URBAN AND RURAL SETTLEMENTS IN BHUTAN: A LOW EMISSION DEVELOPMENT STRATEGY

2017

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2017

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ABBREVIATIONS AND ACRONYMS

AAED	Alternate Energy Division
BAU	Business as Usual
CDM	Clean Development Mechanism
CDM EB	Clean Development Mechanism Executive Board
CER	Certified Emission Reduction
CSMI	Cottage, small and medium industries
DRE	Department of Renewable Energy
EDP	Economic Development Policy
EE&C	Energy Efficiency and Conservation
EF	Emission Factor
EUR	Euro
FYP	Five Year Plan
GCF	Green Climate Fund
GHG	Greenhouse Gas
GDP	Gross Domestic Product
GNH	Gross National Happiness
GNHC	Gross National Happiness Commission
GWh	Gigawatt hour
GWP	Global Warming Potential
INDC	Intended Nationally Determined Contribution
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
JCM	Joint Crediting Mechanism
KP	Kyoto Protocol
KPI	Key Performance Indicators
kWh	Kilowatt hour
LCD	Low-Carbon Development
LDC	Least Developed Country
LECB	Low Emission Capacity Building
LEDS	Low Emissions Development Strategy
LPG	Liquefied Petroleum Gas
MoWHS	Ministry of Works and Human Settlements
MRV	Measurement, Reporting and Verification
MW	Megawatt
MWh	Megawatt hour
NAB	National Assembly of Bhutan
NAMA	Nationally Appropriate Mitigation Action
NCB	National Council of Bhutan
NDC	Nationally Determined Contributions
NEC	National Environment Commission
NGO	Non-Governmental Organization
NKRA	National Key Result Area
NSB	National Statistics Bureau
Nu	Bhutanese Ngultrum
PA	Paris Agreement
PCD	Planning and Coordination Division
PFC	Perfluorocarbons
PoA	Programme of Activities
QA	Quality Assurance
QC	Quality Control
R&DD	Research and Development Division
RDF	Refuse Derived Fuel
RGoB	Royal Government of Bhutan
RMA	Royal Monetary Authority of Bhutan
SDG	Sustainable Development Goals
SEA	Strategic Environment Assessment
SLCPs	Short-Lived Climate Pollutants
SWH	Solar Water Heating
tCO_2e	Tonnes of carbon dioxide equivalent
TERI	The Energy and Resources Institute
toe	Tonnes of oil equivalent
tph	Tons per hour
TSPM	Total suspended particulate matter
TVET	Technical and Vocational Education and Training
TWG	Technical Working Group
UNDP	United Nation Development Programme
UNFCCC	United Nation Framework Convention on Climate Change

POLICY BRIEF

The Royal Government of Bhutan (RGoB) is currently articulating its 12th Five Year Plan, which has the objective of a "Just, Harmonious and a Sustainable Society through Enhanced Decentralization". Furthermore, since 2009, the RGoB has stated its determination to remain carbon neutral. These dual objectives are being challenged by a number of drivers, including a strong urbanization trend, growing population, and increasing wealth, which has led to higher demand for modern buildings, transportation services and consumer goods. Greenhouse gas (GHG) emissions from human settlements are expected to grow rapidly; mainly in the buildings, transport and waste management sectors.

Under the "business as usual" scenario, emissions are expected to increase from a range of 0.25-1.3 million tonnes of carbon dioxide equivalent (tCO_2e) in 2018 to 0.5-2.0 million tCO_2e in 2030[1]. About two-thirds of these emissions would come from the building sector, one-fifth from waste and the remainder from the transport sector.

This low emission development strategy (LEDS) prioritises 13 options to reduce GHG emissions based upon mitigation potential, costs, and sustainable development benefits (Table 1). Implementation of these measures could reduce emission by 15% from the baseline in 2030.

Table 1: Prioritization of mitigation measures for human settlements in Bhutan

Mitigation measure	Rankings				Recommended for rural (R) or urban (U) areas
	Mitigation potential	Abatement cost (payback period)	Sustainable development benefits	Overall	
Waste composting	+++	+++	+++	1	U + R
Energy efficient buildings	+++	++	+++	2	U + R
Reduce, reuse and recycle solid waste (3R)	++	++	+++	3	U
Energy efficient street lighting	+	++	+++	4	U
Electric mass public transport	++	+	+++	4	U
Wastewater management	+	++	+++	4	U
Cable cars	++	+	+++	4	U
Energy efficient appliances	++	+	++	5	U + R
Electric vehicles	+	+	+++	5	U

1 The volume of baseline emissions, as well as the mitigation potential for the different technical interventions proposed, strongly depends on the choice of emission factors in two contexts. The first one relates to the electricity grid, and the second one to the production of fuelwood. For electricity, theoretically either the (high) emissions intensity of the Indian electricity grid or the zero-emission of Bhutan's hydroelectricity can be chosen. For fuelwood, the emission factor can either be its carbon content or zero, given that Bhutan's sustainable forest policy makes fuelwood a renewable resource.

Mitigation measure	Rankings				Recommended for rural (R) or urban (U) areas
	Mitigation potential	Abatement cost (payback period)	Sustainable development benefits	Overall	
Solar PV	+	+	+++	5	U + R
Non-motorized transport	+	+	+++	5	U
Biofuels	++	+	+	6	R
Landfill gas flaring	+	+	+	7	U

Mobilization of these priority mitigation options will require policy and fiscal instruments that provide upfront financing for the incremental investment costs. However, the scarcity of domestic financial resources in Bhutan makes it imperative to also access foreign funds for implementation. Therefore, international public climate finance, as well as revenues from carbon market mechanisms, need to be harnessed. Moreover, government should act quickly to introduce efficiency standards for buildings, appliances and vehicles in order to accelerate no-regret mitigation options.

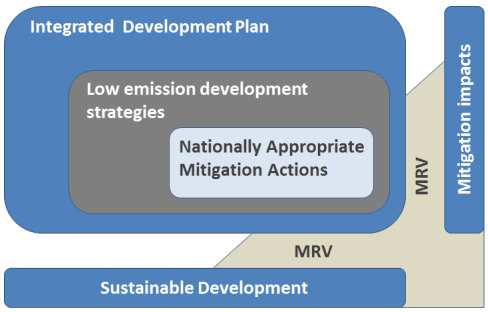
1 INTRODUCTION

The Kingdom of Bhutan is a landlocked country located in the Eastern Himalaya region. It shares borders with the Tibetan region of China in the north and India in the south, east and west. It has a total area of 38,394km2, which is mostly mountainous and heavily forested. Bhutan is classified as a least developed country (LDC), but has a goal to graduate to become a lower middle-income country by 2020. Guided by the philosophy of Gross National Happiness (GNH), Bhutan has always placed high priority on conservation and protection of natural heritage and ensuring sustainable socio-economic development. GNH is closely aligned with the concept of sustainable development, including equitable socio-economic development, preservation of culture, good governance and conservation of the environment. The 12th Five Year Plan, currently under preparation, has the objective of a *"Just, Harmonious and a Sustainable Society through Enhanced Decentralization"*.

In order to guide the country in its endeavour to protect the environment and transition to a sustainable low carbon development, the Royal Government of Bhutan (RGoB) has developed a number of low-emission development strategies (LEDS) for transport, industry, and energy efficiency, as well as Nationally Appropriate Mitigation Action (NAMAs) for waste, buildings, and transport. Collectively, these documents set out a pathway for climate-compatible development that reduces emissions below a business-as-usual scenario, while meeting economic and social development goals. They are the outcome of comprehensive, high-level and country specific processes.

Figure 1 illustrates the interplay between the different interventions. NAMAs are interventions that target specific sectors with carefully selected policy and project measures to reduce GHG emissions. They can be embedded in LEDS, which are broader strategies that address one or several sectors. LEDS also address risks, vulnerabilities and uncertainties associated with global climate change and the pressing development needs countries face as they pursue sustainable development. This overarching LEDS on human settlements has been prepared to ensure that the sectoral LEDS are complementing each other and aligning Bhutan's low-carbon development actions.

Figure 1: Generic structural hierarchy of Bhutan's mitigation strategies and actions



1.1 Objectives of the LEDS

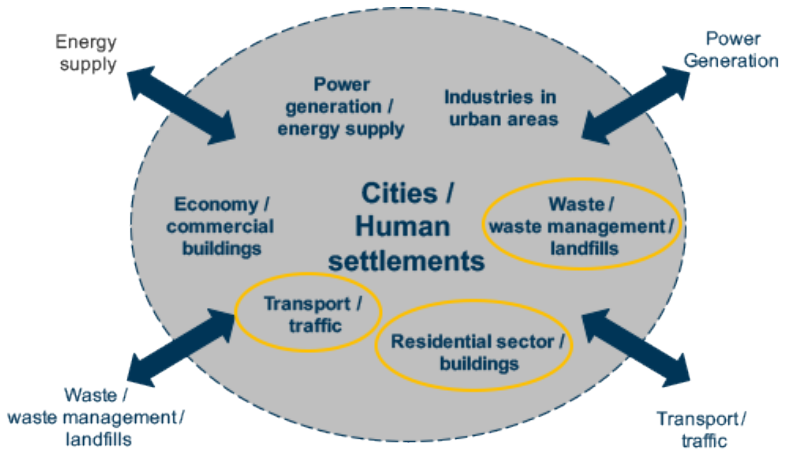
This document acts as overarching framework for low-emission development in rural and urban human settlements in Bhutan. It aims at setting out the main mitigation measures in sectors that are relevant for human settlements and seeks to integrate LEDS and NAMAs that are relevant in this context. GHGs from human settlements are generated through three key sectors: buildings, transport and waste management. The building sector can be differentiated into residential and commercial/ institutional buildings. For transport, passenger and freight transport need to be distinguished. Direct GHG emissions are due to the use of fossil fuels in these three sectors, while in the waste sector methane emissions occur from decay of solid waste as well as from anaerobic processes in wastewater. But human settlements are not just emitters: buildings in Bhutan contain significant quantities of wood and sequester carbon, thus contributing to GHG mitigation.

This LEDS focuses on the following three sectors:

- Buildings (mainly energy for heating/cooling and cooking);
- Transport (mainly passenger transportation); and
- Waste (mainly municipal solid waste management).

Energy (power generation) has not been considered as Bhutan primarily relies upon hydropower, which does not generate significant emissions. Industries are located far away from settlements and are therefore also not considered in this overarching LEDS.

Figure 2: Priority sectors in cities in Bhutan for GHG emissions



A number of different policies, initiatives and studies exist for developing urban and rural settlements in Bhutan. The objective of this LEDS is to develop an emissions baseline for human settlements in Bhutan with a time horizon of 2030 and assessm the overall GHG mitigation potential in buildings, transport and waste for the period. Furthermore, the LEDS reviews and analyses the existing policy framework and identifies the most promising mitigation measures for human settlements. Subsequently, the mitigation measures were prioritised through close consultation with relevant stakeholders.

1.2 Status of urban and rural settlements in Bhutan with regards to GHG emissions

Bhutan is in a development phase of rapid transition from rural economy to urban society. In 2005, rural residents still constituted 69% of the total population. The average annual urban population growth rate has been around 4% since 2007, with the projection of 60% urbanization by 2020 (World Bank 2016). This trend has various social, economic and environmental impacts on the country, including generation of GHG emissions. For example, there are more than 44,000 vehicles in the capital city, Thimphu alone, and the total vehicle population in the country has grown from about 30,000 vehicles in 2005 to over 86,000 in 2017 (RSTA 2017).

Universal electrification has been achieved through a strong policy push, with more than 99.5% of Bhutan's households connected to the grid (BPC 2016). This has led to a massive shift in household fuel use from wood, kerosene and Liquefied Petroleum Gas (LPG) for heating and cooking to electricity over the last decade, and is still ongoing in rural areas (DRE 2016). However, as fuelwood would be deemed to be almost a 100% renewable source as a result of Bhutan's sustainable forest management practices, its replacement does not lead to GHG emissions reduction.

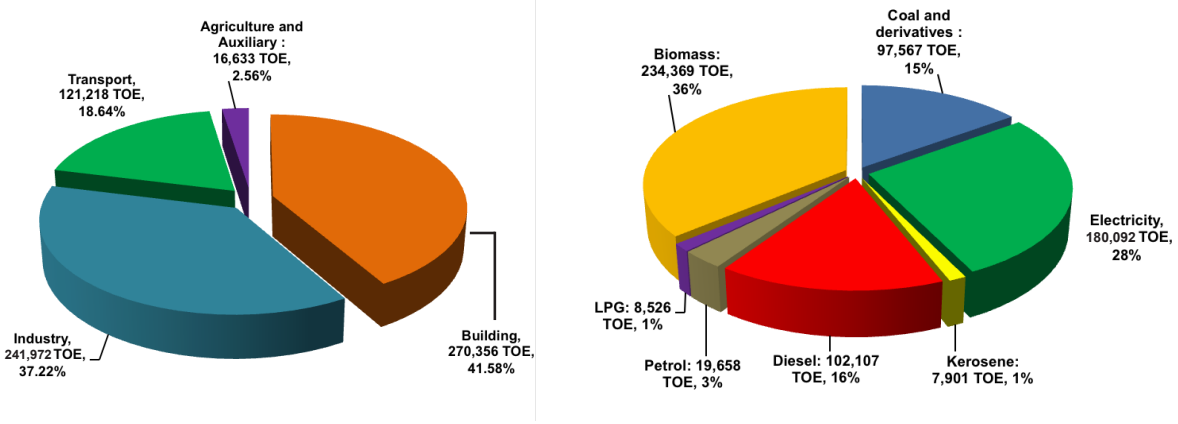
Electricity generation in Bhutan is 100% hydropower and thus emissions from electricity production are zero. As discussed in detail in LEDS for industrial sector (NEC, 2017) and below, this means that any activities reducing electricity use or increasing renewable electricity production do not generate mitigation benefits. Bhutan might therefore want to apply the higher emission factor of the Indian electricity grid, to which the bulk of Bhutan's electricity production is exported, for calculating GHG emission reductions. On the other hand, if this approach is applied, replacing fossil fuel through electricity, e.g. in the context of replacing conventional vehicles by electric vehicles, becomes less attractive or even generates emissions increases.

Due to the mountainous nature of Bhutan, transport infrastructure is costly and difficult to maintain. The first roads were built only 60 years ago, and railways are absent. This means that all land transport is currently done with motor vehicles, which use fossil fuel. Even within settlements, providing a good road network is challenging due to steep mountainsides and lack of space. Fuel use is high due to steep gradients and low speeds which lead to inefficient motor use.

In 2014, the building sector consumed 270kt oil equivalent(toe), or 41.6% of the total energy consumed in Bhutan. Transport was responsible for 121 ktoe, or 18.6%of energy consumption (see Figure 3). Almost all the revenue earned from exporting electricity is spent on transport fuel import from India (DRE 2016).

Figure 3: Energy consumption in 2014, by sector and fuel mix

SOURCE: DRE (2016)



2 RELEVANT POLICIES FOR THE DEVELOPMENT OF URBAN AND RURAL SETTLEMENTS

This section outlines key legislation and policies that can contribute to sustainable development of urban and rural settlements.

Overarching policy documents include:

i) **The Constitution of the Kingdom of Bhutan 2008** enshrines Gross National Happiness (GNH) as a principle of state policy, where it spells out the duties and rights of the parliament, the government, and the people to safeguard and enhance environment. Among other duties, the constitution requires government to secure ecologically balanced sustainable development while promoting justifiable economic and social development and ensure a safe and healthy environment. The constitution also mandates people to contribute towards protection of the natural environment and prevention of all forms of ecological degradation including noise and visual and physical pollution through the adoption and implementation of environmentally friendly practices and policies.

ii) **The National Environment Protection Act (NEPA) 2007** establishes the legal requirement to ensure that development pursuits should take place within the limit of environmental sustainability.

iii) **The Economic Development Policy (EDP) 2016** promotes a "green and self-reliant economy". It identifies number of areas of economic opportunities, based on unique selling points, with the aim of creating employment opportunities.

iv) **Carbon Neutral Declaration 2009**. In December 2009, the Kingdom of Bhutan made a commitment to remain carbon neutral by ensuring that the emissions of GHGs do not exceed the sequestration capacity of the country's forests. Bhutan committed to use soft power to mobilize resources for pursuing a development pathway that is in line with the overall development philosophy of GNH.

v) **National Strategy and Action Plan for Low Carbon Development 2012**: This strategy defines an emissions baseline until 2040 and discusses mitigation options for all sectors of the Bhutanese economy.

vi) **Intended Nationally Determined Contribution (INDC), 2015**: Bhutan re-iterated the resolve to remain carbon-neutral and to undertake mitigation actions between 2020 and 2030, conditional on the provision of international support. Key mitigation areas include green buildings and smart cities, low carbon transport and sustainable waste management.

In addition, there are number of specific building, transport and waste sector-related policies and strategies (Table 2):

Table 2: Sectoral policies and strategies for sustainable development of urban and rural settlements

Policy / strategy / regulation	Target area	Description
Alternative Renewable Energy Policy 2013	Buildings, transport, waste	Aims to promote the following clean renewable energy technologies: solar (PV and thermal), wind, bio-energy and geo-thermal, pico/micro/mini/small hydro, and waste to energy (WTE). The indicative targets for 2025 include: • electricity generation from solar (5 MW), • Wind (5 MW), • Biomass (5 MW); • Energy generation from biomass energy system (3 MW equivalent), • Solar thermal system (3 MW equivalent) and • Fossil fuel energy in transport sector (1000 kilo litres of oil equivalent) to be replaced by 111 GWh of electricity; 20% of state owned and 10% of private vehicle fleet to be encouraged to run on clean and green fuels by 2025.
Bhutan Green Building Design Guidelines, 2013	Buildings	The Guidelines have been developed to motivate regulations, standards and projects to minimize negative impacts of buildings and encourage practices for green and sustainable construction.
Guidelines for Planning and Development of Human Settlements in Urban and Rural Areas of Bhutan to minimise environmental impacts, 2013	Buildings, waste	The document presents a guiding framework for the development of human settlements by mainstreaming environment, climate change and poverty. The recommendations are based on eco-friendly technologies, conservation, and resilience against environmental hazards.
National Energy Efficiency and Conservation Policy (draft), 2016	Buildings, transport	The Policy aims at creating the framework to promote, govern and monitor energy efficiency and conservation activities. It also sets out energy savings targets in building, appliances, industry and transport sectors. Finally, it specifies institutional responsibilities.
Energy Efficiency Roadmap 2030, 2017	Buildings	A 10-year roadmap for EE measures to be implemented by various agencies to enhance productivity and implement the INDC. The roadmap is mainly focused on buildings, industries and appliances.
Bhutan Green Transport and Electric Vehicle Initiative (EVI), 2014	Transport	Policy to promote electric vehicles as part of RGoB's efforts to curb the dependency on fossil fuels and simultaneously address environmental issues by imposing heavy tariffs on conventional vehicles, which are the major consumers of petroleum (DRE 2016). Shift from use of fossil fuel to clean hydro-power generated electricity is encouraged through implementation of tax exemption on electric vehicles.

Policy / strategy / regulation	Target area	Description
Low Emission Development Strategy for the Transport Sector, 2017	Transport	This LEDS describes the key initiatives with the potential to reduce GHG emissions from the transport sector, as articulated in Bhutan's NDC.
Bhutan Transport 2040: Integrated Strategic Vision, 2013	Transport	Incorporates all existing transport-related plans, policies, initiatives, and actions in Bhutan to create a long-term, integrated and comprehensive transport strategy for the next three decades. The overall vision is "to provide the entire population with a safe, reliable, affordable, convenient, cost-effective and environment-friendly transport system in support of strategies for socio-economic development".
Waste Prevention and Management Regulation, 2012 and Amendment 2016	Waste	This Regulation establishes procedures to implement the 2009 Waste Prevention and Management Act by identifying roles and areas of implementation of the Implementing Agencies for establishing a sound waste management system, including monitoring procedures at every organization level, through efficient collection, segregation, treatment, storage, transportation, reduction, reuse, recycling and safe disposal of solid, liquid and gaseous wastes. The regulation assigns costs in proportion to the waste volume generated from the point source or by degree of their hazardousness by levying fees, charges and fines for non-compliance and controls/ prohibits illegal dumping or releasing of waste into the environment.
Waste Prevention and Management Act, 2009	Waste	The purpose of the Act is to protect and sustain human health through protection of the environment by: a) reducing the generation of waste at source; b) promoting the segregation, reuse and recycling of wastes; c) disposal of waste in an environmentally sound manner; and d) effective functioning and coordination among implementing agencies.
National Strategy Action Plan – Integrated Solid Waste Management, 2006 and update 2014	Waste	Bhutan wants to attain Zero Waste through maximizing resource recovery in the long run by applying a 4 Rs strategy (reduce at source, reuse, recycle, and responsibility). Citizens are to participate in waste segregation and resource conservation to achieve maximum processing and landfill diversion. Realistic fees are to be levied from waste generators for waste collection, transfer, treatment and disposal. Public Private Partnerships are to serve as key vehicles for waste management. Extended Producers' Responsibility for all non-recyclable products is to be introduced.

A number of other national policies with high relevance for human settlements are currently under elaboration and due for finalisation in late 2017 or early 2018. They include the National Hygiene and Sanitation Policy, Human Settlement Policy, National Construction Industry Policy and Spatial Planning Act. The need for a National Construction Act has also been prioritized.

A number of international donors have financed specific projects that can contribute to GHG mitigation in the human settlements sector. Most of these have taken place in Thimphu. Some of the ongoing initiatives include upgrading the city bus system, introducing electric and hybrid vehicles, upgrading the municipal solid waste management system, and building a composting plant and a new wastewater treatment plant.

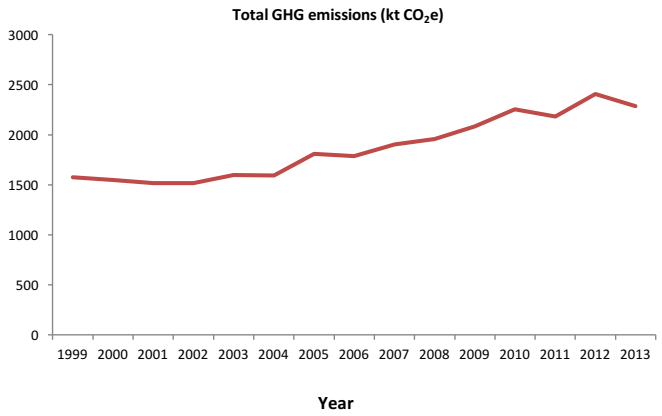
Three NAMAs have been developed for the transport, waste management and buildings sectors for funding support. This LEDS took into account the NAMAs to create alignment with the envisaged measures.

3 CURRENT GHG EMISSION LEVELS AND BASELINE SCENARIO FOR SETTLEMENTS

By the end of 2013, Bhutan's total GHG emissions reached 2.2 million tCO_2e, an increase of 45% compared to the 1999 level (NEC 2016). Figure 4 shows the emission trend from 1999 to 2013.

Figure 4: Historical GHG emission development in Bhutan

SOURCE: NEC (2016)



As noted earlier, various sources of GHG emissions are created within human settlements, including direct and indirect emissions. For electricity and wood fuel use, two scenarios are applied under this study:

- **SCENARIO 1**: Indian grid emission factor for electricity and carbon content in fuelwood
  Assuming any electricity not consumed in Bhutan can be exported to India, the emission reduction attributed to the human settlements sector is the Indian grid emission factor (see Chapter 3.5 for further details). Moreover, assuming that fuelwood not used for the settlements sector would be available to serve as a carbon sink or used by the industry sector in Bhutan (e.g. production of domestic charcoal), the related emission reduction potential could be attributed to the settlement sector (see Chapter 3.6 for further details).
- **SCENARIO 2**: Zero emission factor for electricity grid and fuelwood
  Electricity produced in Bhutan is deemed to generate zero emissions, as well as biomass used for fuelwood.

For both scenarios, baseline emissions of methane are treated alike. Degradation of bio-degradable waste fractions in landfills results in the generation and release of methane. Methane has a Global Warming Potential (GWP_{100}) of 25 compared to carbon dioxide (GWP_{100} of 1).

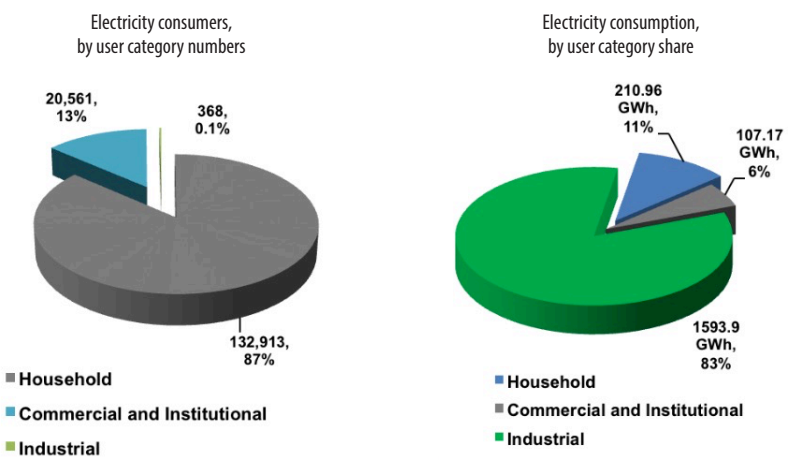
GHG emissions not included under the scope of this study are industrial gases (hydro-fluorocarbon compounds) resulting from the release of refrigerants from refrigerant equipment or release of foam blowing agents.

3.1 Historical GHG emissions from the energy sector

Biomass continues to serve as the primary energy resource for Bhutan in the form of fuelwood, biogas and briquettes, amounting to 234 ktoe (36%).This is followed by electricity, amounting to 180 ktoe (28%). Over the last decade, electricity consumption of an average Bhutanese has increased almost three times while annual fuelwood consumption has tapered off slightly. The majority of electricity is consumed by the industrial sector (83%), followed by by households (11%) and commercial and institutional buildings (6%) (Figure 5). During 2000-2013, emissions from the energy sector almost tripled from 0.27 million tCO2e to 0.79 million tCO_2e (DRE 2016).

Figure 5: Electricity consumption in Bhutan in 2014

SOURCE: DRE (2016), REFERRING TO BPC POWER DATA HANDBOOK 2014

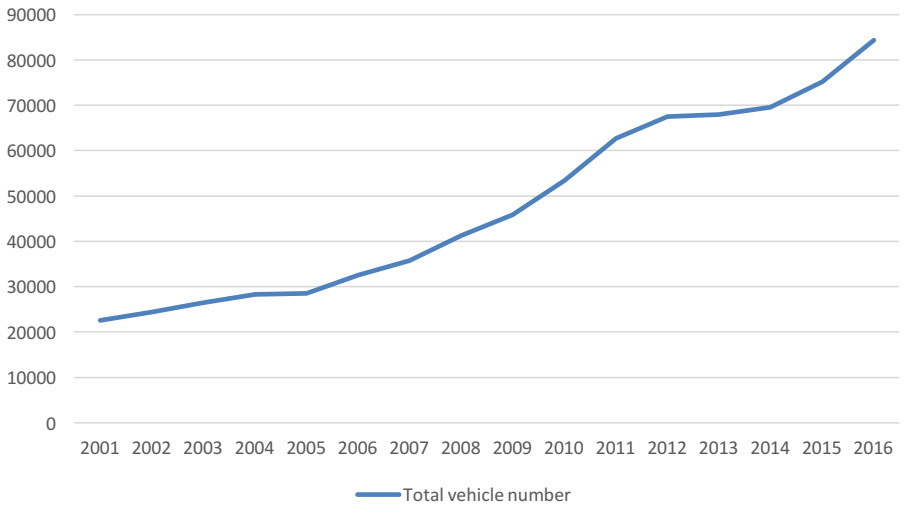


Passenger transportation in Bhutan is dominated by taxis that consume 2.25 million l petrol and 3.9 million l diesel annually. However, fuel use from freight transport exceeds that of passenger transport, with trucks consuming 4.9 million l and buses 4.3 million l (Ernst and Young 2015). Bhutan's urban public transport systems are still developing to meet increasing demand and customer expectations for higher quality of service. In 2015, the Thimphu city bus service fleet of 32 buses had 1 million rides (MOIC 2015). However, a World Bank study estimated that taxis account for roughly 28% of trips per day in Thimphu and bus services for only 6% of such trips (GNHC 2016).

Vehicle numbers in Bhutan stabilized in the mid-2010s due to a temporary vehicle import ban (see Figure 6), but have increased significantly since then, reaching over 86,000 vehicles in early 2017 (RSTA 2017).

Figure 6: Number of vehicles in Bhutan, 2001-2016

SOURCE: MINISTRY OF INFORMATION AND COMMUNICATION (2016)



3.2 Historical GHG emissions from the building sector

Traditional Bhutanese architecture, which uses local building materials, is highly valued (Figure 7). Building regulations therefore encourage use of traditional and local materials. In the construction of rural houses, timber is used extensively, while urban and sub-urban housing stock is dominated by reinforced-concrete frame buildings (with infill walls) of up to six floors. (DRE 2015)

Figure 7:Building typologies in Bhutan

SOURCE: DRE (2015)

Residential building
(Single ownership bungalow type, apartment type, quarters, etc.)

Commercial building
(Private office buildings, shops, hotels, restaurants, etc.)

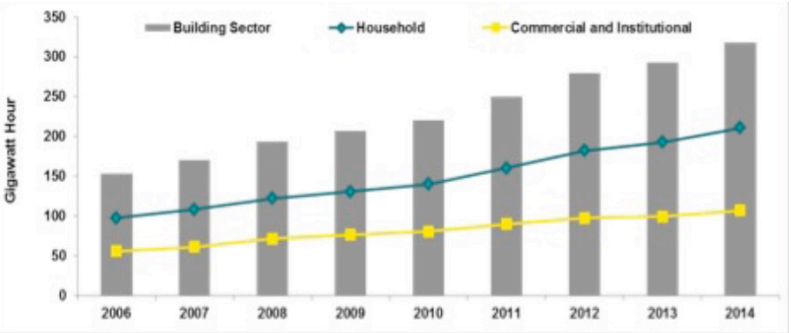
Institutional building
(Government buildings, academic institutions, hospitals, etc.)

The main energy consumption end-uses in the residential sector are cooking, space heating, lighting, as well as entertainment, cold storage, etc. In the non-residential segment, energy is mainly used for supplying electricity to either commercial activities (such as shops and hotels) or institutional activities (such hospitals, schools, monasteries, government offices, and municipal services).

In 2014, energy consumption in the building sector amounted to 213 ktoe for residential buildings (households) and 56 ktoe for commercial and institutional buildings, of which 243 ktoe was thermal energy and 27 ktoe electricity (Figure 8).

Figure 8: Electricity consumption of buildings sub-sectors (in GWh)

SOURCE: DRE (2016)



In residential buildings, the consumption of electricity has increased by 10.1% per year between 2005 and 2014, while biomass and kerosene consumption has decreased by 1% and 6.9% p.a. respectively. Liquefied Petroleum Gas (LPG) use grew by 6.9% (DRE 2016, see also Table3). In commercial buildings, for the same period, electricity use grew by 8.4% and biomass by 5.5%, while kerosene use fell by 9.9% per year.

Table 3: Energy types used in residential and commercial buildings, 2014

SOURCE: DRE (2016)

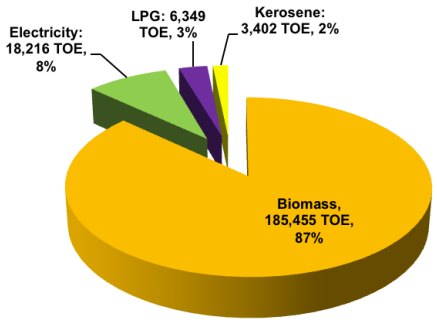
		Residential		Commercial	
Feul	**Units**	**2005**	**2014**	**2005**	**2014**
Electricity	GWh	89	211	51	107
Kerosene	kl	6,442	3,402	5,828	2,271
Biomass	t	543,503	494,831	74,065	119,838
Liquefied Petroleum Gas	t	3,522	6,348	950	681

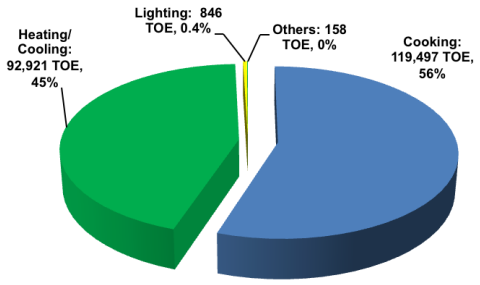
In 2014, the fuel composition in the residential sector is dominated by biomass (87%) and electricity (8%). Despite access to electricity, biomass in the form of firewood, briquettes and biogas are still prevailing for cooking and heating in the rural areas. The high dependence of rural areas on biomass is based on the affordability and easy accessibility of biomass given the socio-economic and geographical conditions of the rural population (DRE 2016). Fuelwood usage has fallen from 91% in 2005 to 87% in 2014. In the commercial sector, values are surprisingly similar (see Figure 9).

Figure 9: Energy consumption mix and fuel mix for residential and commercial buildings, 2014

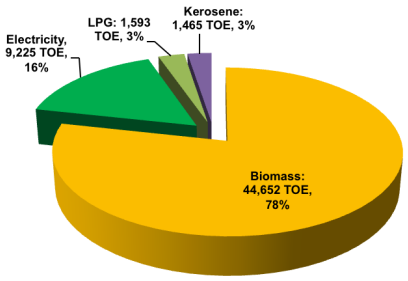
SOURCE: DRE (2016)

a) Residential

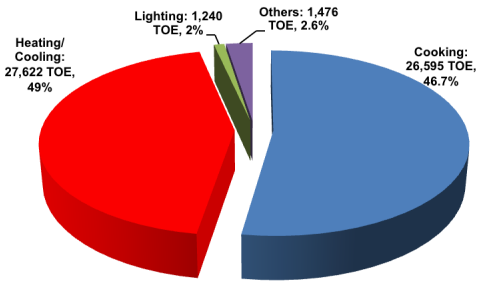




b) Commercial



Institutional and Commercial Segment Fuel Mix
Total Consumption: 56,934 TOE



Institutional & Commercial Segment Consumption Mix
Total Consumption: 56,934 TOE

The choice of building material has a strong impact on the emissions intensity of a building. Unfortunately, current Bhutanese buildings use low-energy-efficiency materials, such as weak insulation, and energy technologies, such as biomass stoves for heating and cooking purposes. In Bhutan's highland districts where night temperatures fall below 0°C in winter, heat loss from the building envelope was observed to be in the range of 40% to 70% (DRE 2015), depending on the type of building and materials used. Heat loss through the walls is the highest, in the range of 40% to 70% of the total heat loss, followed by air infiltration loss through windows and the roof (DRE 2015). The wall heat loss was lowest for traditional rammed earth buildings and highest for brick walls. In most buildings in Bhutan, even modern buildings in the capital, single glazed windows with wooden frames are used. This leads to heat loss in the range of 20 to 25%.

Buildings in lowland districts with high summer temperatures currently suffer from significant heat gain through the building envelope, which increases cooling loads. Over 95% of buildings in the lowlands have walls without insulation, and single glazed windows with wooden and aluminium frames. Rammed earth construction is generally absent. Heat gain through walls is the highest, followed by air infiltration through the roof, windows and floor.

3.3 Historical GHG emissions from the transport sector

The transport sector is one of the major consumers of energy in Bhutan and almost all the energy used in the sector is derived from imported fossil fuels. An analysis of vehicle types in Bhutan conducted by the Department of Renewable Energy (2016) shows that diesel and petrol are the main fuels used in road transport, along with some minor amount of electricity. In comparison to 2005, the fuel consumption in the transport Sector has increased by a factor of two for all fuel types (see Table4). The composition of transport sector fuel mix remains almost the same as compared to 2005 (see Table4).

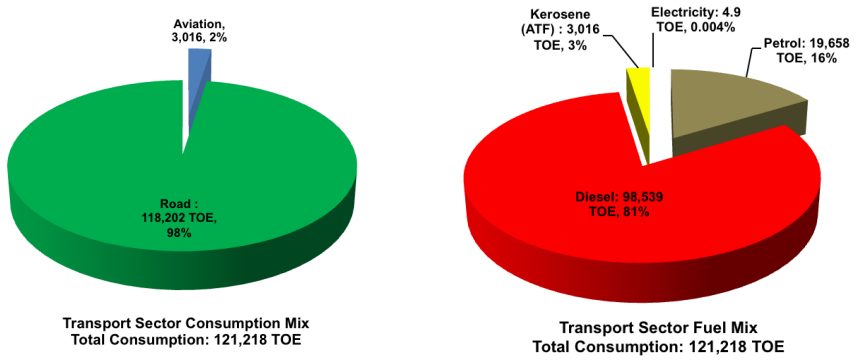
Table 4: Transport sector fuel types

SOURCE: DRE (2016)

Fuel	Units	2005	2014	Annual growth (%)
Petrol	kl	13,879	24,129	6.3%
Diesel	kl	48,702	110,281	9.5%
Aviation Turbine Fuel	kl	1,145	3,546	13.4%
Electricity	GWh	0	0.1	NA

Figure 10: Transport energy consumption mix and fuel mix, 2014

SOURCE: DRE (2016)



The fuel-wise breakdown of vehicles for the last four years is shown in Table 5[2].

Table 5: Number of vehicles in Bhutan, by fuel type, 2013-17

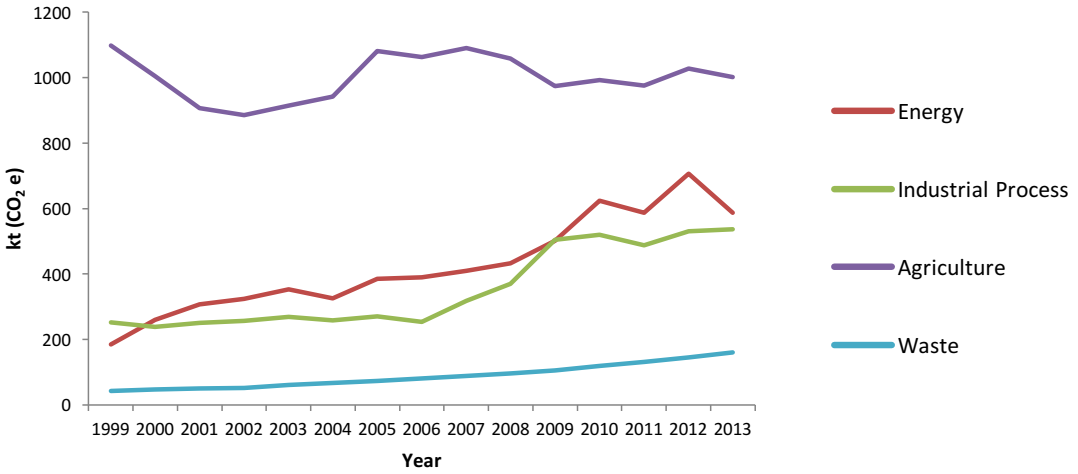
SOURCE: RSTA STATISTICS 2017, UNDP/RGOB (2016) REFERRING TO RSTA STATISTICS

Year	Diesel				Petrol		Electric Vehicles
	Heavy vehicle	Medium vehicle	Work (Power tiller, tractor & earth moving	Light vehicle	Two wheelers	Light vehicle	
2014	8,474	1,392	3,715	23,016	9,988	23,017	0
2015	8,610	1,489	4,184	25,598	10,563	25,599	75
2016	9,480	1,605	4,960	29,251	9,641	29,251	109
2017	9,688	1,630	5,122	30,014	9,726	30,014	111

Figure 11 shows emissions by sector.

Figure 11: GHG emissions, by sector, 1999-2013

SOURCE: NEC (2016)



3.4 Historical GHG emissions from the waste sector

During the period 2000-2013, emissions from waste management more than tripled from 0.047 to 0.16 million tCO_2e (DRE 2016). This is due to a significant increase in waste quantities, as well as emissions-intensive waste management methods. So while emissions remain low in absolute numbers, a continued growth in line with rising affluence and urbanization would eventually bring them to a level where they become a major component of the national emissions inventory.

3.5 How to account for emission reductions in electricity consumption

Given that electricity in Bhutan is primarily produced by hydropower, the grid emission factor is zero. Only during some winter months, electricity imports from India are observed. Under a GHG inventory approach within the boundary of Bhutan, however, such emissions resulting from power generation in India would not be accounted. Similarly, electricity exports from hydropower to India would not be accounted as emission reductions. Accordingly, all measures related to reducing electricity consumption or leading to electricity generation under the LEDS would not result in accountable emission reductions. However, as any excess in electricity generation as a result of savings or additional generation will be exported to India, the Indian grid emission factor should be applied to calculate total mitigation potential. This has already been done for Bhutan's hydropower projects under the CDM (Ogino and Hamanaka 2010). Under the Paris Agreement, so far no regulation exists for how such a situation is to be accounted for. The values determined for the Indian grid (operating (OM), build (BM) and combined margin (CM) emission factors) under the CDM approach are shown in Table 6.

Table 6: Grid emission factors for India

SOURCE: BHAWAN AND PURAM (2016)

Average	OM	BM	CM
0.82	0.99	0.93	0.96

3.6 How to account for emission reductions in fuelwood consumption

Fuelwood in Bhutan can be deemed 100% renewable, hence the emission factor is zero. Almost no emissions from fuelwood consumption under the GHG inventory approach exists, but nearly 60 $ktCO_2e$ from biomass combustion were "noted" in 2000, i.e. they were not formally part of the national inventory. The accounting for the assessment of mitigation options would suggest that replacement of fuelwood does not generate mitigation benefits. However, saved fuelwood can be used for domestic charcoal production serving as reductant in the heavy industry sector, provided that local dust emissions from charcoal combustion are mitigated (see the related discussion in Cleaner Production assessment report[3]). Generally, double counting needs to be avoided. In addition, the mitigation potential of fuelwood replacement will decline over time. With regards to fuelwood harvesting, proper account of biodiversity protection needs to be done; harvest in old growth forests should be limited to common species.

3.7 Baseline energy and emission projections until 2030

The approach followed under Bhutan's National Strategy and Action Plan for Low Carbon Development (NEC 2012) assumes that an increase in GDP triggers an increase in GHG emissions. The approach taken by NEC (2012) to project the GHG emissions for the period 2005 to 2040 distinguishes between energy-related emissions and process-related emissions. Within the energy-related emissions, industries and road transportation dominate the emissions trend.

Table 7: Baseline projection of carbon emissions from energy related and non-energy related emissions (kt CO_2e)

SOURCE: NEC (2012)

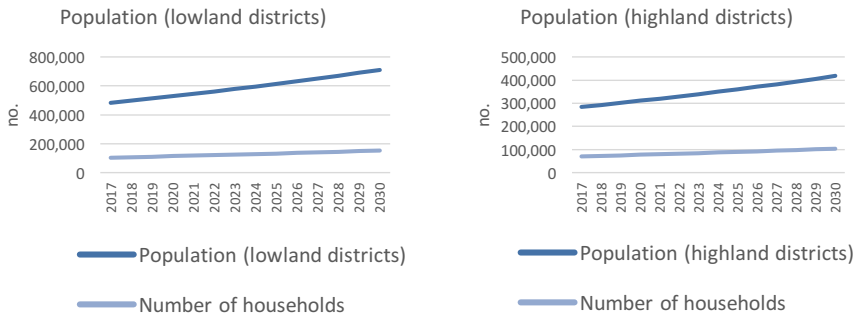
	2005	2010	2020	2030	2040
Energy related emission (kt CO2e)	357	468	905	906	885
Energy intensive industries	*62*	*69*	*221*	*189*	*159*
Other industries	*70*	*91*	*154*	*180*	*208*
Domestic aviation	*-*	*-*	*2*	*2*	*2*
Road transport	*177*	*228*	*376*	*361*	*348*
Tertiary sector	*18*	*35*	*56*	*60*	*60*
Residential sector	*28*	*42*	*91*	*106*	*98*
Agriculture and forestry	*2*	*3*	*5*	*8*	*11*
Non-energy related emission (kt CO2e)	1.454	1.764	3.492	3.678	3.837
Industrial processes	*243*	*465*	*1.947*	*1.947*	*1.947*
Livestock	*567*	*567*	*567*	*567*	*567*
Crop	*550*	*603*	*734*	*811*	*903*
Urban municipal solid waste	*94*	*130*	*246*	*353*	*422*
TOTAL (kt CO2e)	**1.811**	**2.232**	**4.398**	**4.585**	**4.723**
Population	634.982	695.822	809.397	886.523	964.838
Tons CO2e per capita	2,9	3,2	5,4	5,2	4,9

3 Department of Industry, Ministry of Economic Affairs (2017): Cleaner production and greenhouse gas mitigation in the industrial sector in Bhutan, Thimphu

3.7.1 Assumptions and baseline for the residential buildings sector

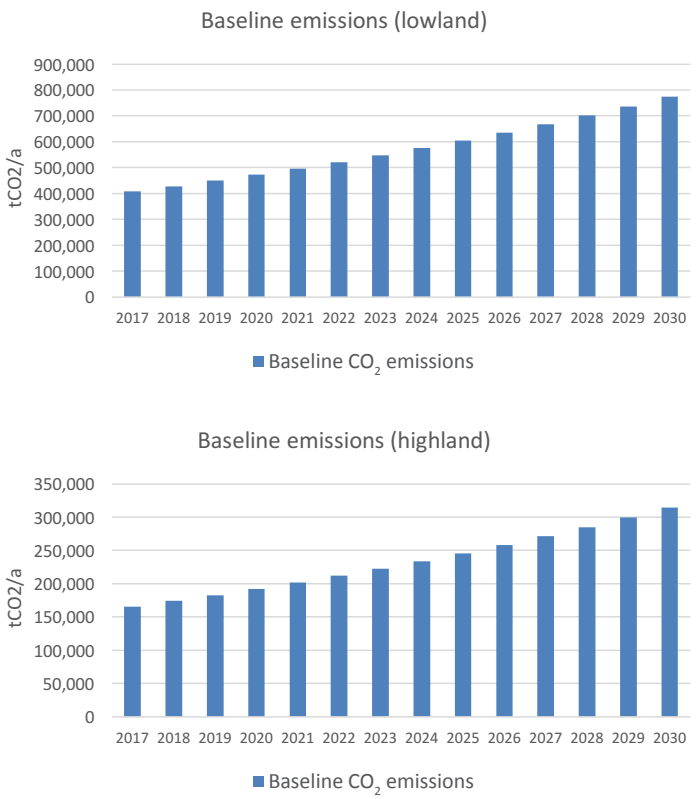
It is estimated for population to grow by 3% per year from 2016 levels (NSB 2016), reaching a total of 1.13 million in 2030. The average number of persons per household is assumed to be 4.6. Figure 12 shows the population split between lowland and highland districts over time, based on the 2013 share of people living in corresponding Dzongkhags (MoLHR 2013).

Figure 12: Population and number of households, by district, 2017-30



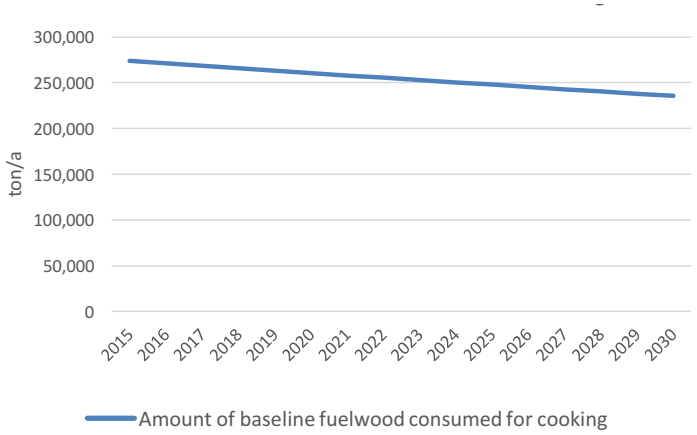
The baseline emissions for residential buildings due to energy demand for cooling in lowland districts are estimated at approximately 400 ktCO2/a and are expected to grow to almost 800 ktCO2/a by 2030. In highland districts, the baseline emission from energy for heating are projected to double as well until 2030, from approximately 150 ktCO2/a in 2017 to more than 300 ktCO2/a in 2030. In sum, the total baseline emissions for the sector amount to 550 ktCO2/a in 2017 and will increase to approximately 1,100 ktCO2/a in 2030.

Figure 13: Baseline emissions from heating/cooling in residential buildings until 2030 in Bhutan



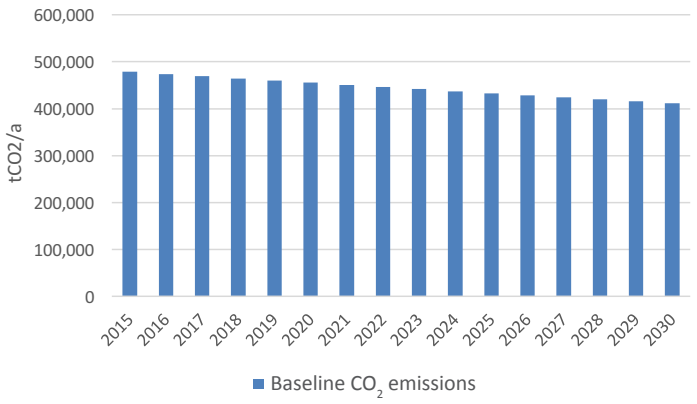
The amount of baseline fuelwood consumed for cooking in households is assumed to further decrease due to continued shift to electricity and LPG as fuels for cooking. The current amount is estimated at approx. 270,000 tonnes/a in 2017, falling to around 240,000 tonnes/a in 2030 (Figure 14).

Figure 14: Amount of baseline fuelwood consumption until 2030 in Bhutan



The resulting baseline emissions from cooking with firewood (see discussion on emission factor in Section 3.6 on How to account for emission reductions in fuelwood consumption) are illustrated in Figure 15.

Figure 15: Baseline emission from fuelwood consumption until 2030 in Bhutan

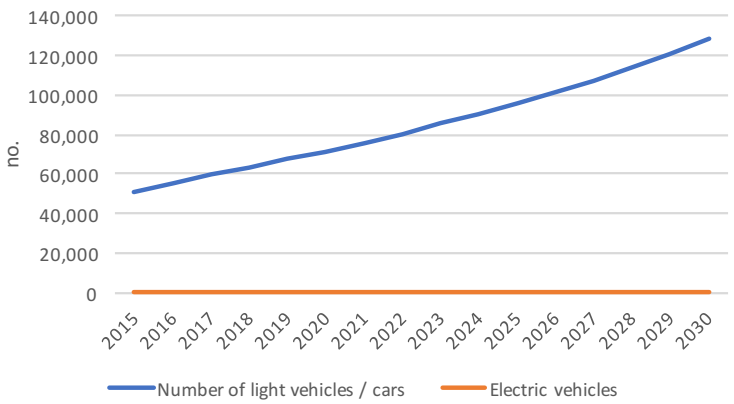


3.7.2 Assumptions and baseline for the transport sector

Currently the increase in ownership of vehicles in Bhutan is extremely high and can be explained by satisfying "suppressed demand"; in the long run vehicle numbers will likely be aligned with the GDP increase. But this will only occur once urbanization begins to slow down. A 6% increase per year until 2030 from 2017 values (RSTA 2017) is therefore applied for light vehicles/cars, which leads to about 125,000 such vehicles in 2030. In the baseline, a small shift towards electricity is envisioned for light duty vehicles. The number of electric vehicles is assumed to also increase by 6%/year,resulting in 240 electric cars in 2030.

Figure 16: Baseline number of light vehicles until 2030 in Bhutan

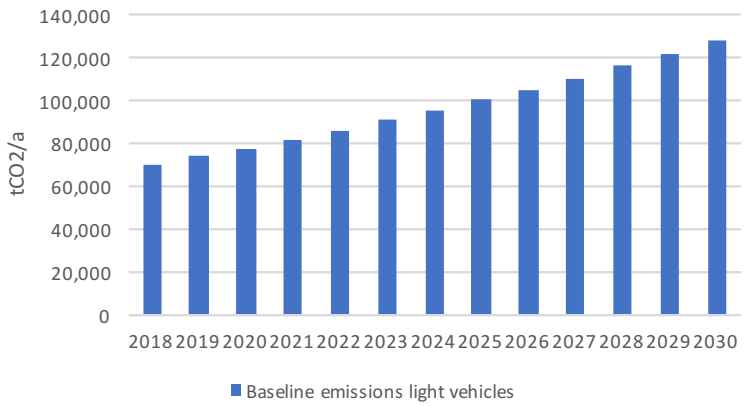
SOURCE: EXPERT ELABORATION BASED ON DATA FROM NEC (2012)



ADB and AusAid (2013, p. 5) estimated an increase in vehicle numbers to over 200,000 in 2030 based on RSTA data. Therefore, the estimate used in this report is conservative.

An average annual car use of 5,000 km/a is assumed and fuel consumption of 9.0 l/100 km in 2018, which goes down by 0.8% per year to 2030 (Figure 17).

Figure 17: Baseline emissions of light vehicles until 2030 in Bhutan



3.7.3 Assumptions and baseline for the solid waste sector

In the baseline for the solid waste sector, it is assumed that currently 99% of the total waste (ca. 126,000 t/a, assuming a daily waste quantity per capita of 0.45 kg/cap/day as valid for Phuentsholing) is landfilled on controlled landfills without landfill gas capture. It is further assumed that approximately 10% is currently recycled (glass, paper, cardboard, metals). The per capita waste volume is expected to increase to 0.75 kg/cap/day by 2030, which is a typical value for a middle-income country (Figure 18). In addition, a population growth of 3% per annum is taken into consideration. Recycling rates of non-organic and organic waste fractions are expected to increase to 20% and 10% by 2030, respectively.

Figure 18: Baseline estimate of treated solid waste until 2030 in Bhutan

SOURCE: EXPERT ELABORATION, USING IFEU (2009)

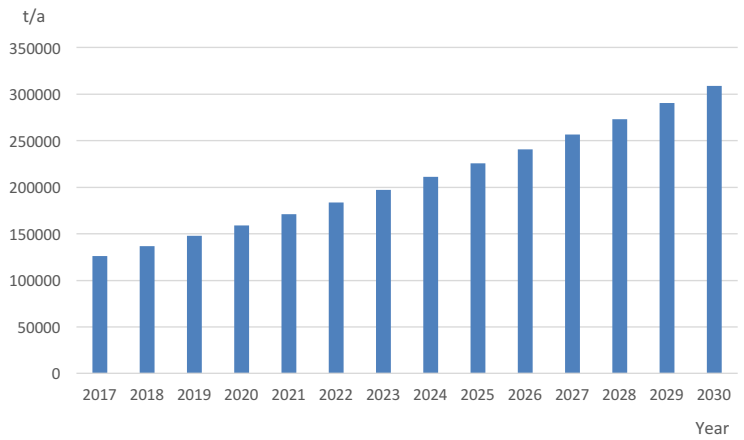
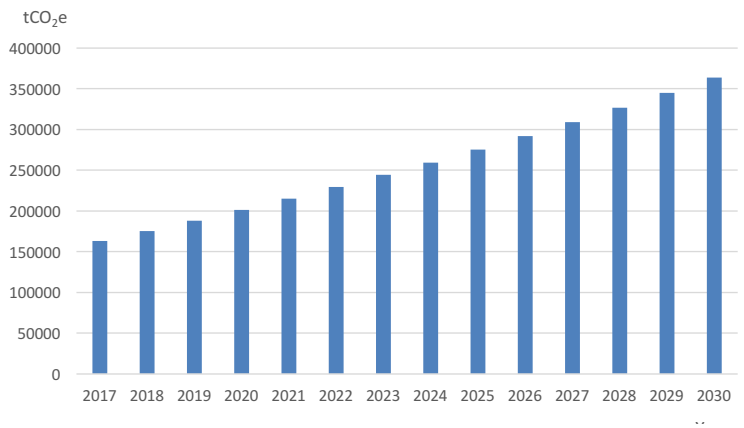


Figure 19: Baseline emissions in the solid waste sector until 2030 in Bhutan

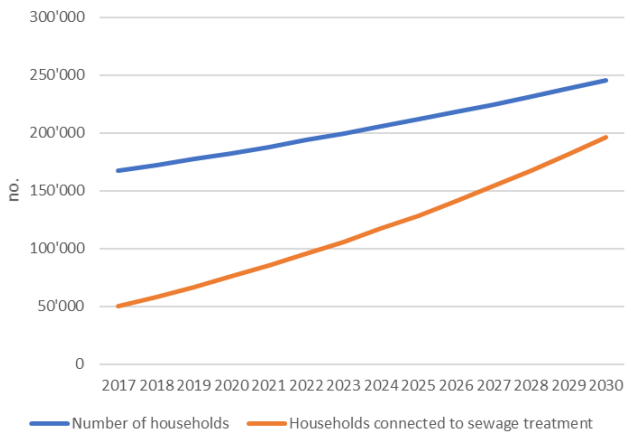
SOURCE: EXPERT ELABORATION, USING IFEU (2009)



3.7.4 Assumptions and baseline for wastewater management

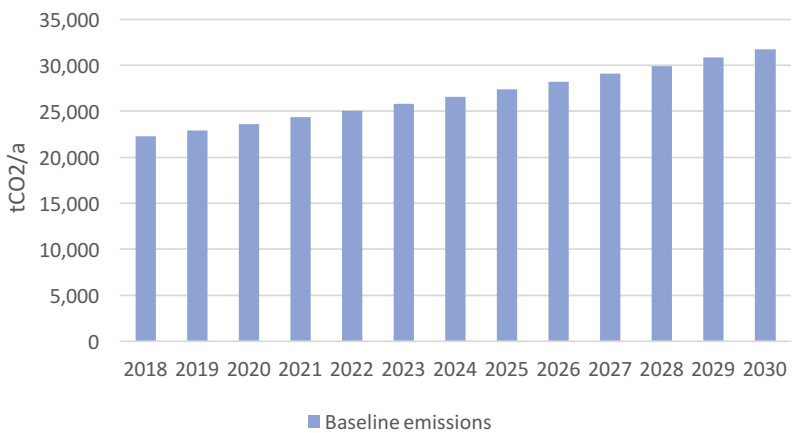
In the past, most Bhutanese households have used septic pits or tanks or put their wastewater in the nearest stream. Sewage systems have now been introduced and are being expanded in the urban centres. As per the 11th Five Year Plan (GNHC 2013b), 30% of households were to be connected to sewerage systems by the end of the plan period (June 2018). It is assumed that this trend continues and by 2030 80% of households are connected to a sewage system, which leads to an anaerobic wastewater treatment plant (Figure 20).

Figure 20: Baseline of households connected to sewage systems until 2030 in Bhutan



The volume of baseline emissions from the wastewater treatment plants then develops as per the anaerobic wastewater treatment coverage (Figure 21).

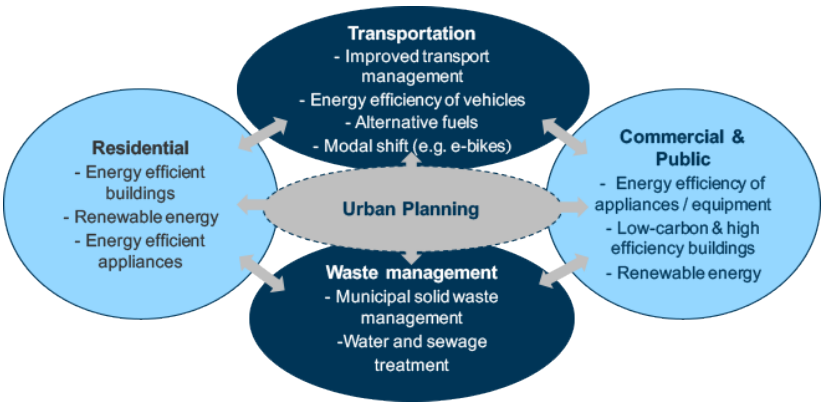
Figure 21: Baseline emissions from wastewater treatment until 2030 in Bhutan



4 MITIGATION POTENTIAL IN URBAN AND RURAL SETTLEMENTS IN BHUTAN

The mitigation potential described in this chapter is calculated based on a review of the current situation of urban and rural settlements in Bhutan, differentiated by the sub-sectors of buildings, transport and waste (Figure 22). This takes into account a review of existing literature. The assessment of mitigation potential is used as a key criterion for the prioritization of the available mitigation measures (mainly energy use for for heating/cooling and cooking, passenger transport, and municipal solid waste management and wastewater treatment) and therefore also used as starting point to define policy measures to mobilize implementation of the selected mitigation measures. The prioritised measures are elaborated below.

Figure 22: Generic mitigation actions in cities / human settlements



4.1 Mitigation measures and mitigation potential in buildings

4.1.1 Green buildings and sustainable construction standards (building codes)

Green building construction focusing on efficient energy usage can help to reduce energy consumption (thermal and electricity demand) for space heating and cooling through enhanced building insulation.

Energy efficiency interventions for districts having high heating load, i.e. located in high altitudes (more than 2000 metres) should focus on reducing the heating load of the building. Measures in districts in lower altitudes (less than 1000 metres) should focus on reducing the cooling load of the building. In addition, concrete measures should be identified for both retrofit and new building constructions (DRE 2015).

Reducing heating and cooling demand, respectively, will help to reduce the specific energy demand (kWh/m2a of thermal energy or electricity). Energy efficiency standards in the form of a maximal energy demand (kWh/m2a) could be introduced to encourage investments in energy efficient buildings. The Bhutan Green Building Guidelines provide information, recommendations, and guidance to incorporate sustainable green principles and approaches – mainly for new design and construction (MoWHS 2013). The implementation and introduction of standards in corresponding building codes will trigger technical interventions such as:

- For existing buildings: refurbishment of windows with double/triple glazed windows, enhanced wall insulation, or replacement of lighting with LEDs could be suitable.
- For new construction: urban planning aspects could be factored in, for instance, location close to public infrastructure and public transport facilities. In addition, buildings could use a passive solar design to harvest solar gains by having the main window front oriented southwards in areas with heating demand. As with existing buildings, new double/triple glazed windows, enhanced wall insulation, and replacement of current lighting with LEDs will further reduce the energy demand in new construction. Where possible, the integration of renewable energies, e.g. solar rooftop PV, solar heat pumps and Solar Water Heating (SWH) could be used to generate required energy locally. Bhutan has adequate solar potential, with annual average values of global horizontal solar radiation ranging from 4.0 to 5.5 kWh/m2-day (4.0 to 5.5 peak sun hours per day) (MoEA 2008).

Figure 23: Emission reduction through reduced energy demand for cooling in lowland districts

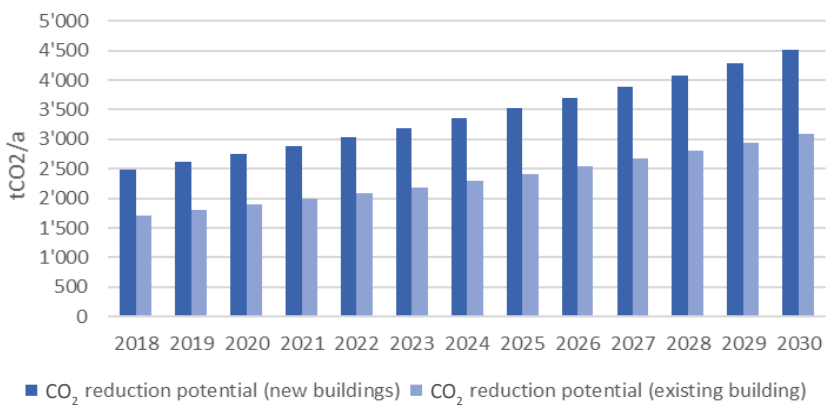
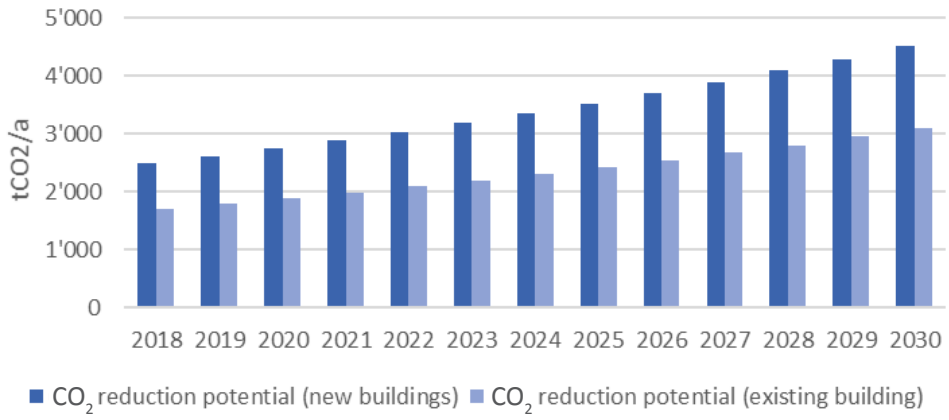


Figure 24: Emission reduction through reduced energy demand for heating in highland districts

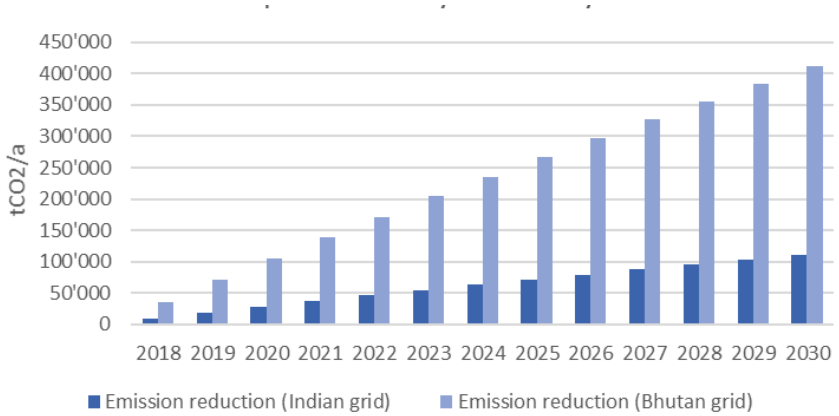


The use of sustainably harvested wood products as construction material for buildings can be seen as a carbon sink and thus promotion of this type of construction can be seen as an additional mitigation measure. In addition, earth, stone, and locally manufactured bricks will indirectly contribute to emission reduction by reducing demand for long-distance transportation of construction materials. Locally-manufactured construction materials will further help in emission reduction as the primary source of electricity in Bhutan is hydropower.

4.1.2 Fuel switch from biomass and LPG thermal energy to electricity

Replacing biomass (wood) and LPG for heating and cooking purposes with electricity, e.g. electric stoves, will reduce overall GHG emissions of households using these energy fuels. However, the emission reduction potential due to the fuel switch to electricity depends on the choice of the grid emission factor (see section 3.5).

Figure 25: Emission reduction through replacement of woodfuel with electricity in Bhutan



Although not covered under the detailed assessment due to their currently limited potential, further potential mitigation actions could comprise:

- District heating system for space heating based on waste heat recovery;
- Solar for tap water heating and supporting the heating systems;
- Energy demand-side management by promoting energy efficiency in appliances, e.g. energy efficiency standards for (imported) electricity appliances, including labelling;
- Biogas plants in rural areas, e.g. small scale domestic biogas usage, for electricity production, cooking/heating purposes and/or LPG replacement.

4.2 Mitigation measures and mitigation potential in transport

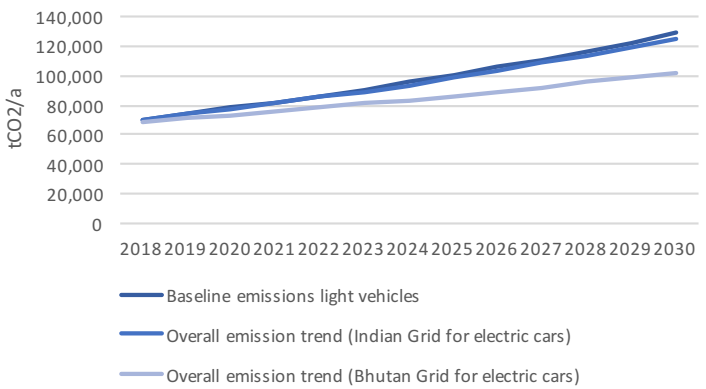
4.2.1 Electric/hybrid vehicles (replacing petrol/diesel cars)

While there are substantial emissions from conventional vehicles, electric vehicles are emission-free, provided the electricity is generated from renewable energies – see Chapter3.5. Introduction of electric vehicles in the transport sector in Bhutan has started, albeit on a small basis. Development of supportive infrastructure (e.g. charging stations) can revolutionize the domestic economy, with a possibility of substitution of petrol/diesel vehicles for electric ones consequently reducing the burden on government budget.

To further promote the use of electric vehicles, the following pilot activities and incentives could be implemented:

- Electric vehicle fleet for institutional cars and taxis. There are more than 4,200 taxis in Bhutan, which could be replaced by electric vehicles over time.
- Install required infrastructure, e.g. charging stations.
- Introduction of energy efficiency/fuel standards for conventional diesel/petrol-fueled cars and trucks, e.g. maximum fuel consumption or CO2 emissions per kilometer.
- If a replacement rate of 2% per year is assumed until 2030, approximately 24,000 electric cars can replace conventional cars. As a result, ca. 3,500 tCO2 (Indian GEF) or 26,600 tCO2 (Bhutan GEF) can be mitigated until 2030.

Figure 26: Emission reduction through introduction of electric vehicles in Bhutan



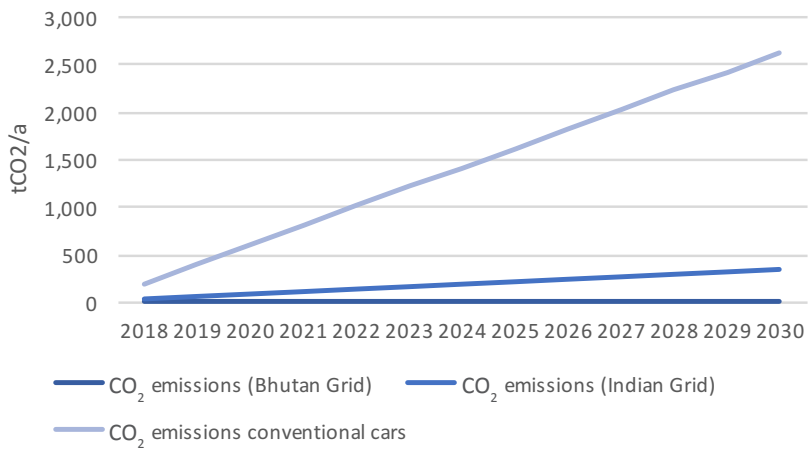
4.2.2 Public mass transit

As with electric vehicles, electricity driven public mass rapid transport could be promoted and improved, including electrical bus-trolley and battery buses for bus operators (e.g., Bhutan Post which runs the city bus service in Thimphu city), Tourism Council of Bhutan, private bus operators and tourist agencies. The NAMA, Enhancing Sustainable Low-Emission Transport in Bhutan, proposes operation of an electric bus line between Paro airport and Thimphu. The bus rapid transit system can reduce the number of trips by car and taxi, resulting in reduced fuel consumption for mobility. Additionally, the use of electric buses will additionally reduce emissions through a fuel switch from fossil fuels to electricity (if electricity is from renewable energies).

Autonomous electric buses[4] could be introduced with an energy storage device (either a battery or a flywheel) located on-board. Alternatively, non-autonomous electric buses that are powered by electric wires or power lines located outside the bus – either overhead or located within the roads on which the bus travels – could be used.

If 10 electric buses are newly introduced per year until 2030, approximately 182,500 trips by conventional cars/taxis could be avoided. As a result, ca. 16,000 tCO2 (Indian GEF) or 18,400 tCO2 (Bhutan GEF) can be mitigated until 2030.

Figure 27: Emission reduction through introduction of electric buses in Bhutan



Further potential mitigation actions that are not assess in detail due to the currently limited potential and the lack of a robust basis for estimating their future penetration include:

- Demand-side management of individual modes of transport and promotion of non-motorized transport. It is difficult to calculate the mitigation benefit of non-motorized transport in the absence of regular traffic counts;
- Ropeway networks, e.g. in Thimphu, Paro and Haa (this would require a study to assess which connections would be attractive to users and investors);
- Railway connection to India (the transboundary character would make an estimate of emission reductions attributable to Bhutan rather complex).

4 For the transport NAMA, viable autonomous electric battery powered bus options are proposed (UNDP/RGoB 2016)

4.3 Mitigation measures and mitigation potential in waste management

4.3.1 Solid waste management

Application of the 3R waste management concept (reduce, reuse, recycle) could be expanded significantly in Bhutan, where recycling is currently developing as a practice.Composting of bio-degradable waste fractions can be done in many sizes and is highly appropriate to small and medium-sized settlements, such as those in Bhutan, as long as the share of organic waste is high and the waste can reliably be segregated at the source. In cold highland areas, composting may be hampered by the low temperatures, while it will work very well in moist sub-tropical and tropical areas.

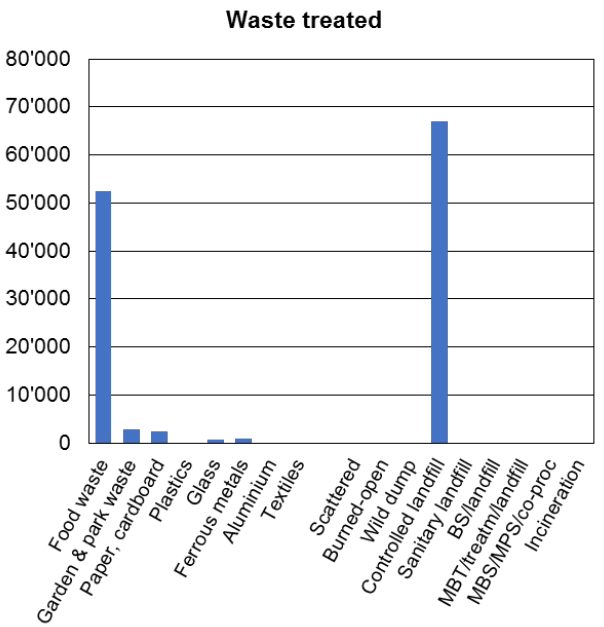
In the long run, production of alternative fuels (Refuse Derived Fuel, RDF) could become attractive, especially as the share of non-organic components in waste increases. RDF can be used, for example, by cement plants to replace fossil fuels such as coal. However, a minimum waste volume is required to justify an RDF production plant and its viability would need to be assessed.

If large, sanitary landfills are used for waste disposal, landfill gas capture and burning can reduce methane emissions from anaerobic processes in the landfill. No Bhutanese city currently has a landfill large enough to justify such an investment, although Thimphu could reach a critical size in the timeframe of this LEDS.

Under the mitigation scenario, the share of recycled non-organic material would increase to 50% in 2030, with 75% of food and 50% of garden waste composted and inert material landfilled.

Figure 28: Amount of solid waste treated in 2030

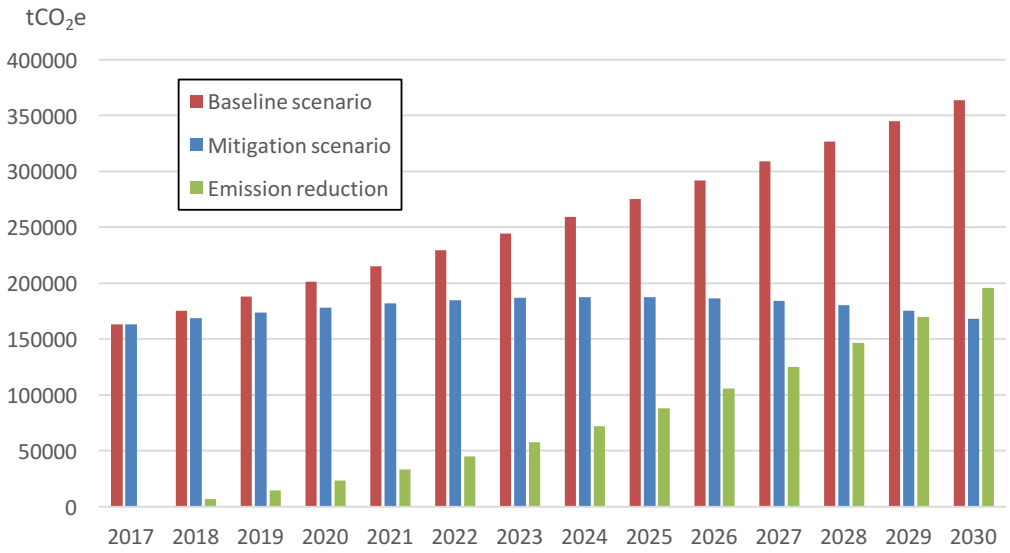
SOURCE: EXPERT CALCULATION, APPLYING IFEU (2009)



Under the assumptions above, the net emission reduction would reach up to 195,500 tCO_2e/a.

Figure 29: Emission reduction from solid waste management in Bhutan

SOURCE: EXPERT CALCULATION, USING IFEU (2009)



4.3.2 Wastewater treatment

As discussed in the section 3.7.4., capture of methane from anaerobic treatment system as well as aerobic treatment of wastewater sludge can eliminate the majority of methane emissions from wastewater treatment.

4.4 Estimation of the abatement costs

Generally, mitigation measures can be categorized into measures that have a significant investment or initial outlay and measures without such an upfront investment. Measures with significant investment can be differentiated further into measures with revenues, e.g. due to energy savings achieved, and measures that do not result in monetary revenues or savings. Due to the low electricity costs in Bhutan of 0.04-0.05 EUR/kWh, the revenues generated through electricity savings from energy efficiency measures are low. Hence, depending on the level of initial investment costs, the marginal abatement cost is higher than in other countries with high electricity prices.

The abatement costs in Table 7 are calculated based on a set of key measures proposed for Phuentsholing Thromde[5].

5 The Phuentsoling pilot project information note can be found in a separate document. Please note that in general data from Phuentsholing appeared to be robust and was used as proxy if no national values have been available.

Table 8: Overview of abatement cost estimations

DATA SOURCE: IFEU (2009)

Measure	Abatement cost in EUR/tCO2[6] (Nu/tCO2)[7]	Payback period (years)
Buildings in cooling load district		
Energy efficiency measures in new buildings	~17 (967)	~5
Efficient air conditioning	> 112 (6,445)	~50
Transport		
Cable car	~34 (1,934)	~11
Waste		
Solid waste composting	~11 (645)	~4
Wastewater treatment	~112 (6,445)	N/A

4.5 Evaluation of sustainable development co-benefits

Mitigation measures do not only result in a reduction of GHG emissions but often contribute to sustainable development. These contributions are referred to as co-benefits. Co-benefits can be evaluated based on a set of criteria and indicators as a way to provide a more complete analysis of a mitigation measure's value. Under the visionary leadership of Their Majesties the Kings, development in Bhutan has always proceeded with people at the forefront, giving equal considerations to Bhutan's rich cultural and natural heritage. The philosophy of Gross National Happiness (GNH) embodies a holistic approach to the development of the well-being of the people, especially in the pursuit of socio-economic development.

Since 1961, Bhutan has followed a regular five-year planning cycle that sets out the country's development priorities and programmes for the upcoming period. GNH has been a guiding principle of this development process. In 2008, efforts were initiated to quantify Bhutan's progress on maximizing happiness by introducing the GNH index. The index is defined by a set of variables that represent happiness of nine different domains: Psychological wellbeing, health, time use, education, cultural diversity and resilience, good governance, community vitality, ecological diversity & resilience and living standards (GNHC 2013b). Bhutan's Five-Year Plans are focused around National Key Result Areas (NKRAs), which are specific target areas that include Key Performance Indicators (KPI). NKRAs are based on national priorities, analysis of the current development situation and stakeholder consultations. Moreover, they are aligned and contribute to one or more of the above mentioned GNH domains.

6 Applying exchange rates of EUR/USD of 0.8916 (average rate of 2017 until June)
7 Applying exchange rate of 64.4507 BTN/USD

Similarly, the Sustainable Development Goals (SDGs) are relevant in the context of mitigation co-benefits. While the NKRAs define the sustainable development priority areas at the national level, the 17 SDGs represent global goals of the international development agenda. Of the 17 SDGs, those related to Affordable and Clean Energy (SDG7), Decent Work and Economic growth (SDG8), Industry, Innovation and Infrastructure (SDG9), Sustainable Cities and Communities (SDDG11) and Climate Change (SDG13) are especially relevant for the Human Settlements LEDS. To identify the co-benefits that are most relevant for the Royal Government of Bhutan and its population, it is sensible to evaluate which co-benefits are reflected by the NKRAs. Screening the NKRAs of the 11thand the 12th five-year plans, a number of co-benefits can be considered aligned with the NKRAs and KPIs (and SDGs) and thus suitable for use in prioritizing mitigation measures (Table 9).

Table 9: Selected co-benefits for prioritization of mitigation measures in human settlements

No	Selected co-benefit	Aligned with NKRA/KPI	Related SDGs
1	Supporting clean development (reduction of air pollution)	(12th 5YP) NKRA 5: Healthy Ecosystem Services Maintained/ Ambient Air quality levels (PM10) (11th 5YP) NKRA 7: Carbon neutral/Green & climate resilient development/Ambient air quality sustained or reduced	SDG11, SDG13
2	Improved public services	(12th 5YP) NKRA 9: Infrastructure, Communication & Public Service Delivery Improved/ Gewogs connected by public transport (12th 5YP) NKRA 9: Infrastructure, Communication & Public Service Delivery Improved/Travel time in trucking hours along the national highway	SDG9
3	Promotion of eco-efficient new technologies	(12th 5YP) NKRA 9: Infrastructure, Communication & Public Service Delivery Improved/Electric Vehicle Penetration	SDG9, SDG11, SDG13
4	Employment created	(12th 5YP) NKRA 11: Productive & Gainful/ National Unemployment Rate (11th 5YP) NKRA 4: Employment	SDG8
5	Improved liveability of human settlements	(12th 5YP) NKRA 15: Liveability, Safety and Sustainability of Human Settlements Improved/ Waste Managed at National Level	SDG11

4.6 Characteristics of rural vs. urban measures

Due to the rapid urbanization in Bhutan, the focus of low-emission development in settlements should lie on urban areas as this helps to prevent "lock-in" of high carbon urban infrastructure. Measures in cities should target primarily buildings and fixed transport infrastructure – through introduction of cable cars, electric vehicle charging stations and/or dedicated bus lanes – as here a lock-in is most difficult to reverse. Shifts in vehicle characteristics may be easier to implement but can be very costly. Unless waste incineration plants are already built, waste management approaches have less risk of lock in but should nonetheless be undertaken rapidly due to the high sustainable co-benefits. As consumption patterns change, e.g., air conditioning penetrates households in the lowlands, mitigation measures need to target the appliances where penetration is increasing significantly.

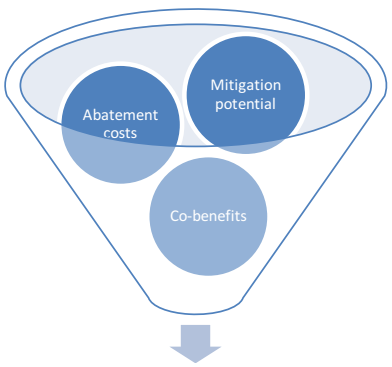
Measures in rural areas should focus on "no-regret" options that are not made obsolete due to movement of people from villages to cities. For example, focus on replacement of less-efficient appliances instead of measures for buildings where long-term use remains uncertain. The replacement of biomass or fossil fuels by electricity, which is now principally possible due to universal electrification, is crucially dependent on the emission factors used for fuelwood and electricity. Use of biogas from livestock can play an important role with regard to cooking and is technically not overly challenging. In the very long run, rural lifestyles will align with urban lifestyles in terms of energy types used and overall level of energy consumption. Due to the dispersed nature of rural settlements in Bhutan, however, the transport sector will play an increasingly important role and be responsible for a significant share of rural emissions.

4.7 Prioritization of mitigation measures

Prioritization of mitigation measures is based on three key categories (i.e., mitigation potential, abatement costs (payback period) and sustainable development co-benefits) as visualized in Figure 30 below.

Figure 30: Prioritization of mitigation measures

SOURCE: EXPERT ELABORATION



The ranking in each category is shown in Table 10.

Table 10: Prioritization approach

Prioritization	Description
+++	Mitigation measure that has a top position in the category analysed.
++	Mitigation measure that has a medium position in the category analysed.
+	Mitigation measure that has a low position in the category analysed.

The ranking of the different mitigation measures and the resulting prioritization as per the discussions with key Bhutanese stakeholders is shown in Table 11.

Table 11: Prioritization of mitigation measures for human settlements in Bhutan

Mitigation measure	Ranking				Recommended for rural or urban settlements
	Mitigation potential	Abatement costs	Sustainable development	Overall ranking	
Solid waste composting	+++	+++	+++	1	Urban + Rural
Buildings: energy efficiency	+++	++	+++	2	Urban + Rural
Waste management (3Rs)	++	++	+++	3	Urban
Efficient streetlighting	+	++	+++	4	Urban
Public transport	++	+	+++	4	Urban
Wastewater management	+	++	+++	4	Urban
Cable cars	++	+	+++	4	Urban
Appliance efficiency	++	+	++	5	Urban + Rural
Electric vehicles	+	+	+++	5	Urban
Solar PV	+	+	+++	5	Urban + Rural
Non-motorized transport	+	+	+++	5	Urban
Biofuels	++	+	+	6	Rural
LFG flaring	+	+	+	7	Urban

5 STRATEGIC POLICIES AND MEASURES TO PROMOTE MITIGATION MEASURES

To address the identified barriers that prevent implementation of mitigation measures in the human settlements sector, it is crucial to apply flexible strategic measures and policy instruments. The following section presents cross-sectoral and sub-sector specific policy instruments that can help deliver the prioritized mitigation options.

5.1 Addressing the financial barriers

The key barrier for all the identified mitigation measures is the additional investment cost for the low-carbon technology options. These investment costs accrue either to citizens (e.g., private building shells and appliances, private vehicles) or to administrations (public building shells and appliances, public lighting, public transport, waste management infrastructure, etc).

The budget for infrastructure at all administrative levels (central government, Thromde, gewog) is severely constrained. Thus, only measures with immediate benefits for citizens can be undertaken by the administrations, which will usually lead to the choice of the lowest investment cost option for a specific kind of public service. Even if mitigation measures have an attractive payback period, there are currently no domestic financing institutions that would be willing to provide third party financing, given that administrations cannot provide securities for loans.

The financing barrier can be addressed through various means, ranging from direct grants to concessional loans to loans at market rates, but with government guarantees. There is no "catch-all" solution. Tailor-made solutions are critical to ensure long-term sustainability of the mitigation options.

Ideally, international climate finance or revenues from market mechanisms are mobilized. Some international climate finance, for example, funding from the Green Climate Fund (GCF) or the NAMA Facility is allocated ex ante, but competition for this type of financing is very strong. Meanwhile, revenues from market mechanisms and "results based financing" will only accrue ex post, i.e., after a certain mitigation volume has been verified and certified. This type of financing will be proportional to the mitigation volume achieved and so it will not cover the additional upfront investment costs. Thus,

Bhutan should pursue a flexible financing strategy that addresses both upfront and ex post financing opportunities.

The most innovative mitigation options that exceed a threshold of 10,000 t CO_2e emission reduction per year and can be mobilized within 1-2 years should be submitted for ex ante financing. If the financing volume is less than 20 million USD and German institutions can be actively brought in, the NAMA Facility would be the first choice. For a multi-sector activity with significant adaptation co-benefits and a volume of 50-250 million USD, the GCF would be a good opportunity. However, it should be noted that the RGoB needs to prioritize which activities to submit to these two funding windows taking all sectors of the economy into account. This is necessary as a country of Bhutan's size will probably only get one project financed from each source. Given the advanced stage of mitigation projects in other sectors, it is unlikely that a human settlements proposal would be prioritised unless it becomes an all-encompassing framework (e.g., an urban NAMA).

As ex post financing is more likely to accrue than ex ante financing, the RGoB should develop a revolving fundthat would provide concessional or even zero interest loans to municipalities and private actors willing to engage in mitigation actions for buildings, transport and waste management. These loans would be paid back through the revenues from ex post financing as well as energy savings. Such a concept requires government money in the short term, and is contingent on forecast ex post financing revenues actually materializing. So, there is some risk for the government if the international carbon market under the Paris Agreement does not take off as expected, or if willingness to provide results-based financing is less than envisaged.

A least-risk approach would be for the government to provide guarantees for domestic loans at commercial rates, and direct Bhutanese banks to provide such loans for mitigation measures that have a payback period that allows the investor to pay back the loan at a profit. This would mean that, at minimum, "no regret" – i.e., profitable – mitigation options would be implemented.

Direct grants could also be provided for mitigation options whose co-benefits exceed the cost of the grant, e.g. in the context of solid waste and wastewater management. However given that grants can lead to a higher risk of technology failure, grants should only be given where it is clear that the technology can be well managed by the responsible entity. Grants could also be linked to a requirement to levy charges. This would ensure proper maintenance of the technology.

5.2 Addressing technological and capacity barriers

Most municipal administrations in Bhutan lack experience with advanced building, transport and waste management technologies. Pilot projects for high-efficiency residential buildings, electric vehicles and composting have encountered challenges in maintaining the technologies in the long run. It is thus crucial to ensure that the entities overseeing the specific technical intervention:

- understand the strengths and weaknesses of the technology;
- can maintain the technology for the envisaged technical lifetime; and
- can adjust the technology to changing conditions, if required.

Any intervention aimed at public sector infrastructure needs to ensure that involved personnel is able to fulfil these three points. Dedicated capacity building is required, ideally with hands-on training on operation of the technology in a real-life setting.

If the technology is operated by third parties, as is the case for solid waste management in Thimphu, the administration needs to be able to assess whether the third party is fulfilling the terms of its contract. Generally, public-private partnerships are encouraged as these improve the effectiveness of public interventions and reduce government outlays, provided they are properly managed.

5.3 Addressing institutional barriers

Given the decentralization of Bhutanese government structures over the last decade, many different institutions are now involved in policy implementation. Central level government institutions have better access to international financing than Dzongkhags, Gewogs or Thromdes. But the 12thFive-Year Plan will provides budget directly to local administrations. Therefore, it will be important to have strengthened coordination mechanisms for the implementation of relevant policies and regulations. International financiers have demonstrated interest to be engaged in Thimphu, which exhibits the largest challenges of urbanization in the whole country. However, it will be important to ensure that policies encourage uptake of mitigation activities in human settlements across the country. Especially for diffuse measures such as improvement of energy efficiency in building shells, fuel efficiency of vehicles, and efficiency of appliances (lighting, cooling and heating), the central government needs to play a key role by deciding on and enforcing efficiency standards. It will be impossible for lower level government entities to decide on such standards on their own.

6 INSTITUTIONAL STRUCTURE FOR IMPLEMENTATION OF STRATEGIC MITIGATION MEASURES

Given the complexity of institutional settings for local administrations in Bhutan, as defined in the Local Government Act of 2009 and the amendments made in 2014, responsibilities for mitigation strategies need to be clearly allocated for each level of government and differentiated as per the level of the intervention.

6.1 Institutional responsibilities

The Gross National Happiness Commission (GNHC), in collaboration with the Ministry of Finance (MOF), is responsible for mobilizing public international and bilateral climate finance for funding of NAMAs and specific mitigation activities. This will be undertaken throughout the duration of the LEDS, and be adjusted as per international developments. These may include changes of allocation of funding to specific finance vehicles, changes in the eligibility of Bhutan for certain forms of financing as Bhutan graduates from the category of Least Developed Countries, and changes in the rules of the international climate policy regime.

The National Environment Commission (NEC) is responsible for design of all NAMAs and coordinates with the responsible line ministry regarding the introduction of policy instruments that aim at mobilization of mitigation under each NAMA. If required by law, NEC submits proposals to the Cabinet or the National Assembly. The NEC also serves as the entity to provide letters of approval to activities that want to generate credits under the Paris market mechanisms.

The Ministry of Works and Human Settlements (MoWHS) coordinates the implementation of cross-Thromde programmes for mitigation measures in the Thromdes under its oversight (i.e., Thimphu, Phuentsholing, Gelephu and Samdrup Jongkhar), such as solid waste management under the proposed NAMA. Similarly, the Department of Local Government in the Ministry of Home and Cultural Affairs coordinates with the Dzongkhags regarding the implementation of mitigation measures. Gewogs take the responsibility for activities that take place exclusively in that Gewog. Likewise, Thromdes are responsible for activities that take place exclusively in that Thromde.

The Department of Renewable Energy (DRE) under the Ministry of Economic Affairs (MoEA) is mandated for planning, coordination and implementation of energy related policies and programmes, acting as the central coordination agency and the focal point of RGoB on all matters related to renewable energy development and energy efficiency initiatives.

The Ministry of Information and Communication coordinates transport-related activities, with Bhutan Post being responsible for activities linked to city bus systems. Over time, the final responsibility for operating city bus systems should transition to Thromdes.

For more detailed information on roles and responsibilities, please refer to Annex 1.

6.2 Institutional activities andtimeframes for mobilization of mitigation under the LEDS

The LEDS for urban and rural settlements is an overarching framework. Other strategies such as the LEDS for the transport sector and for energy efficiency, as well as NAMAs for waste and buildings, form a part of the implementation actions of the framework. Some of the institutional activities and the corresponding timelines are described below. An illustrative work plan is attached in Annex 2.
Within one year, the following activities will be undertaken:

- NEC provides guidance on mitigation actions in human settlements in Bhutan, which can be utilized by line ministries and local administrations.
- MoWHS will make a survey for prioritizing mitigation actions in the Thromdes under its supervision, while the Ministry of Home Affairs coordinates a survey in all Dzongkhags to identify and prioritize mitigation actions outside the large Thromdes.
- The GNHC prioritizes sources of international and bilateral climate finance and selects specific activities for proposals to those climate finance institutions.

After three years, an evaluation of volumes of international/bilateral climate finance mobilized will be made by GNHC and NEC. Such an evaluation will be repeated every three years.

Within four years, the Cabinet will introduce efficiency standards for buildings, air conditioners and vehicles of all categories and direct the relevant line ministries to enforce these standards. These standards are to be updated every five years.

Within **five** years the following activities have been achieved:

All Thromdes under the supervision of MoWHS, and other Thromdes that reach similar degrees of urbanization, will:

- levy a fee to cover the operational costs of solid waste segregation and composting and methane collection from sewage;
- fully segregate waste at the household level and recycle the non-organic fractions or process into RDF;
- collect methane from anaerobic sewage treatment ponds and flare it;
- routinely procure appliances of the highest Indian BEE star rating;

- operate a city bus system and encourage mass transit; and
- have a linked system of footpaths that is separate from the road space used by vehicles.

Every five years, a new prioritization of mitigation options will be undertaken.

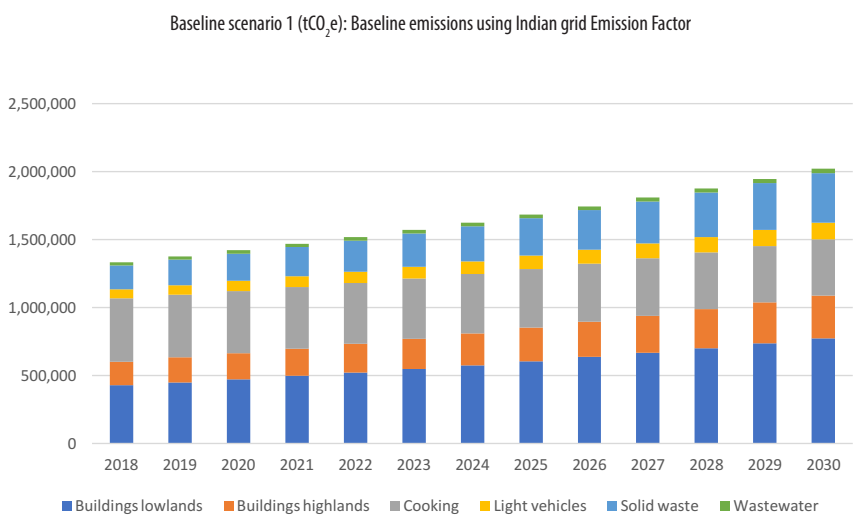
Within **ten** years, all public administrations that operate vehicle fleets will procure new vehicles that do not directly use fossil fuel for a significant share of their energy need.

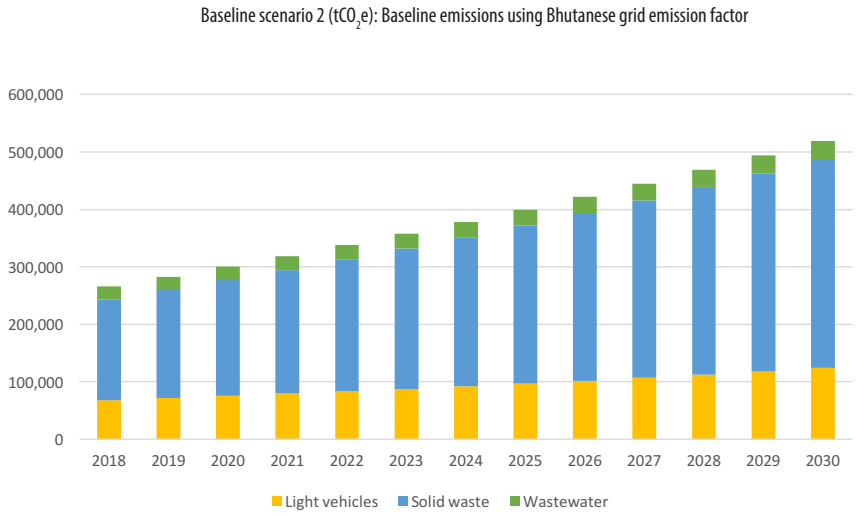
7 CONCLUSIONS AND RECOMMENDATIONS

GHG emissions from human settlements in Bhutan are increasing rapidly and becoming significant. These emissions accrue primarily in the three sectors: buildings, transport and waste management. While a number of high-level policy documents exist that could mobilize GHG mitigation, international support is important to increase the momentum for these actions. In this context, a number of NAMAs have been developed for the three sectors, but their implementation is contingent on international climate finance, which has not yet been mobilized.

This LEDS for the first time undertakes a detailed sub-sectoral assessment for a GHG emissions baseline for human settlements for the period until 2030. Two baseline scenarios have been developed – one applying the Indian grid emission factor for electricity and the carbon content of fuelwood, the other one applying a Bhutanese zero emission factor for electricity and fuelwood. The difference between these scenarios reaches a factor of three (Figure 31).

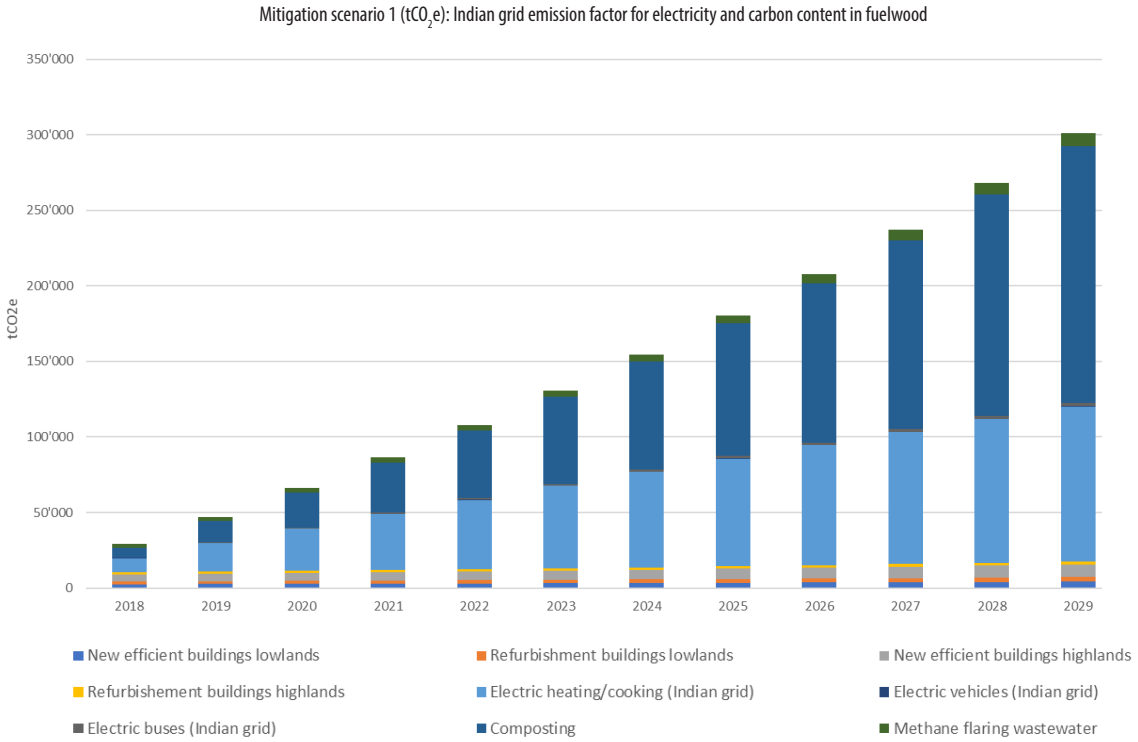
Figure 31: Overall emissions baseline of human settlements in Bhutan until 2030

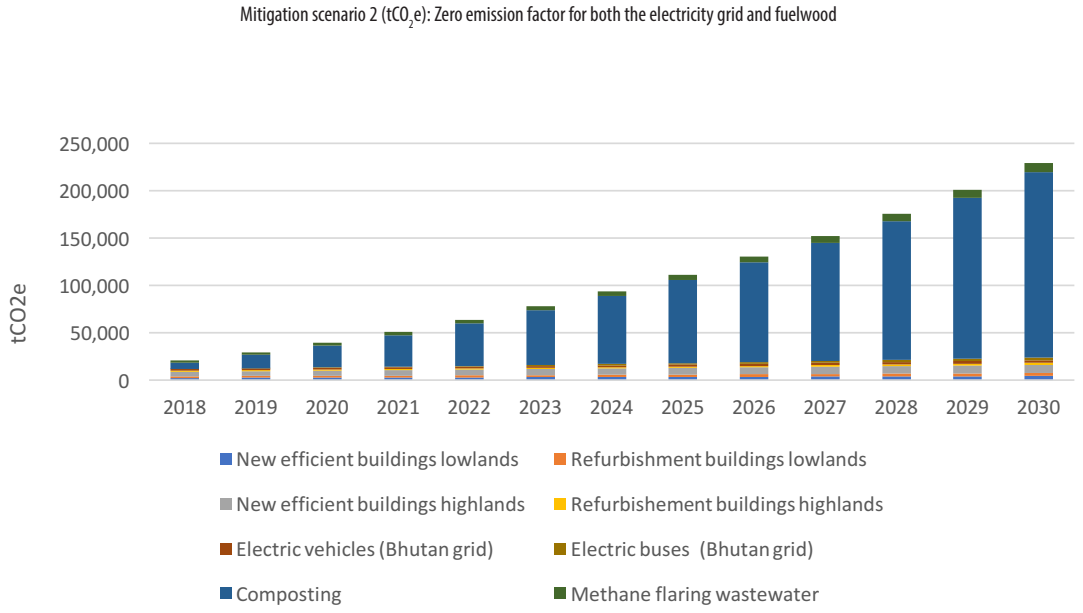




A detailed assessment of the mitigation potential during the timeframe 2018-30 finds a high potential for the solid waste sector. The mitigation potential in the buildings and transport sectors depends on the electricity grid and fuelwood emission factors used. In both scenarios, the potential is approximately four times lower than the potential of the waste sector. Improvement of efficiency of electric appliances in buildings would not generate mitigation benefits in the first scenario, while replacement of fuelwood through electric cooking would have an initially high, but later declining, potential.

Figure 32: Overall mitigation potential from human settlements in Bhutan until 2030





Given the NAMAs and project ideas for mitigation in the human settlements sector that are already in place, strong coordination of the climate finance outreach by the RGoB and engagement of all levels of government is crucial to successfully mobilize financing.

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ANNEX 1
ROLES AND RESPONSIBILITIES OF EXISTING INSTITUTIONS/AGENCIES RELEVANT TO HUMAN SETTLEMENTS

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

Ministry of Economic Affairs (MoEA)
The Ministry of Economic Affairs (MoEA) has a mandate to set economic development agenda of the country. As the custodian of EDP 2010 and FDI policy of 2010, the ministry promotes a "green and self-reliant economy". The Department of Renewable Energy (DRE) under the Ministry is mandated to plan, coordinate and implement energy-related policies and programmes. DRE was established in December 2011 to serve as the central coordination agency and the focal point of RGoB on all matters related to renewable energy development and energy efficiency initiatives in the country.

Divisions under the DRE:

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

Planning and Coordination Division (PCD): PCD is involved in formulation of policies and regulations for renewable energy and energy efficiency and conservation, and responsible for planning and coordination of programmes and initiatives on renewable energy and energy efficiency. PCD is also mandated to administer and implement subsidy programmes and initiatives on renewable energy and energy efficiency and conservation. Techno-economic clearances and technical sanctions for renewable energy projects are routed through this division. The division is also responsible for energy data collection and analysis.

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

Ministry of Works and Human Settlement (MoWHS)

The Ministry formulates policies and develops plans related to physical infrastructures and human settlements. It develops and implements related acts/regulations/standards, is engaged in capacity building of technical human resources, and sets policies to promote appropriate construction. Finally, the Ministry promotes research and development that would serve to maintain a synergy between technology, environment and traditional values and develops plans and policies for proper human settlement through growth centers. The MOWHS has three main technical Departments: the Department of Roads, the Department of Engineering Services and Department of Human Settlement.

Ministry of Labour and Human Resource (MoLHR)

The Ministry is in charge of developing skills sets for economic development to ensure gainful employment for all Bhutanese. Under the Department of Human Resources, the Ministry has eight technical and vocational education training (TVET) institutes, offering number of specialized technical skill development courses. These institutes are spread all over the country, reflecting the need for balanced regional development.

Ministry of Finance

The Ministry is mandated to formulate and implement dynamic fiscal policies and sound financial management through maximization of resource generation, efficient allocation, prudent expenditure and debt management, and proper accountability of public resources. The Ministry aims to steer and sustain a robust economy through a dynamic fiscal policy and strong culture of fiscal discipline.

Ministry of Agriculture and Forests (MAF)

The Ministry has a mandate to enhance rural livelihoods and therefore pursues a number of activities that will improve economic returns for rural agro-based enterprises. This includes application of production boosting technologies, mechanization of farming, reduction of post–harvest losses, reduction of losses incurred by pest and diseases, application of information and communication technology, and improvement of vital farm infrastructure and production inputs.

National Environment Commission (NEC)

The NEC is a high level multi-sectoral body, chaired by the Hon'ble Prime Minister, and with representatives from various ministries, NGOs and the private sector. It is responsible for coordinating all the matters relating to the protection, conservation and improvement of the natural environment. One of the core functions of the NEC is to ensure that socio-economic development activities are planned and executed with minimum adverse impact to the environment and human health. NEC also has a mandate to coordinate climate actions across various sectors, including waste.

Gross National Happiness Commission (GNHC)

GNHC is charged with promoting coherence and collaboration during formulation and implementation of all government policies, irrespective of their origin, including reaching out to stakeholders. This is to ensure that GNH is mainstreamed into the planning, policy making and implementation process by evaluating relevance to the GNH principles of:

i. Developing a dynamic economy as the foundation for a vibrant democracy;
ii. Harmonious Living – in harmony with tradition and nature;
iii. Effective and good governance; and
iv. Our people: investing in the nation's greatest asset.

Ministry of Information and Communication (MOIC)

The Ministry is the apex body responsible for all policies and regulations relevant to the development of the transport sector in Bhutan.

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

ANNEX 2
IMPLEMENTATION PLAN FOR MEASURES IN HUMAN SETTLEMENTS LEDS

Focus area	2017				2018				2019			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Overarching LEDS framework		NEC provides guidance on mitigation actions for human settlements, which can be used by line ministries and local administrations.										
		MoWHS makes survey for prioritising mitigation actions in the Thromdes under its supervision.										
		MoHA coordinates survey in all Dzongkhags to identify and prioritise mitigation actions outside the major Thromdes.										
		GNHC prioritises sources of internatioanl and bilateral climate finance and selects specific proposals for those funding sources.										
Buildings		Introduce efficiency standards for buildings, air conditioners, and vehicles of all categories. Cabinet directs the relevant line ministries to enforce these standards.										
			Initiate EE building code (study and awareness raising on EE building standards).									
						Routinely procure appliances of the highest Indian BEE star rating.						
			Implement EE upgrades (installion of LED lighting in residential, institutional and commercial buildings).									
Waste												
					Capacity building, awareness raising and outreach.							
					Implementation of NAMA at selected sites.							
				Undertake feasibiltiy study on RDF production.			Set up RDF plant if seen as viable.					
										Monitoring and reporting.		
Transport					Introduce electric buses.							
					Installation of quick EV chargers for Thimphu-Paro-Phuentsoling route.							
					Introduce EVs within government fleet, police cars, and public transport.							
		Undertake feasibility study on cable car systems.					Develop cable car system if suitable location identified in feasibility study.					

2020				2021				2022			
Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
GHNC & NEC evaluate volumes of international/ bilateral climate finance mobilized (every 3 years)										Reprioritize mitigation options (every 5 years)	
Develop EE building code of practice , build capacity of relevant stakeholders, awareness raising and roll out of EE standards.											
								Implement EE building standards.			
								Certify EE buildings.			
Levy waste fee to cover operational costs of waste segregation and compositing, as well as methane collection from sewage (all Thromdes).											
Fully segregate waste at household level and recycle the non-organic fractions or process them into RDF.											
Collect and flare methane from anaerobic sewage treament ponds.											
Operate a city bus system: infrastructure development, renovation of existing bus stops and terminals, and development of new bus stops.											
Introduce new fleet and reduce headway (time between buses) to 10 minutes.											
Introduce a linked system of footpaths that is separate from the road space used by vehicles.											
Expansion of quick-charging stations: total of 150 to be installed in Bhutan.											
Expansion of EVs within government fleet, police cars, and public transport.											
			Further expansion of cable car systems.								

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