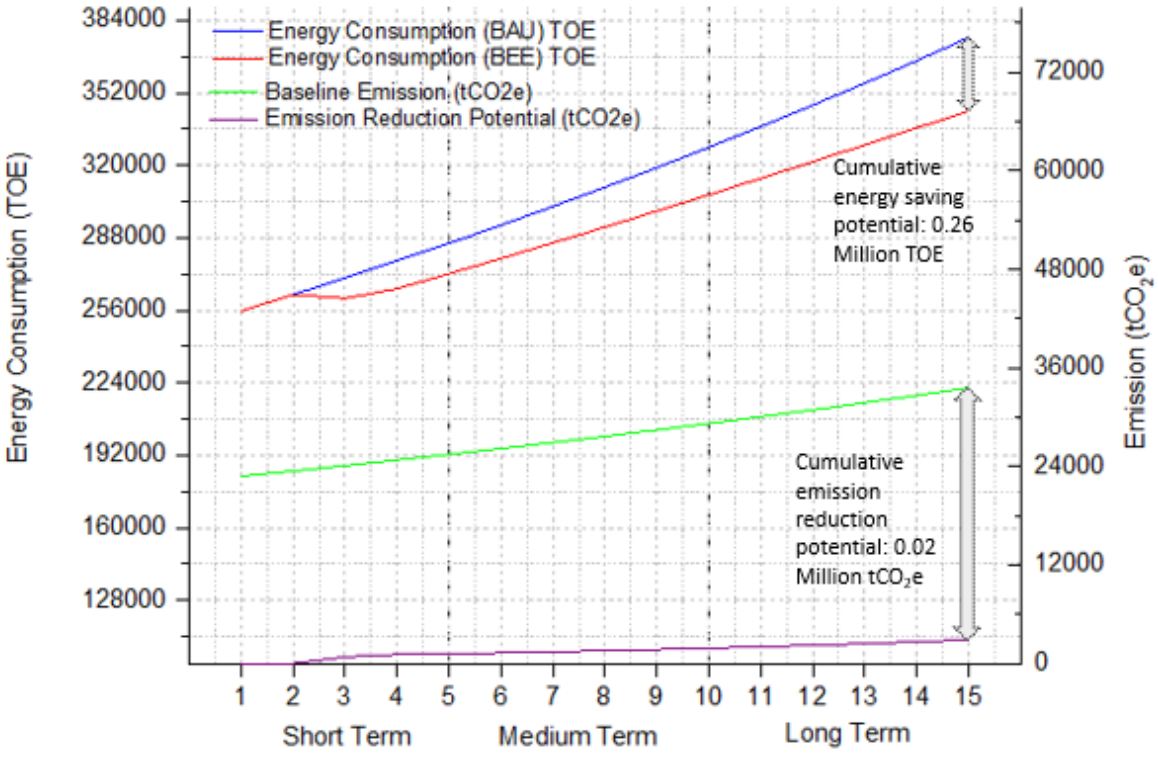


Figure 7: BAU & BEE Scenario- Industry sector

Implementation of extensive EE&C measures is expected to achieve a cumulative energy savings of 0.2 Million TOE through lower energy demand and reducing energy intensity. The same measures are expected to generate cumulative GHG emission reduction of 0.2 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 7).

9. Means of implementation

Effective implementation of the proposed energy saving measures in building, appliances and industry sectors will depend of the availability of resources and capacity building. Effective implementation and realization of EE targets are influenced by other cross cutting needs and support. 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, appliances and construction materials. 2. Resource mobilization for implementation of EE&C measures from international sources including climate finance, bi-lateral and multi-lateral development partners
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 needs, gaps and challenges 2. Technology Match Making & Best practices
Market	1. Promote/ access to different business models such as ESCO Policies and Incentives or de-risking private investments 2. Develop precise and clear market regulation for the use of EE equipment, appliances and materials. 3. Promote innovations for accelerated adoption or market transformation approaches

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 ➢ Office of the Consumer Protection, MoEA
Industry	➢ Department of Industry, MoEA ➢ Department of Cottage and Small Industry, MoEA	➢ Department of Renewable Energy ➢ 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 ➢ National Commission for Women and Children

10.1. Department of Renewable Energy (DRE)

The Department of Renewable Energy (DRE) under the Ministry of Economic Affairs (MoEA) shall be the nodal agency to 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 facilitate the mobilization of fund resources from international bilateral and multilateral development partners, green climate finance through NAMAs, NDC and emerging international mechanisms to implement the EE&C measures.

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.

10.6. Ministry of Works and Human Settlements (MoWHS)

The DoES under the MoWHS shall develop the energy efficiency building codes of practice 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.

The DES along with Thromdes and Dzongkhag Administrations shall implement and enforce the energy efficiency codes of practice.

10.7. 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.

10.8. 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.

10.9. Bhutan Chamber of Commerce and Industries (BCCI) and Association of BhutaneseIndustries (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.

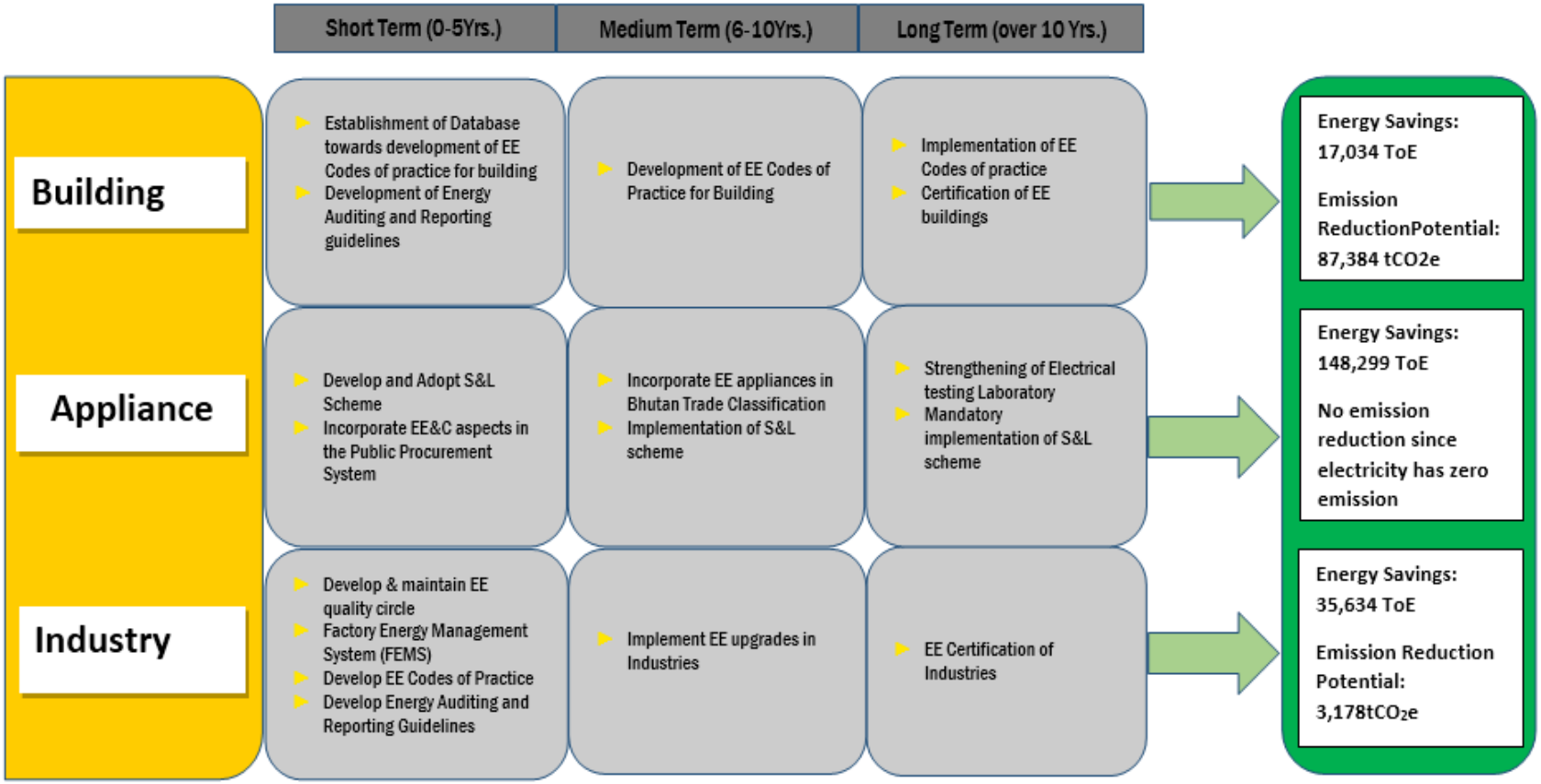


Figure 8: EE roadmap framework

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

BUILDING SECTOR						
Sl. No.	**Intervention**	**Time line**	**Lead Agency**	**Collaborating agency/ies**	**Budget Estimate (Million Nu.)**	**Outcome**
1	Establishment of Database towards the development of EE codes of practice for building	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	Development of Energy Auditing and Reporting Guidelines	Short Term (0-5 years)	DRE	DES, MoWHS	8	Mandate periodic energy audits and reporting of energy performance of energy intensive buildings, as defined in the energy efficiency building codes of practice.
3	Development of EE codes of practice for building	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.
4	Implementation of EE codes of practice for building	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	Short Term (0-5 years)	DRE	GPMD, MoF	0.10	Reduce in the import of inefficient appliances

	System					
3	Incorporate EE appliance in Bhutan Trade Classifications	Medium Term (6-10 years)	DRE	DRC, MoF	0.10	Reduce in the import of inefficient appliances
4	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	Factory Energy Management System (FEMS)	Short Term (0-5 years)	DoI	DRE, DIT, MoIC	8.10	EMIS developed for energy information system and monitoring EE&C measures
3	Develop Energy Efficiency codes of practice	Short Term (0-5 years)			8.60	EE&C codes of practice developed to streamline EE&C measures for the industries
4	Develop and implement Energy Audit and Reporting Guidelines	Short Term (0-5 years)	DRE	DoI	5.50	Mandate periodic energy audits and reporting of energy performance of the industries
5	Implement EE upgrades in Industries	Medium Term (6-10 years)	DRE	DoI, BCCI, ABI	3.00	Increased productivity of the industries with less energy consumption
6	Certification of Industries	Long Term (>10 years)	BSB	DRE, DoI, BCCI, ABI	1.00	Encouraging industries to implement EE&C measures

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	85,766	490	20,801
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	1.58	254	29,683	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 practices	0.58	163	10,716	40

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	115	16,813	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	661	28,502	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	425	1,255	103

Note: The details of the intervention options may be subject to change according to the available funding.

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	0	0	1,902
2	Water Boiler				41,732	93.90	0	0	2,901
3	Electric heater				23,585	129.72	0	0	9,892
4	Refrigerator				139,580	2791.59	0	0	109,330
5	Storage water boiler				92,794	927.94	0	0	21,293
6	Washing Machine				22,131	287.71	0	0	97
7	Television				17,468	138.00	0	0	618
8	Fans				33,181	49.77	0	0	1,017
9	Air Conditioner				257	12.86	0	0	12
10	Microwave Oven				19,204	115.22	0	0	221
11	Curry Cooker				42,464	84.93	0	0	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	81	31,623	906
Improvement of power factor in motors through addition of capacitor banks			3.16	120	26.463	1,340
Downsize and Usage of Energy Efficient Motors			4.22	59	71,473	661
Replacement of outdated pumps with right sized energy efficient pumps for blade cooling			0.12	1	119,410	11
Replacement of 40W FTLs with 36W FTLs			0.40	9	45,477	4093
Installation of servo stabiliser in the lighting distribution board and optimization of operating voltage			1.36	16	84,998	7483
Installation of VFD to the high-power cooling water circulation			1.48	60	24,831	27,979

pumps						
Enhancement of operating power factor of utilities	Uptake of energy efficient techniques	Savings in terms of energy and resources, capacity building, on job training,	1.22	70	17,409	33,017
Downsize and use of auto star-delta-star starters to the identified motors			0.96	23	41,321	10,849
Replacement of identified lesser efficient blowers with more energy efficient ones			0.26	9	27,544	4.346
Installation of VFD in ID fans			12.15	260	46,803	121,860
Replacement of bottom cooling fans of centrifugal type with axial type			0.37	22	16,794	247
Improvement of insulation in rotary kilns in cement factories outer surface			3.20	272	11,776	3,047
Revamping of coal burner systems for efficient combustion of coal inside kilns			30.00	1130	26,538	12,674
Replacement of lesser efficient fans with high efficiency fans of apt. size			0.80	16.43	48,700	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	0.14	691,543	2
Improvement of insulation in oil fired boilers			0.04	1.3	30,254	15
Replacement of high watt HPMV with low watt HPMV			1.32	23	56,789	260
Replacement of high watt HPSVL with low watt HPSVL			0.22	5	44,946	54
Ranking of air compressors based on performance and replacement of inefficient ones with efficient ones			0.30	4.5	66,868	50
Replacement of standard motors with energy efficient motors			23.23	317	73,316	3,552
Others			3.48	680	5116	7,623

12. Preparatory Activities

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

12.1 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)

12.2 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.

12.3 International Collaboration

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

- 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.

12.4 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 codes of practice for Buildings and Industries, S&L scheme, tax rebates program, Energy Information and Management Systems, etc.

12.5 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 exec

…….ution of the EE Roadmap with the required support from all the relevant stakeholders.

12.6 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.).

12.7 Orientation on gender/social aspects in EE&C

While EE&C measures will majorly contribute to reducing energy intensity and enhancing energy security of the country, it is crucial to note the role of women in EE&C measures. It is mostly women who has to bear the brunt of household chores that includes the use of appliances for heating and cooking, fuelwood for the same purpose and also as retailers. Therefore, there is a strong need to include women in all aspects of EE&C measures included in the roadmap. The is a need to sensitize them on but not limiting to the use of EE appliances, encouraging them as E-suppliers and capacity building of women entrepreneurs and engineers.

13. 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 measurable, 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 are 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

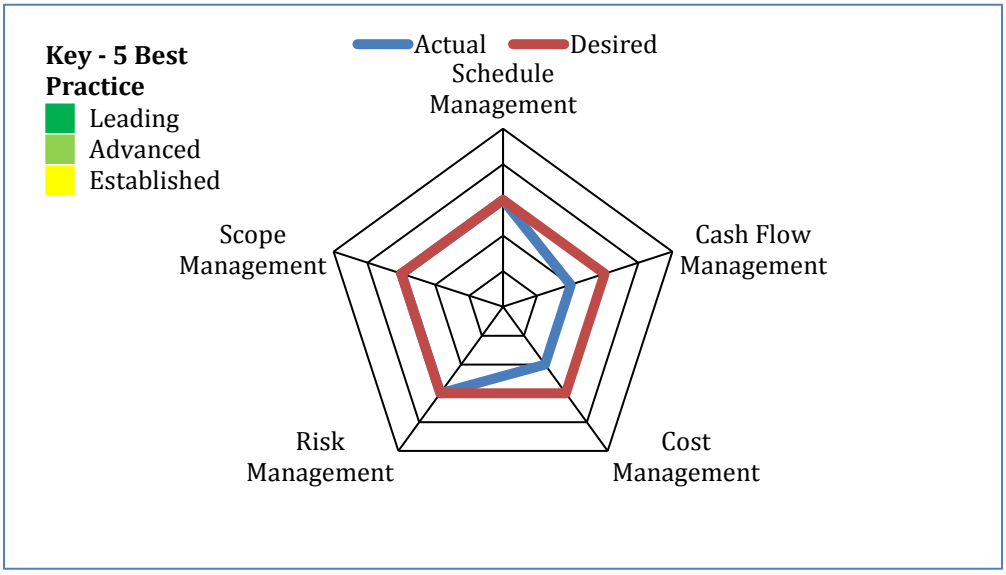
Table 14: Draft Monitoring Framework

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

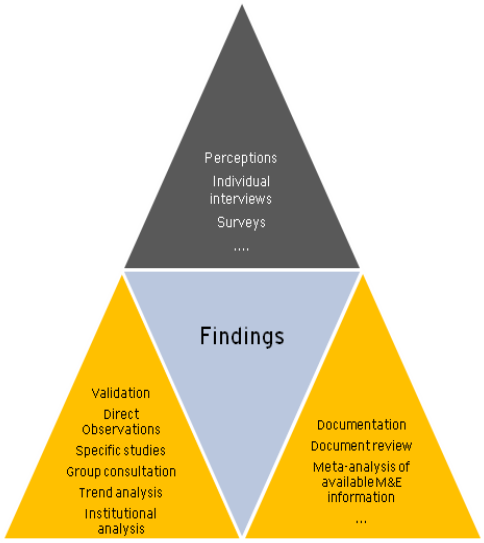


b. Use of evaluation tools – Triangulation Matrix

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

14. The Way Forward

Various technical studies and detailed energy audits carried out by DRE had sufficiently proven the potential of energy savings and its positive impacts on the Country's economy, environment and contribution to international climate change efforts.

This EE roadmap will enable and guide the Government to integrate the EE&C activities into the 12th FYP and the subsequent five-year plans with the objective of efficient energy consumption, and reduced GHG emissions thereby leading to lower energy intensity and maintaining the carbon neutral commitment.

However, for each target sectors, 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 and attractive finances will depend on the quality program design and adequate international collaboration for the implementation of energy efficiency interventions.

Few interventions in the roadmap can be initiated with active public participation and imparting right information on EE&C measures aligned with institutional strengthening & capacity building of the stakeholders.

The EE roadmap shall strive to achieve the following with the implementation of the EE&C measures:

- Consumers are better informed therefore continuous effort should be given to create awareness.
- Piloting the interventions in public buildings which can be a platform to showcase the benefits of the various EE&C measures.
- For the purpose of understanding the energy situation in the country online energy information and monitoring system can be implemented.
- Innovative business models and financing tools implemented to support energy efficiency projects.
- Market transformation with energy efficient appliances.
- Behavioral changes induced with enhanced energy efficiency and conservation awareness and its benefits, and knowledge on energy efficient technologies.
- Effective monitoring to evaluate the real impact of energy-efficiency and conservation measures.
- International and regional cooperation enhanced on energy efficiency.

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.

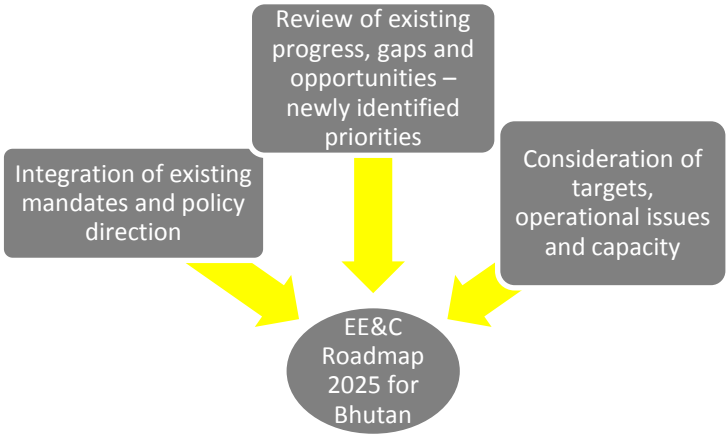


Figure 11: EE Roadmap Development Process (Source: EY Analysis)

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. The use of the Indian grid emission factor is restricted to CDM projects only. Therefore, under this study the use of electricity is considered no emission and thus no emission factor of electricity is considered.

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.

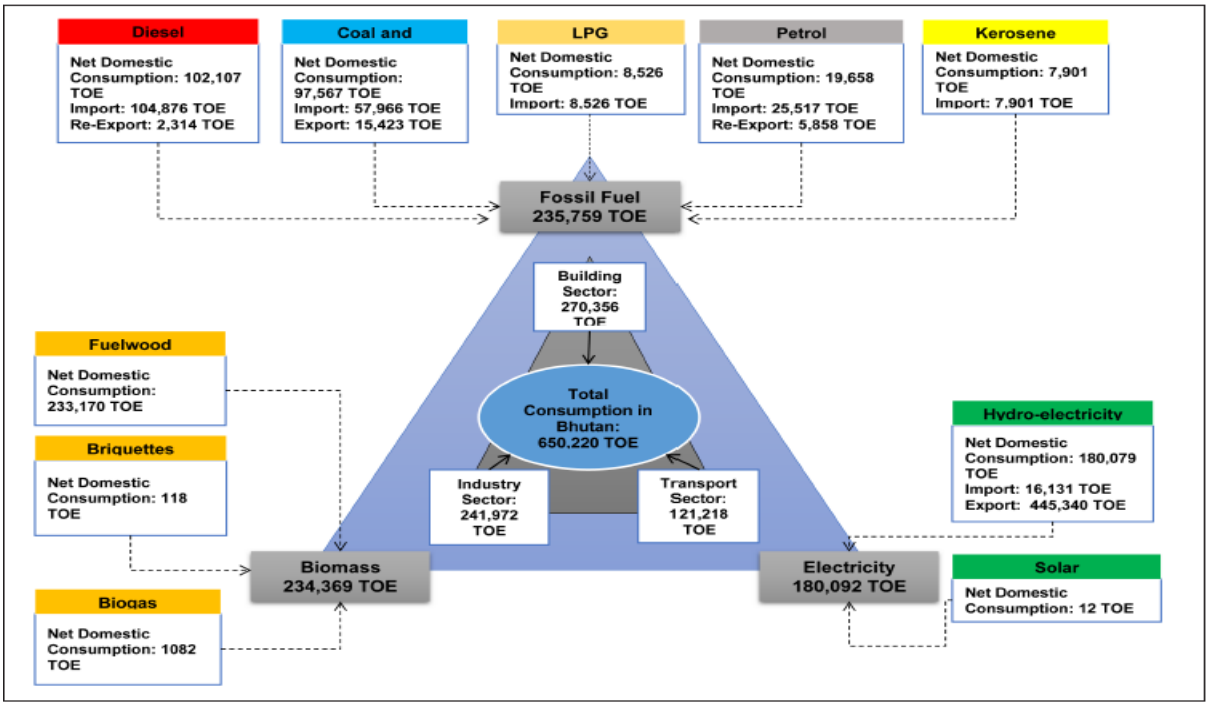


Figure 12: Energy forms and flows[11]

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	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	0		
Building Sector Total Energy Consumption	270,357					

[11]Bhutan EDD 2015

(ToE)	
Building Sector total Emission (tCO2e)	1,114,708
Building Sector emission Factor (tCO2e/ToE)	**4.12**

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	370,798	40,265
2	11,172	303,915	390450	46,063
3	12,781	316,047	411,144	52,696
4	14,621	328,687	432,935	60,285
5	16,727	341,858	455,880	68,966

6	19,135	355,582	480,042	78,897
7	21,891	369,884	505,484	90,258
8	25,043	384,789	532,275	103,255
9	28,649	400,325	560,485	118,124
10	32,775	416,518	590,191	135,134
11	37,494	433,400	621,471	154,593
12	42,894	450,999	654,409	176,854
13	49,070	469,349	689,093	202,321
14	56,136	488,482	725,615	231,455
15	64,220	508,434	764,073	264,785
Cumulative emission (tCO2e)				1,823,950

Step 4: Impact of energy savings target considered under the national EE&C 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 EE policy action plan if implemented can bring about savings in the order of around 1% of baseline emission which grows up gradually. However, the development of EE building codes of practice or incorporation of EE&C aspects in the existing 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	74.1	96.1
Industry sector consumption (ToE)	4262	18	584	137071	2490	97567
Industry Sector emission(tCO2e)	19986	54	1543	0	7725	392581
Industry Sector total Energy Consumption (ToE)	241992					
Industry Sector total Emission (tCO2e)	1551678					
Industry Sector emission Factor (tCO2e/ToE)	**0.089**					

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	22,809	0
2	0	262,894	23,448	0
3	9,000	270,255	24,104	803
4	12,334	277,822	24,779	1,100
5	13,469	285,601	25,473	1,201
6	14,708	293,598	26,186	1,312
7	16,061	301,819	26,919	1,433

8	17,539	310,269	27,673	1,564
9	19,153	318,957	28,448	1,708
10	20,915	327,888	29,245	1,865
11	22,839	337,069	30,063	2,037
12	24,940	346,507	30,905	2,224
13	27,234	356,209	31,771	2,429
14	29,740	366,183	32,660	2,653
15	32,476	376,436	33,575	2,897
Cumulative emission (tCO2e)				**23,226**

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 EE policy action plan if implemented can bring about savings in the order of around 1.2% of baseline emission which grows up gradually. 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.

Above figures reveal that the emission reduction potential in industry is around 0.02 million tCO_2e for 15 years and that of building and appliance sector is 1.8 million tCO_2e 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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