Energy Efficiency

in

Transport Sector

Department of Renewable Energy

Ministry of Economic Affairs

Royal Government of Bhutan

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Disclaimer:

This report is intended solely for the purpose of drafting the Bhutan Energy Efficiency and Conservation Policy. It provides an outline of energy consumption in the Transport Sector. Relevant agencies may use this report as a source of information on Energy Efficiency in Transport Sector in Bhutan. However, professional advice must be sought for making decisions or implementing the recommendations. The Department of Renewable Energy and Ernst & Young LLP accepts no responsibility for any loss arising from any action taken or not taken by anyone using this report.

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List of Abbreviations

ADB	Asian Development Bank
BAU	Business As Usual
BEV	Battery Electric Vehicle
BRT(S)	Bus Rapid Transit (System)
CBA	Cost-Benefit Analysis
CO	Carbon monoxide
DRE	Department for Renewable Energy (of Bhutan)
ECMT	European Conference of Ministers of Transportation
EE	Energy Efficiency
EV	Electric Vehicle
FSI	Floor Surface Index
GDP	Gross Domestic Product
GJ	Giga Joules
GHG	Green House Gas
GIZ	Gesellschaft für International Zusammenarbeit (German Agency)
HC	Hydro carbon
IPCC	Intergovernmental Panel on Climate Change
JICA	Japan International Cooperation Agency
kl	Kilolitre
kWh	Kilo Watt Hour
LPG	Liquid Petroleum Gas
MJ	Mega Joules
MCA	Multi-Criteria Assessment
MOIC	Ministry of Information and Communications
MPT(S)	Multimodal Public Transport (System)
NMT	Non-Motorized Transport

NOx	Nitrogen Oxides
NPV	Net Present Value
NTA	National Transport Authority
OECD	Organization for Economic Co-operation and Development
PBS	Public Bicycle Sharing
PHEV	Plugin Hybrid Electric Vehicles
PIS	Passenger Information System
PM	Particulate Matter
PR	Public Relations
PT	Public Transport
PUC	Pollution Under Control
RSTA	Road Safety and Transport Authority
RZ	Restricted Zone
SOx	Sulphur Oxides
SPE	Special Purpose Entity
SPV	Special Purpose Vehicle
SSEFF	System Selection and Eco-Friendly Feasibility report
SUV	Sport Utility Vehicle
tCO_2	Ton of Carbon dioxide
TDM	Travel Demand Model
TSP	Thimphu Structure Plan
UNEP	United Nations Environment Programme
USD	United States Dollar

Executive Summary

Being a developing country, the demand for transport service is increasing in Bhutan, thus escalating the use of energy. Also, due to rural-urban migration and urban growth, people's need to travel is increasing as well as the car ownership of Bhutan's emerging middle class. This increase in energy consumption is happening in a global era of environmental, economic and social challenges. Climate change, limited oil resources, increasing energy prices, environmental pollution and health risks are issues that all countries in the world need to address.

In the last 10 years, Bhutan has witnessed a multifold increase in vehicle ownership, consumption of energy by transport and the expected impacts of increased pollution, congestion and accidents. The business-as-usual scenario will see the same trends leading to increasing allocation of foreign exchange to buy fuel for the transport sector. A comprehensive audit of the existing vehicular fleet, and the condition of the roads was carried out in this study to establish and quantify the baseline regarding the energy consumption by the transport sector. Additionally, willingness to shift to electric vehicles was also studied since it would establish the feasibility of looking at the introduction of electric vehicles as one of the solutions.

This report on Energy Efficiency in Transport Sector intends to provide recommendations in order to plan and implement an energy efficient transport system in Bhutan with the aim to reduce energy consumption, emissions, and increase the energy security of the country. To achieve this, the strategies in this document are based on different levels of energy efficient interventions: individual vehicles (vehicle efficiency), trips (travel efficiency), as well as the whole transport system (system efficiency). Strategies corresponding to these levels can be described as:

1. Shifting demand to more energy efficient modes of transport like;
    a. Mass transport
    b. Non-motorised transport

2. Shifting to the use of more energy efficient vehicles and methods;
    a. Provision of electric vehicles like electric and hybrid buses, cars and two-wheeler
    b. Providing eco-driving training to drivers to further minimise the energy consumption

This report also summarizes the interventions suggested for these strategies and their respective direct energy saving benefits.

Intervention	**Brief description**	**Energy savings (GJ)**	**Emission reduction (t CO_2)**	**Net Present Value (Nu. (Million))**
Transit planning	Public transport (PT) can move more number of passengers than private cars thus resulting into low per capita energy consumption. Therefore, it is essential to have reliable PT services for inter and intra city movement in Bhutan.	965,950	50,230	781
Non-motorized transport planning	State of the art non-motorized transport (NMT) infrastructure encourages people to cover short distance trip by walking or cycling. Walking and cycling	1,454,187	127,161	548

Intervention	Brief description	Energy savings (GJ)	Emission reduction (t CO_2)	Net Present Value (Nu. (Million))
	both are zero energy consumption modes. Thus, in tandem with mix land use planning and accessible PT system, NMT provides highly energy efficient transport system.			
Electric vehicles	During operation, the Energy Efficiency of electric vehicles is much higher than that of conventional cars and they do not emit any CO_2 or other pollutants while driving. At the local level, improved air quality and reduced noise are major advantages of electricity as a fuel.	4,016,84	287,627	-0.87 to -1.26
Eco driving training	The way in which a vehicle is driven or maintained has a direct impact on fuel consumption, and subsequently on emissions. Through the provision of 'Eco-Driving' education and training, driver behavior may be altered to achieve greater fuel efficiencies.	13,295	11,362	14.30 to 38.51

Note: Energy savings and emission reduction figures are on an annual basis.

All these interventions are complementary and have to be implemented strategically. Although not a very viable option as of date, increasing taxes on fuel will discourage the use of private vehicles. Before the tax increments take place, NMT infrastructure and an efficient public transport have to be provided. It will thus allow private vehicle users to shift to these energy saving modes of transports for short and medium trips. Moreover, the introduction of electric vehicles and Eco-Driving trainings of bus drivers will improve Energy Efficiency of the overall transport system.

1. Introduction

Like all developing countries and emerging economies, Bhutan is experiencing a rapid increase in demand for transport energy. Urbanisation causes transport needs to expand as the emerging middle class aspires to the use of private motor vehicles. This means that fuel consumption is also escalating. It is therefore of critical and urgent importance to establish an efficient transport system that meets demand, but consumes as little energy as possible. This is important as the fast and safe transportation of people and goods is a pre-requisite for economic growth. Considering the challenges of climate change, limited oil resources, increasing energy prices, environmental pollution and health risks, it is essential to take the right path in order to cope with the rapidly growing demand for transport. The starting point is to understand the context of development and growth in Bhutan and the transport challenges this brings.

The transport system in Bhutan consists mainly of road and air transport services. Road transport is the most commonly used internal transport mode in Bhutan. The near absence of alternative modes of transport such as railways and navigable rivers within Bhutan reinforces the dominance of road transport for passenger and freight movement in Bhutan's overall transport system. The air transport system supports the heavy tourist attraction and business travellers from abroad. Transport sector is one of the major consumers of energy in Bhutan and, specifically, almost all the energy used in the sector is derived from imported fossil fuels. Being a developing country, the demand for transport is increasing in Bhutan, thus escalating the use of energy. Also, due to rural-urban migration and urban growth, people's need to travel is increasing as well as the car ownership of Bhutan's emerging middle class. This increase in energy consumption is happening in a global era of environmental, economic and social challenges. Climate change, limited oil resources, increasing energy prices, environmental pollution and health risks are issues that all countries in the world need to address.

This document intends to provide recommendations in order to plan and implement an energy efficient transport system in Bhutan with the aim to reduce energy consumption, and emissions, and increase the energy security of the country. To achieve this, the recommendations in this document are based on three levels of energy efficient interventions: individual vehicles (vehicle efficiency), trips (travel efficiency), as well as the whole transport system (system efficiency). Strategies corresponding to the three levels are described as:

- **Vehicle efficiency:** reducing or avoiding travel distance or travel needs by simplifying and optimizing the infrastructure organization of human activities.

- **Travel efficiency**: making people shift to less energy-consuming mode of transports like public transport or non-motorized transport.

- **System efficiency**: improving the overall transport system by optimizing vehicle operations and implementing technology of vehicle fleets.

This document is based on primary survey conducted for the study to develop the baseline scenario of fuel efficiency amongst the different modes of transport and infrastructure. The baseline was used to develop strategies and recommend interventions which will lead to an energy efficient mobility future for Bhutan. The interventions recommended have been assessed for cost-benefit analysis and their potential for reduction in energy consumption and emissions leading to development of a decision-making support tool for policymaking in Bhutan.

The strategies listed in this document include improving public transport, improving the taxi services, reducing vehicle ownership, improving conditions of walking and cycling, lowering emission from vehicles, developing compact city and sustainable urban planning. A framework is set for preparing Energy Efficiency plans at different scales, by focusing on the coordination of different processes and depending on funding, phasing, priority and impact maximizations. A special focus is on the phasing in of electric vehicles.

2. Transport Sector in Bhutan

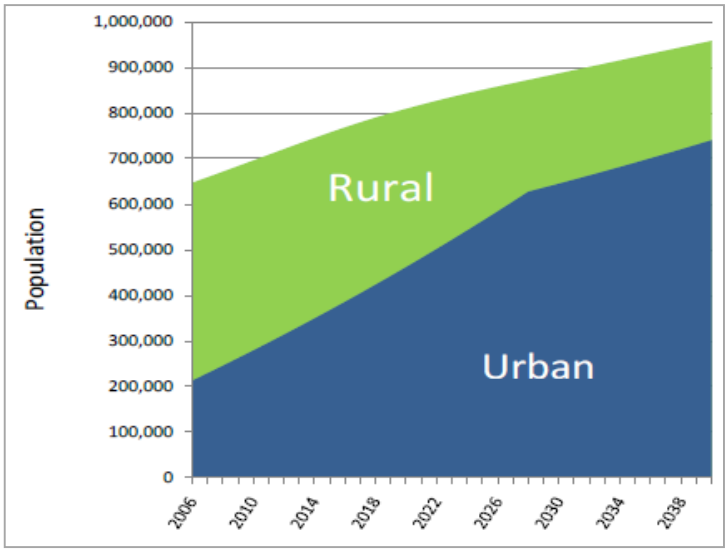
The transport sector almost entirely depends on diesel and petrol to meet its energy requirements and has recently started using electricity in the transport sector as it has introduced electric and hybrid-electric vehicles with tax exemption on plug-in electric vehicles. With the penetration of electric vehicles, electricity also accounts as fuel consumed in this sector with total registration of 61 electric vehicles noted till December 2014. Although the hybrid electric vehicles are not exempted from tax, the tax rates are lower compared to the conventional vehicles. The Ministry of Information and Communication (MoIC) is the apex body responsible for all policies, regulations, and development of Transport Sector in Bhutan. Other government and non-government institutions involved are Project Dantak of the Border Roads Organization of the Government of India, and the Department of Roads under the Ministry of Works and Human Settlement (MoWHS), which are responsible for the construction and maintenance of the roads, Druk Air Corporation and Tashi Air Private Ltd. (trading as Bhutan Airlines), which are the only two airlines in the country, Bhutan Postal Corporation Limited (Bhutan Post), which runs the city bus service in Thimphu city, the Tourism Council of Bhutan; and private bus operators and tourism enterprises. In order to streamline the transport system, all types of motor vehicle related activities, including registration and licensing, road worthiness, emission tests, control over taxis, passenger transport services and other commercial vehicles, were consolidated under the Road Safety and Transport Authority (RSTA) since the beginning of 1997.

1.1. Mobility issues of urbanization

Urbanisation

In 2005 Bhutan's population was mostly rural with 69% people living in rural areas. However, with rapid urbanization, this percentage is expected to reduce to 23% by 2040. Figure 1 shows the expected changes in rural and urban population between 2006 and 2040.

Figure 1: Urban & Rural Population Forecasts (Bhutan) 2006-2040



Source: Strategy for Gross National Happiness 2008

The above graph provides base information for the reducing rural population and migration to urban areas, which will have an impact on number of trips in urban areas.

According to Bhutan Transport 2040 Integrated Strategic Vision report, growing population in Bhutan will be approaching 1 million by 2040, with an estimated 300,000 living in Thimphu. While

the entire country will face this rural-urban migration, Thimphu will experience the effect of it more than any other city in the country.

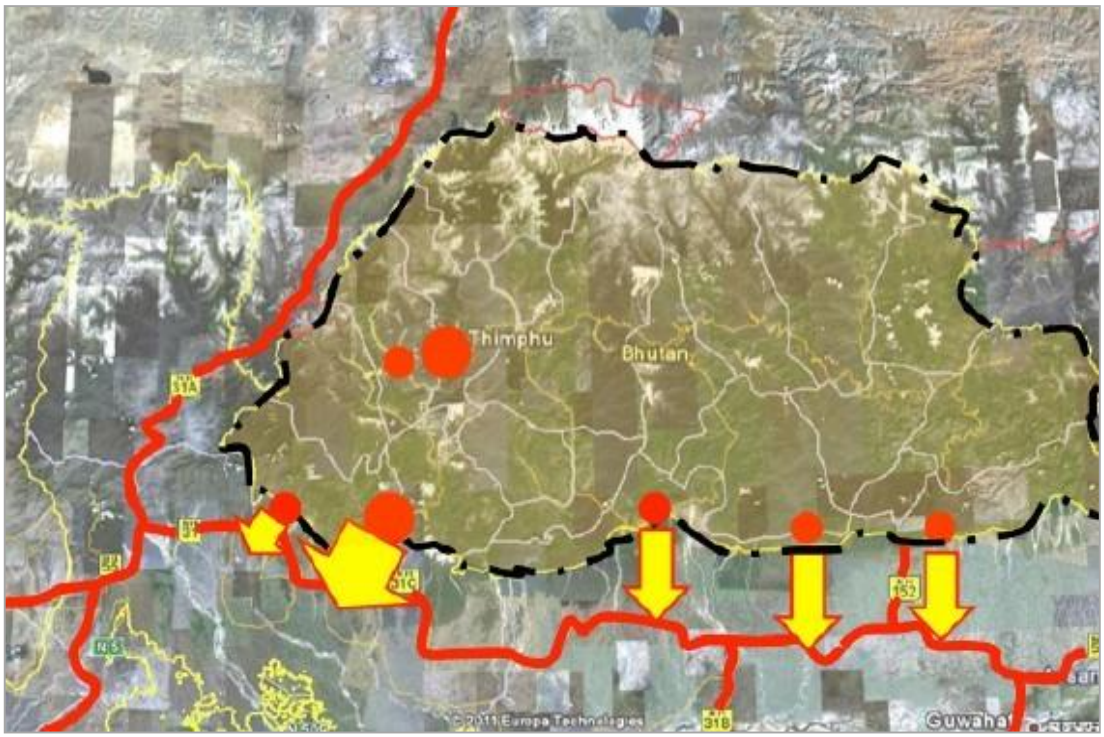
Road and network challenges

The Royal Government of Bhutan has started to open the country to the world. This means more freight traffic and more tourism. At the same time, cities are dealing with rural-urban migration. This will have a threefold impact on travel:

- There will be additional travel demands within cities;
- The inter-city travel demand will increase; and
- Serving remote rural population will be financially more difficult because of decreasing numbers, as discussed in the previous section.

From 2010 to 2020, the traffic is expected to double and increase by eight times by 2040. Already heavily trafficked roads (Thimphu-Phuentsholing) need to cater to this increasing demand. Without any change, they could carry in excess of 8,000-10,000 vehicles per day by 2040. This expected traffic will make the road more and more congested, the speed could reduce to unacceptable levels and impact human activities. For instance, this means delay in the increasing commercial traffic of Bhutan. Rural-urban migration will increase the number of inter-urban travels, and the non-supplied rural demand in transport will still remain. Cross-border roads will suffer from pressure due to the increasing international trade (refer Figure 2).

Figure 2: International Linkages



Source: MMA Group, Bhutan Transport 2040Integrated Strategic Vision,2011

The size of the red circles illustrates the significance of the freight crossing posts.

The size of the arrows illustrates the significance of the cross-border trade.

Passenger transport challenges

Bus services face many issues that prevent its development. They are all related to the mountainous terrain, the scattered population and poor standard of the road network.

- Mountains, limited road network and poor road quality make travelling slow and uncomfortable whether by taxi or intercity bus;
- There are currently only 5 bus terminals in the country (Thimphu, Phuentsholing, Gelephu, Samdrup Jongkhar and Mongar). Even if the roads are motorable, some cities are still not connected by inter-city buses, hence people depend on private car and taxi, or just don't travel;
- The lack of network coverage or unreliable bus frequency force commuters to pay high fare through taxi or private cars;
- Bus services in rural areas need to be implemented since demand is not catered in many Dzongkhags;
- The bus network is limited partly because of the lack of subsidies on non-profitable routes.

To summarise, there lies an opportunity for Bhutan to improve the public transport system and hence improve overall Energy Efficiency for Transport Sector.

Freight transport & regional connectivity challenges

The lack of facilities, the lack of regulation and management of freight transport leads to serious concerns in this sector. Due to high freight rates, the price of goods is higher and Bhutan loses its economic competitiveness. Being a landlocked country doesn't enhance the logistic market, but organizing its logistic industry would at least lead to lower freight rates. There is a lack of dry ports and warehouse facilities in the inner country, and no containers traffic seen. Truck management needs to coordinate the use of trucks: for instance, large construction projects, like hydro-power plants, absorb most of the supply distorting trucks demand for the transport of consumer goods and agricultural products.

With regard to regional connectivity, Bhutan needs balanced arrangements and bilateral agreements for trade and transit with neighbouring countries. This is necessary to streamline the Bhutanese logistic sector. Figure below presents the current main regional trading connections.

Figure 3: Location of Bhutan and Main Trading Connections

Source: MMA Group, Bhutan Transport 2040 Integrated Strategic Vision, 2011

Urban transport challenges

Thimphu's populations expected to be threefold the actual level by 2040, and between 2001 and 2009 the number of cars has almost doubled every 5 years. More and more households own their private vehicles. The number of trips is forecasted to increaseby4 folds by 2030, and the experience in Asia, as in most parts of the world, shows that after buying a car, individuals tend to choose car trip instead of other transport modes trip - mostly because of social status of cars. Moreover, the low prices of car market (imported from India or Korea), along with easily obtained financing, make car ownership easy, thus leading to traffic congestions, pollution and environmental degradation.

Historically, Thimphu was a walk-based trip city, and remains at a pedestrian scale. However, letting car use increase in an uncontrolled manner, and not encouraging pedestrian, bicycle and bus use, will lead to negative impacts of urban growth. The urban spatial and social fabric is threatened by the over growing number of vehicles and the increasing need of road-space. There is a need to implement integrated transport solutions to mitigate this situation.

Current policy scenario affecting transport and mobility

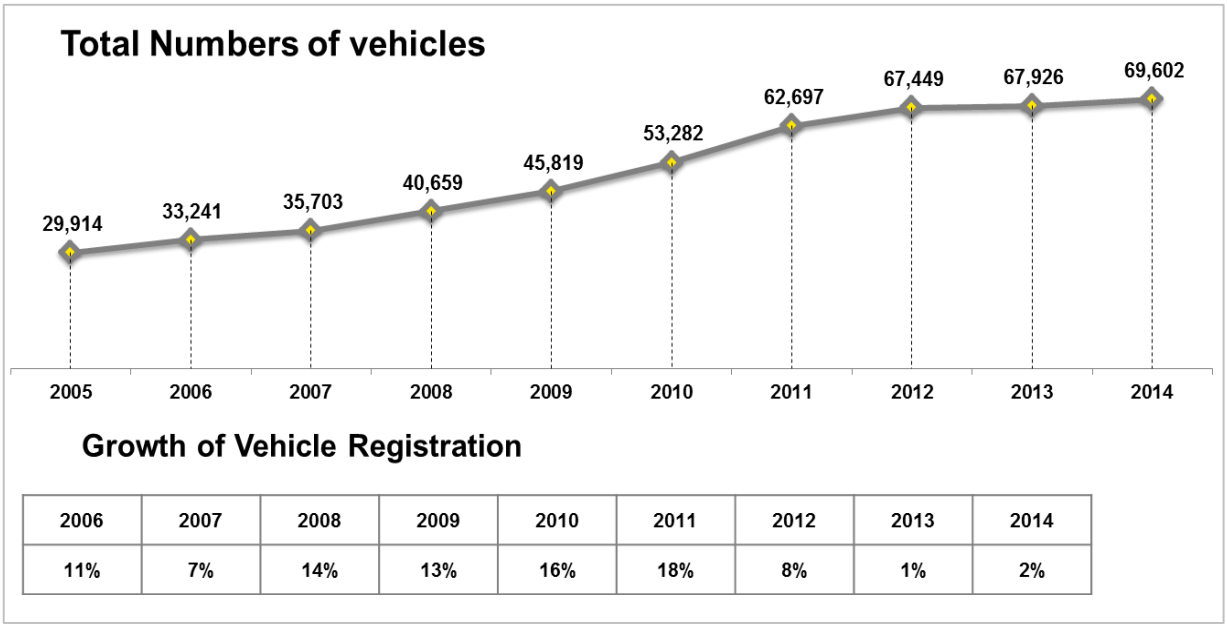
There are several National policies that will have an impact on the transport system in the country. Some of these are listed below:

- Bhutan has planned new hydropower projects and will export its electricity production to India. This policy will create a huge impact on transportation: higher numbers of heavy vehicle will ply the road to build hydropower plants. Then, the wealth created by the export of electricity and hydropower plants construction will boost GDP. The income per capita will rise significantly and thus lead to higher vehicle ownership;
- Industrial development in the south, especially for export-oriented industries, will bring higher traffic of heavy vehicles on Bhutan-India road network;
- Regional connectivity, once improved, will increase the level of trade, and so the use of heavy vehicles on Bhutan's roads;
- Under the Gross National Happiness and poverty reduction policy, Government has connected all Gewogs through a major programme of Feeder Road and Farm Road construction except for very far flung Gewogs like Gasa. Rural electrification is being accelerated as well;
- Branding Bhutan label as per the EDP 2010 promotes the development of the country's comparative advantages. This will also include high level of transport services, innovation and green transport.

2.2. The Business as Usual Future

The number of vehicle in Bhutan has steadily increased since 2005. From March 2012, temporary prohibition on the import of vehicles reduced the annual growth rate from 17.5% in 2011 to 7.6% in 2012.However the annual growth rate of vehicle numbers is 11% between 2001 to 2011, which has led to the increase in vehicle numbers - from 20,000 to 70,000 in 10 years. Figure 4 presents the vehicle growth trend between 2005 and 2014.

Figure 4: Vehicle growth trend, 2005-2014



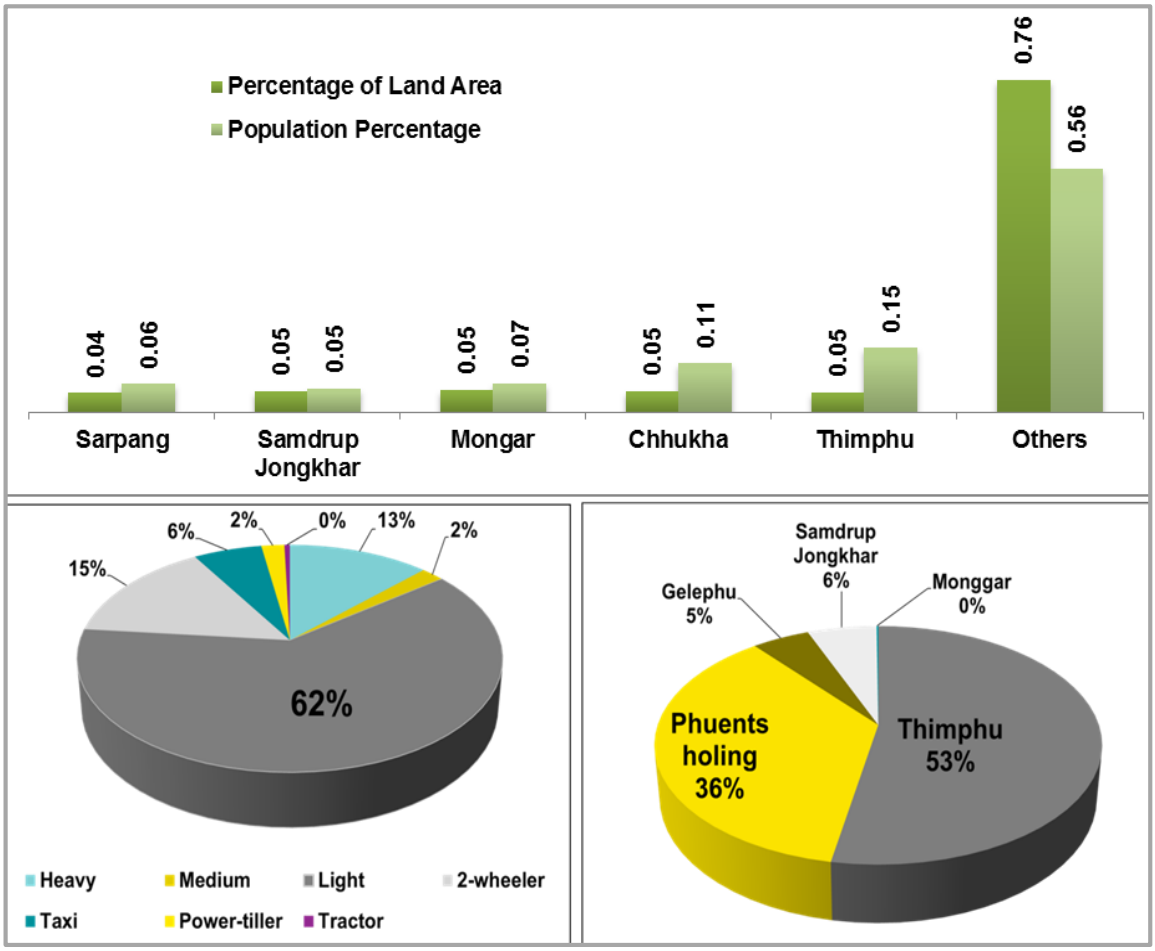
Source: Developed from Annual InfoComm and Transport Statistical Bulletin, 2015

The vehicle population characteristics in Bhutan can be characterized as follows:

- In terms of regional vehicle distribution for registration, 53.2% of total vehicles are registered under Thimphu region, 36.2% under Phuentsholing region, 4.7% under Gelephu region, 5.96% under Samdrup Jongkhar region and very few in Mongar1.
- The total number of vehicles increased from 67,926 in 2013 to 69,602 in 2014, an increase of 2.46% from last year whereas there was a huge dip in the total number of taxis from 5,191 in 2013 to 4,109 in 2014 accruing to a decrease of 20.8% from the last year2.
- The reason behind the decrease in taxi numbers is the heavy tariff on import of vehicles, ban of taxi licence and completion of operation limit of vehicle registered as taxi.
- By vehicle types, light vehicles, which mainly include small four-wheelers, make up around 62% of the entire vehicle population in the country followed by two-wheelers (15%) and heavy vehicles and sedans (13%).
- Considering the total population of the vehicles in the country, the aggregate growth in the number has hemmed in due to the heavy tariffs. The growth in the numbers have fallen from 16% and 18% in 2010 and 2012 to 1% and 2% in 2013 and 2014 respectively, resulting in a flatter slope in the growth curve in the figure below.
- From 2012 to 2014, only 2,153 vehicles were added to the entire vehicular population at large.
- Given the share of land area and population distributions, the vehicle registration trend has shown correspondence.

[1]Annual InfoComm and Transport Statistical Bulletin, 2015
[2]IBID

Figure 5: Segregation of Vehicle Numbers by Type, Population and Registration Region in Percentages

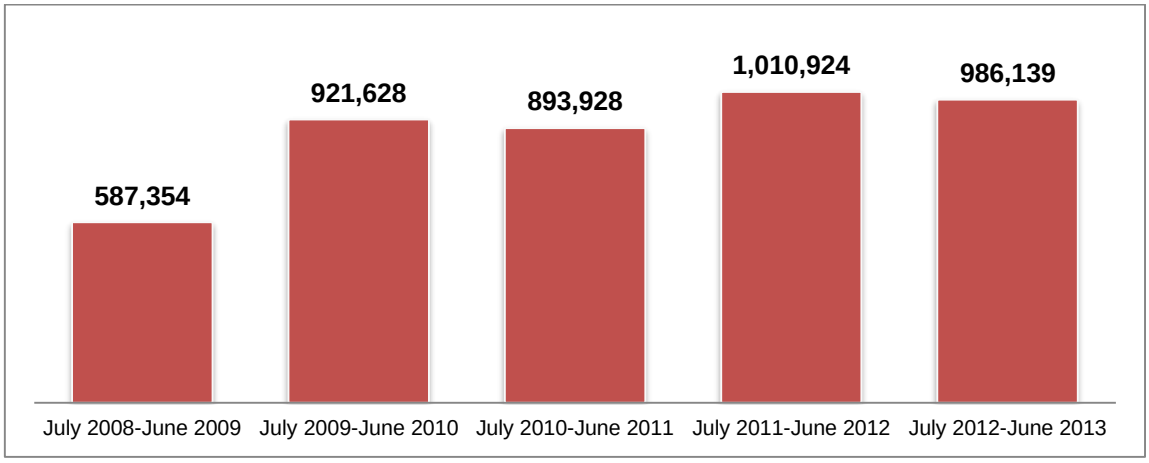


	Sarpang	Samdrup Jongkhar	Mongar	Chhukha	Thimphu
Percentage of Land Area	4.3%	4.9%	5.1%	4.9%	4.6%
Population Percentage	6.4%	5.4%	6.5%	11.2%	14.7%
Per capita percentage Land Area	1.5	1.1	1.3	2.3	3.2
Percentage of Vehicle Registration	5.0%	6.0%	0.1%	36.0%	53.0%

Source: Developed from RSTA vehicle registration data, 2015 and Bhutan Labour Market Information system

The numbers of passengers carried by public transport buses on inter-city routes has not increased significantly since July 2009. This result, presented in Figure 6, confirms the need for improving public transit facilities in the country.

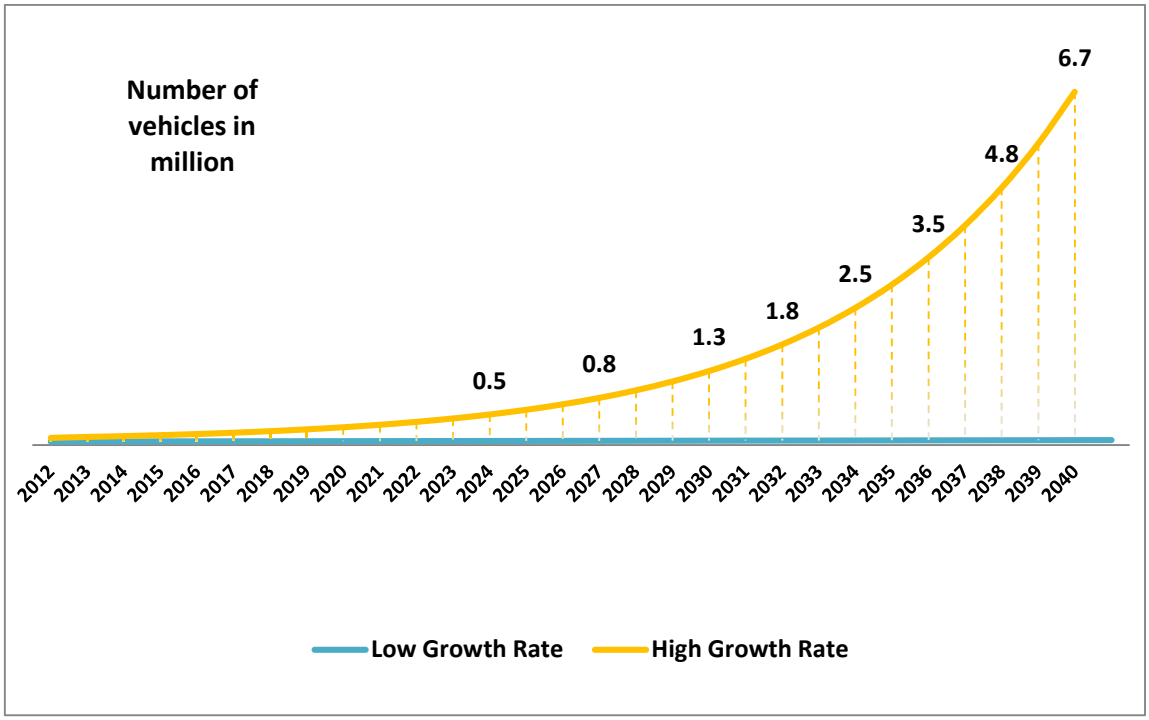
Figure 6: Passenger flow trend, 2001-2013



Source: Developed from Annual InfoComm and Transport Statistical Bulletin, 2014

Besides, economic growth linked to the export of electricity will increase revenues and lead to higher traffic and vehicle ownership. In the BAU scenario, based on the past 10years vehicle high growth rate, vehicle ownership level would probably increase by up to 10 times from 2010 to 2040. If public transport is not significantly improved, this increase will mainly manifest itself in growing numbers of private vehicles. There was temporary prohibition on the import of vehicles since March 2012, the vehicle growth rate has decreased to 1.2 % in 2014, as shown in the Figure 7 (low growth rate series).

Figure 7: Expected vehicle growth trend in Bhutan



Source: Bhutan Transport 2040 Integrated Strategic Vision,2011 and Statistical Yearbook of Bhutan 2014

3. Baseline Scenario Development from Primary Survey

In addition to the secondary data analyzed and presented in the previous sections transport audits have been carried out as a primary data collection. Theses audits aim at getting a deeper and more comprehensive understanding of the energy consumption pattern by Transport Sector in Bhutan.

3.1. Survey Methodology

The audits were divided into two segments – The Vehicle Audits and the Road inventory survey.

Vehicle Audits

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

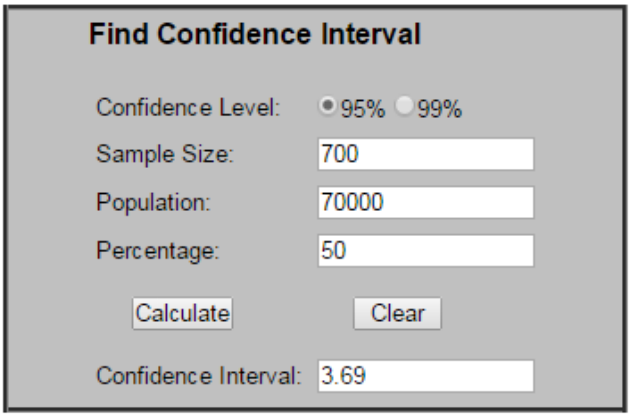
- Type of fuel used, brand and model, engine capacity (CC), year of manufacturing, fuel efficiency, odometer reading, capital and maintenance cost, pollution control certificate, occupancy in case of passenger modes, wiliness to shift to EV and barriers etc. were recorded.
- The modes of transport audited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

The stratified sampling strategy was used to decide the sample size distribution. Based on the desegregated vehicle registration data, 1% of all vehicle types were covered in the survey. Annual InfoComm and Transport Statistical Bulletin, 2014 estimates that the vehicle population in Bhutan to be approximately 70,000 in the given year. With the aim of capturing the sample characteristics in detail, a target of 700 samples was set, which is 1% of the estimated population.

Further, statistical calculations were followed to validate this figure. Following is a list of definitions which will help to understand the statistical results to support the survey.

- The **confidence interval** (also called margin of error) is the plus-or-minus figure usually reported. For example, if you use a confidence interval of 4 and 47% percent of your sample picks an answer you can be "sure" that if you had asked the question of the entire relevant population between 43% (47-4) and 51% (47+4) would have picked that answer.
- The **confidence level** tells you how sure you can be. It is expressed as a percentage and represents how often the true percentage of the population who would pick an answer lies within the confidence interval. The 95% confidence level means you can be 95% certain; the 99% confidence level means you can be 99% certain. Most researchers use the 95% confidence level.

Since, a total sample size of over 700 vehicles distributed over the different vehicle types could be sourced out; there is a better confidence interval for this analysis as calculated in the Survey Calculator shown below.



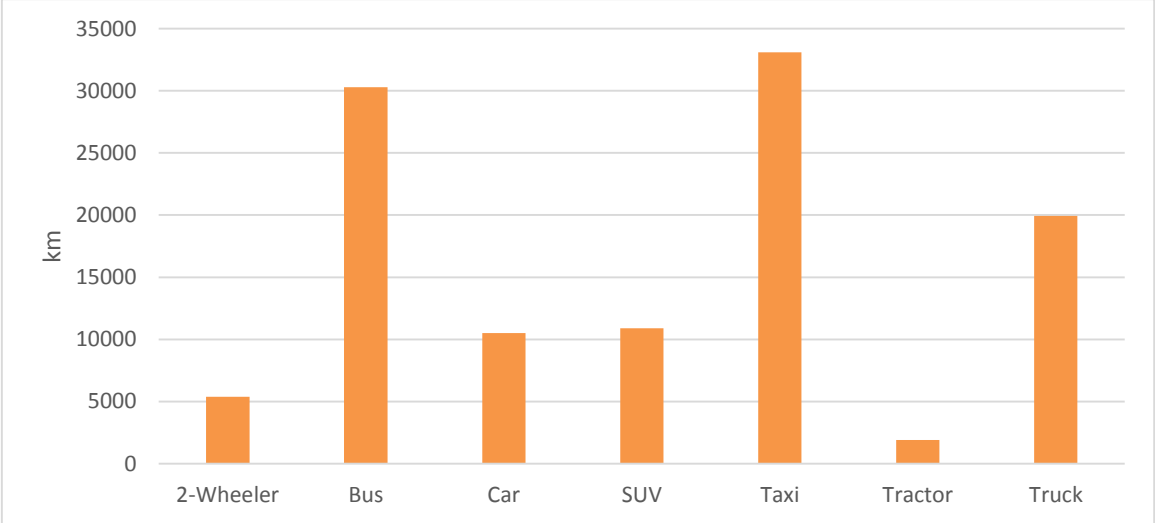
Road Inventory Survey

The road inventory survey was carried out to understand the impact of road surface, terrain and other spatial factors on the energy consumption. The areas covered in the survey were roads connecting Damphu, Gelephu, Pasakha, Phuentsholing, Samdrup Jongkar, Thimphu, Trashigang-Moshi, Trongsa and Paro, and the roads within these urban areas. The results of the audits and the surveys are presented in the following sections.

3.2. Distance covered by different vehicles

Figure 8 below presents the distance travel by a typical vehicle in Bhutan in a year.

Figure 8: Distance travelled by different vehicles in a year



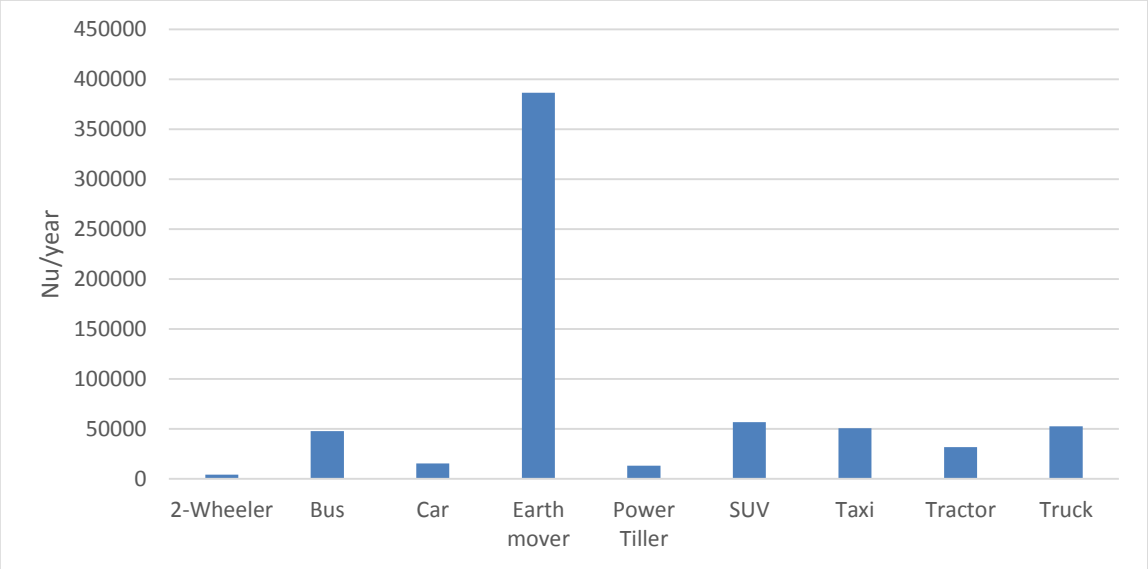
Source: Developed on Primary Survey Findings

A Taxi drives approximately 3.5 times more than a Car or a SUV, and a bus, 3 times more than a Car or a SUV. It indicates that taxis and buses make more number of trips than personal car/SUV. However, the number of passengers in these modes of transport is more than private vehicles. In other words, there is lower per capita consumption of fuel in public transport which must be encouraged. Again, due to larger passenger kilometers travelled by these modes, effect of Energy Efficiency interventions can be expected to be comparatively more. Details on per capita fuel consumption have been discussed in the following sections.

3.3. Maintenance cost

Figure 9 presents the maintenance cost spent on a typical vehicle in a year in Bhutan.

Figure 9: Maintenance cost of different types vehicle



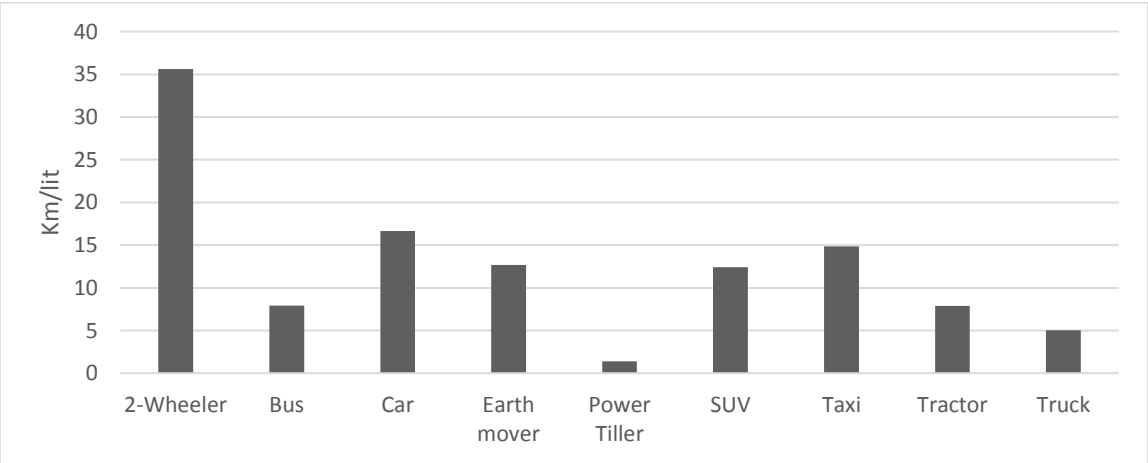
Source: Developed on Primary Survey Findings

A typical bus and taxi spends approximately 4 times more on maintenance cost as compared to cars but buses and taxis cover more distance in a year. It is important to notice that maintenance cost of a bus and SUV is approximately same whereas a bus (average occupancy of a bus is 20) services more passenger than a typical SUV (average occupancy of a SUV is 1.25). This indicates that there is huge economic potential for providing dedicated service infrastructure for buses and taxis.

3.4. Fuel efficiency of different vehicle segments

The figure below shows category wise the fuel efficiency different vehicles in Bhutan.

Figure 10: Fuel efficiency of different vehicles in Bhutan



Source: Developed on Primary Survey Findings

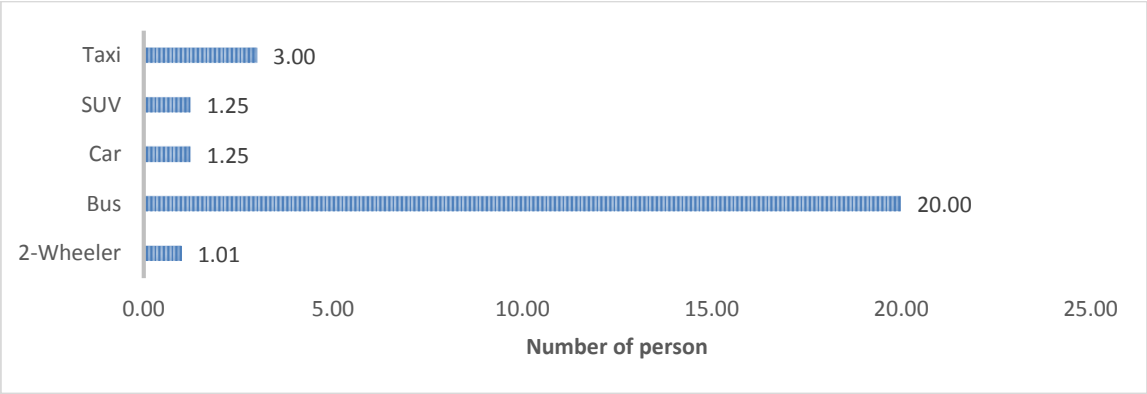
Note: Fuel efficiency of power tiller and earth mover is in hours per lit NOT kms per lit.

Fuel efficiency of a car and SUV is approximately 2.5 times more than bus but a typical bus carries more people. However, fuel efficiency of a taxi is approximately same as SUV which indicates that from fuel efficiency point of view, use of taxis and buses must be promoted. The fuel efficiency of a typical two-wheeler is highest as compared to other modes because of small engine although the average occupancy of a two-wheeler is almost same as a car or a SUV. However, considering the hilly terrain especially during rainy season, discomfort of riding with traditional clothing (like gho and kira) and safety of the riders, the use of two-wheeler may not be encouraged until stringent safety norms are in place.

3.5. Occupancy of different vehicles

The average occupancy of different category of passenger vehicles in Bhutan is presented in the figure below.

Figure 11: Average occupancy of a typical passenger vehicle in Bhutan



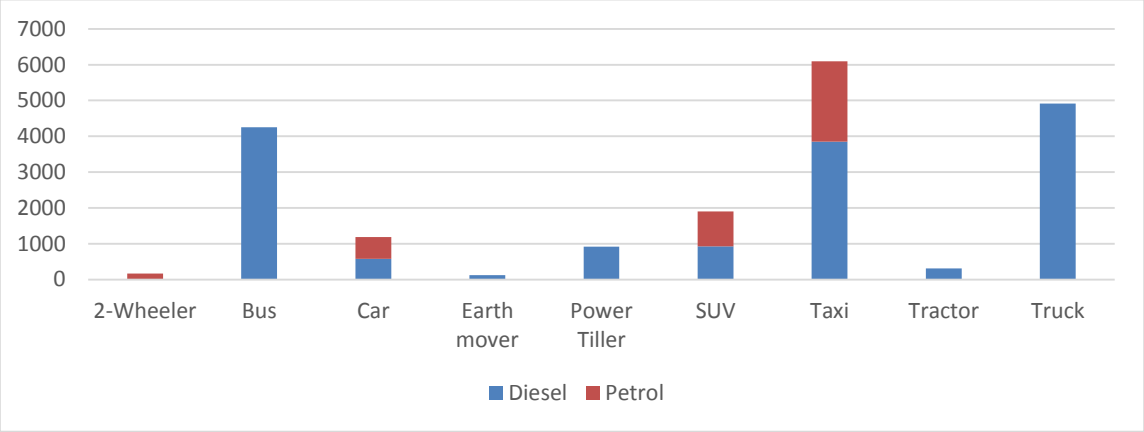
Source: Developed on Primary Survey Findings

Average occupancy of a typical car and SUV is less than a typical taxi and much less than a typical bus. Thus, use of bus for sustainable transport mode should be encouraged.

3.6. Fuel consumption

The figure below presents the quantity of different type of fuel consumed by a typical vehicle in a year.

Figure 12: Fuel consumed in a year by different vehicles in Bhutan (litre)



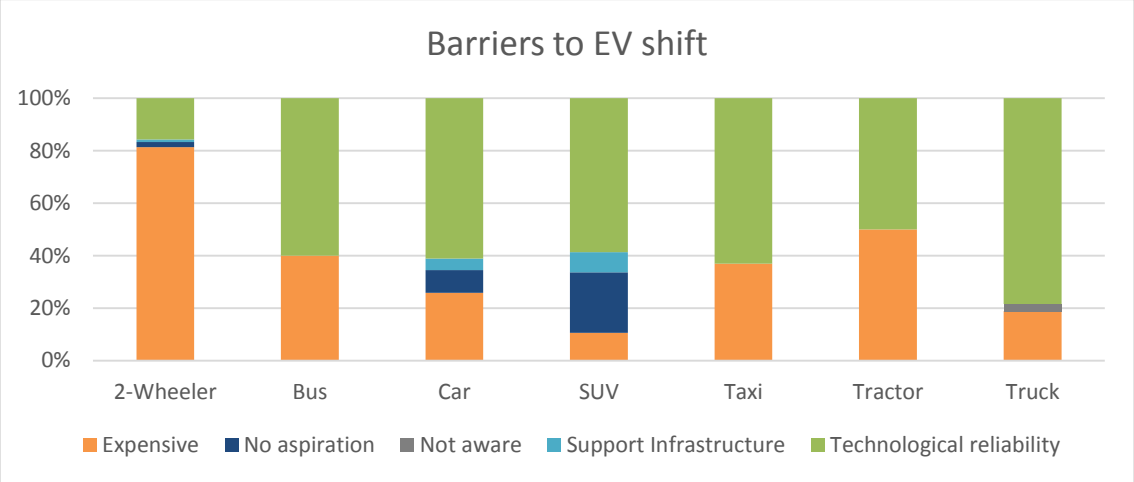
Source: Developed on Primary Survey Findings

Average fuel consumption by a typical car or SUV is much less than a typical bus. Although the latter mode has lower fuel efficiency, it covers more distance than a car or a SUV. The fuel consumed by a typical taxi is high because it covers more distance in a year.

3.7. Barriers to EV shift

During the audit exercise carried out for this study, commuters were asked the challenges they faced in the past related to EVs and perceived barrier to use an electric vehicle. These responses are presented in the figure below.

Figure 13: Barrier to EV shift



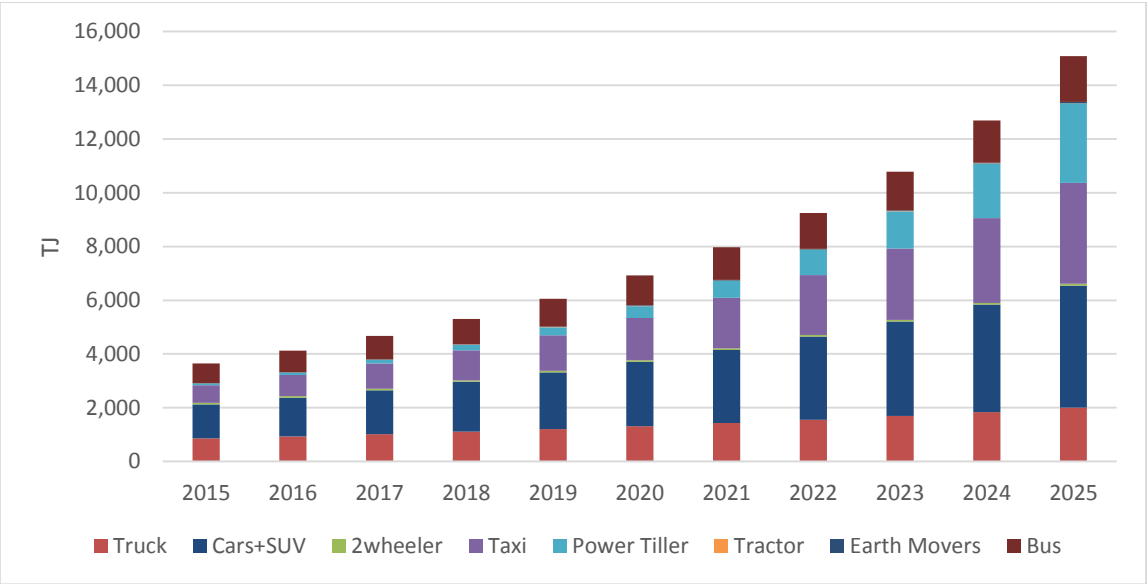
Source: Developed on Primary Survey Findings

Expensive EV and lack of well-established technology are major barriers for shift. In addition, support infrastructure is required for charging /troubleshooting for intercity bus and taxi trips.

3.8. Energy Consumption in Business As Usual Scenario

The figure below presents the energy consumption of different vehicle segments in a business as usual scenario up to next 10 years.

Figure 14: Energy Consumption by different segment of vehicle in Bhutan

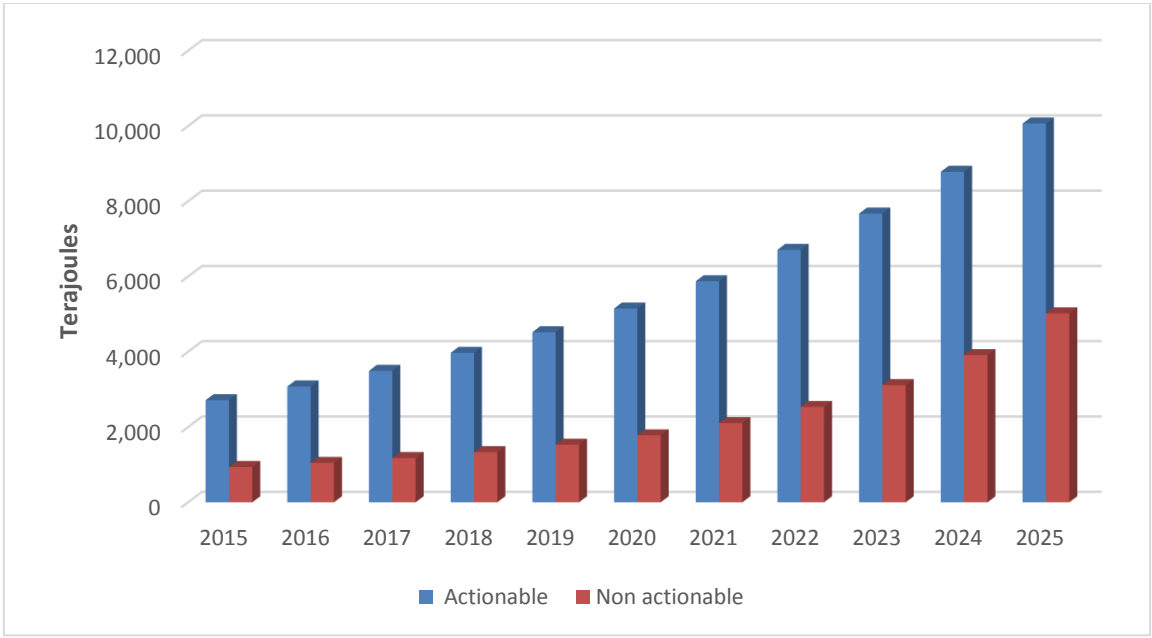


Source: Developed on Primary Survey Findings

It is clear from the above figure that the energy consumed by the private modes (cars and SUVs) are much more than the energy consumed by the public transport mode (buses). Taxis and trucks also have high share of energy consumption.

Out of all the transportation segments some are actionable segments like cars, SUVs, two-wheelers, taxis and buses, and remaining are non-actionable. The trucks, power tiller, tractors, earth movers are in non-actionable category mainly because of two reasons. First, these being the essential for economic growth should not be hampered or discouraged in any way and second, the suitable EV substitutes for these machines are not available currently. The energy consumption by actionable and non-actionable categories is presented in the figure below.

Figure 15: Actionable and non-actionable energy consumption in BAU scenario



Source: Developed on Primary Survey Findings

3.9. Road Condition and Energy Efficiency

To understand the impact of road surface, terrain and other spatial features of roads on Transport Sector energy consumption a nation-wide road inventory audit was conducted. This audit captured various key elements like right of way (ROW), carriageway – dimension and condition, shoulder – hill side and valley side (dimension and condition), footpath – dimension and condition, effect of slope and bad surface on energy consumption of vehicles.

The road inventory audit covered all hierarchy of roads i.e., express way, primary and secondary national highway, dzongkhag road, urban road, farm road, access road, forest road, and project roads (refer Figure 16) throughout the nation.

Figure 16: Different Type of Roads in Bhutan

Source: Photographs during Primary Survey

For the purpose of the road inventory audit a car and a SUV were hired to go around the nation and point based audits were carried out. There were total of 94 locations across Bhutan where road inventory audit was carried out. These locations were geo tagged and pictures are uploaded on google map for reference (refer Figure 17).

Figure 17: Road inventory audit coverage – 94 locations spread all over Bhutan

Source: Developed on primary survey

Note: Access link from a Gmail account for details: https://picasaweb.google.com/lh/albumMap?uname=100836658214616521116&aid=6138573069077073889#map

The length and condition of different hierarchy of roads in Bhutan as per Statistical Yearbook of Bhutan 2014 is presented in Table 1.

Table 1: Length and condition of different hierarchy of roads in Bhutan

Type of Road	Ex-press-way	Primary National Highway	Secondary National Highway	Dzongkhag Road	Urban Road	Farm Road	Access Road *	All road
Black topped	6.2	1,662.4	510.9	202.1	324.5	2.5	266.7	**2,975.3**
Non-black	0.0	197.7	67.3	976.2	25.2	5,252.7	1,083.8	**7,602.9**
Total	**6.2**	**1,860.1**	**578.2**	**1,178.3**	**349.7**	**5,255.2**	**1,350.5**	**10,578.2**

**Access road includes Forest road and Power tiller road*

Source: Statistical Yearbook of Bhutan 2014

It can be seen in Table 1 that out of the total road length in Bhutan, only 28% are paved (black topped). While 90% of the primary and secondary national highways and urban roads are paved only 20% of Dzonkhag and Access roads are paved. All farm roads are unpaved. These conditions were then verified and additional information was collected by the road inventory audit and it is presented in Table 2.

Table 2: Road inventory audit findings

Category	ROW	Carriage way	Hill side shoulder	Valley side shoulder	Remarks	Fuel efficiency* (km/L)
Expressway, Primary and Secondary national highway	7m to 12m	5m to 8m (more than 95% paved)	0.2m to 3m (unpaved)	0.2m to 1m (unpaved)	Small stretches (500-800m) of carriage way was found unpaved at few locations, as these were destroyed by rain water/flood/landslides	9.0
Dzongkhag Road	6m to 8m	4m to 5m (paved)	0.2m to 1m (unpaved)	0.2m to 0.5m (unpaved)		9.0
Urban Road	15m to 20m (sometime divided with 0.5m to 1m median)	10m to 12m (all paved)	2m to 4m (on both side)		Footpath were well built but discontinuous and very high	9.0
Access road, Forest, Feeder, Project, Farm road	5m to 8m	4m to 8m (all unpaved with stones)	0.2m to 0.5m (mostly shoulder is merged with carriage way)		Farm roads are steeper slope but condition of all access roads is bad	8.0

Source: Developed on Primary Survey Result

The study was based on ground audit where the fuel efficiency was measured by hiring a Toyota Prado vehicle and running it on different types of roads. However, change in fuel efficiency observed, was not very significant over different segments with different surface conditions. Road hierarchy wise fuel efficiency is highly questionable statement to drive because it depends on a number variables (other than the construction quality of road especially in hilly terrain) like driving style, vehicle condition, vehicle type (tyres, engine capacity, load at given point of time etc.), weather, geometry of the road (winding roads, slope). Therefore, it will be not viable to attempt to arrive at specific figure of fuel efficiency on particular hierarchy of road. To obtain scientifically correct figures, particular segments of road need to be selected and fuel efficiency is to be measured with different number of vehicles driven by different types of drivers. To obtain such information, a questionnaire/interview-based survey was conducted for different type of vehicles and their driver's experiences and opinions.

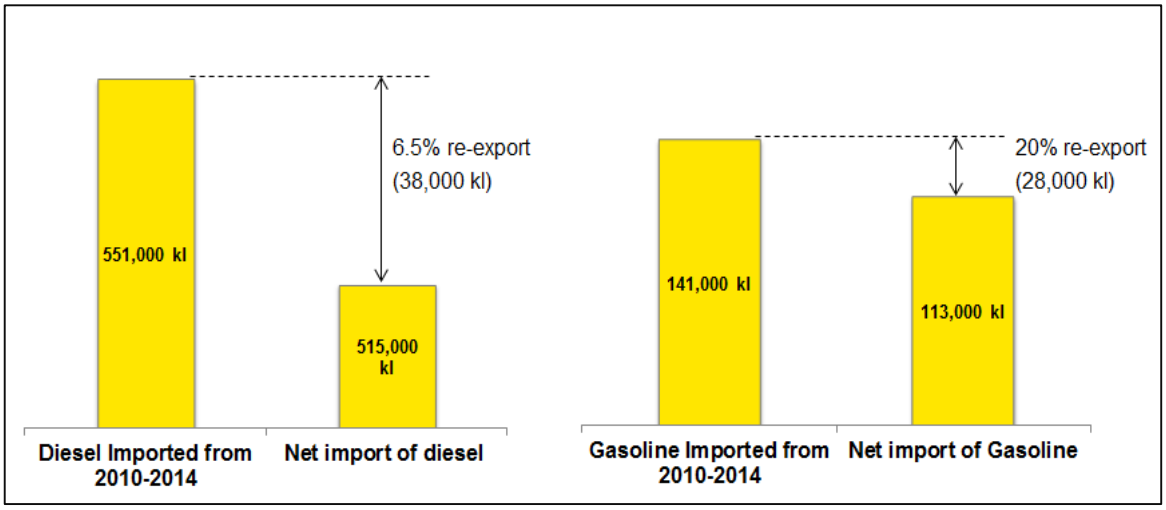
3.10.Total Fuel Imports and Refueling by Indian Vehicles

The import of vehicles in the country has hemmed in after imposition of significant taxes on imports and their registration. However, similar fall in consumption is not very prominent. The country still exports large bulk of petroleum from India, which amounts to 31 thousand Kilolitres of petrol, 88 thousand kilolitres of diesel and 3.5 thousand kilolitres of Aviation Turbine Fuel for the year 2014.

Due to the sharing of porous border towns like Phuentsholing, Gelephu and Samdrup Jongkhar with India and large cross border trade, many Indian goods' vehicle travel across to Bhutan and fuel their vehicles while they return. Reportedly, the National Statistical Bureau accounts that approximately 20% of gasoline and 6.5% of diesel were re-exported from 2010 to 2014. Although the percentage of re-fueling of the total petroleum imports has been vacillating, the refueling reached 11% of the supply in 2012. But re-fueling of petrol increased significantly from 15.2% in 2010 to 23.2% in 2013 and remained close to 22% in 2014[3].

[3]http://www.kuenselonline.com/re-export-of-fuel-on-the-rise/

Figure 18: Total Net Petroleum Imports in Kilolitres for the period 2010 to 2104



Source: POL Section, Department of Trade,MoEA

3.10. Potential strategic implications of baseline scenario

The vehicle and road inventory audit finding highlighted the gaps in the current transport system, which can be addressed by the energy efficient strategies. These strategic implications are presented in theTable 3.

Table 3: Potential strategic implication of baseline scenario

Audit findings	Strategic implications
Buses and taxis serve many more commuting trips than private 4 wheelers and 2 wheelers (Figure 8)	Encourage use of public transport for Energy Efficient transport system – both Bus and Taxi. Shift to electric energy powered vehicles may be promoted.
The fuel efficiency of private 4 wheelers and 2 wheelers is much more than a bus but the per person fuel consumption of a bus is less than half of a private 4-wheeler and 1/3rd more than a typical 2-wheeler	Provide energy efficient transportation mode like bus for longer trips and walk or cycle for shorter trips.
Unwillingness of users to shift to EV due to high capital cost of an electric vehicle and lack of proven technology.	Provision of support infrastructure (all components and repair facilities) for EV and subsides like current practice of tax exemption on EVs. Propose practice of reserved parking area, charging socket in parking etc.
While some roads are well paved except farm and project roads, some roads are in poor condition due to the plying of heavy vehicles for hydropower constructions and quarries. Footpaths are constructed in urban areas but basic design standards like height, continuity, ramps construction were found missing.	Provision of quality Non-motorized infrastructure for energy efficient short trips (zero energy). Need of road maintenance, road widening etc. Shortening of the roads by tunneling, optimum design of roads etc. Need for improvement of foot path.

Lack of Pollution under control (PUC) certificate implementation.	Implementation of stringent PUC norms and driving skills improvement programs to reduce the maintenance cost especially in case of buses. Encourage the practice of periodical car maintenance through the dealer.

4. Energy Efficient Transport Strategies

Bhutan, today, faces the challenge of establishing a sustainable transport system. The pursuit of Energy Efficiency is a huge opportunity for achieving this goal. Not only do Energy Efficiency measures reduce fuel consumption, they also help tackle other transport-related problems. Organising and operating urban transport efficiently reduces costs (for energy), and also lowers congestion, noise emissions, local air pollution, accident risks and global greenhouse gas emissions, while securing economic growth.

Energy efficient transportation needs to be encouraged on different levels. There is potential to achieve greater Energy Efficiency for individual vehicles (vehicle efficiency) and trips (travel efficiency), as well as the whole transport system (system efficiency). Corresponding to these three levels of Energy Efficiency in transport, three basic strategies exist to improve Energy Efficiency:

1. Shifting demand to more efficient modes of transport like;
    a. Public transport
    b. Non-motorised transport
2. Improving the vehicles and fuels used;
    a. Provision of electric vehicles like electric buses, cars and two-wheeler
    b. Providing eco-driving training to drivers to further minimise the energy consumption
3. Urban Planning and road infrastructure improvement

Smart city planning will influence both the demand and the efficiency of transport. The need to travel can be reduced when the various forms of land use (such as residential houses, offices, shops, public services, etc.) are not separated in different city quarters, but mixed within close proximity of one another—a strategy termed “mixed land use”. A smart mixture can significantly reduce the need to travel (or distances travelled)—and thus, energy consumption and emissions. In addition, smart infrastructure design will also include non-motorised transport modes like walking and cycling right from the beginning, e.g., by including pedestrian footways and areas or cycle paths in the infrastructure design. Good access to public transport can be a major contributor to cutting emissions as public transport is, in most cases, much more energy efficient and thus will have lower energy consumption and emissions per kilometre travelled. Taking a more general perspective, the density of an area (i.e., number of people and businesses per square kilometre) will be a crucial factor affecting energy consumption and emissions. Low density development where places of employment, residential areas and key services are separated, can lead to a strong reliance on motorised private vehicles, and consequently high transport energy demand. Concentrated city designs, on the other hand, that work towards higher densities, with a variety of land uses and services within close proximity, will reduce travel needs and emissions. In addition, public transport will be more efficient in densified cities. When major activity centres are concentrated locally, there will be a high demand for transport between these centres, which can be served by efficient and—due to high demand—frequent public transport services. It has been estimated that benefits or savings from effective land use planning, combined with various traffic management schemes can create energy savings of 20 to 30% for bus operators (Martin et al., 1995; in Karekezi et al., 2003), not forgetting additional savings for other road users.

Case Study – Eco-density charter in Vancouver

In 2008, the city council of Vancouver adopted an Eco-Density Charter, which commits the city to strive for environmental sustainability in all planning decisions. Greater density will be created especially in low-density areas and along transit routes. Areas of mixed usage are to be developed, where shopping, employment and public amenities are within walking distance of each other. The aim is to create high-density areas that are attractive, more energy efficient and have a low ecological footprint.

Source and further information: City of Vancouver 2008

http://vancouver.ca/commsvcs/ecocity/pdf/ecodensitycharter-low.pdf

The Thimphu Structure Plan (TSP) states clearly the assumptions, opportunities, and constraints and provides appropriate evaluations and possible alternatives, which mould the Structure Plan. The proposals for action include the creation of Environmental Enhancement Zones supported by the creation of a National Open Space System. The Natural Environmental Zones and the Open Space System will house a walkable footpath system, which includes stairways and footbridges.

The Structure Plan identifies heritage sites, which require conservation, restoration, and improved access. Proposals for linking religious precincts with open spaces will make them more accessible to daily users as the proposed heritage "walks" and "drives" will enhance people's experience of these treasures. The proposal specially stresses on the urgency to enhance the Tashichho Dzongkhag, the Memorial Chorten, Prayer Wheels, and the Heritage Villages. The most compelling structural aspect of the plan is the proposed circulation system which lays out the Urban Corridor, arterial roads, connector roads and a network of pedestrian footpaths.

Unlike the western planning style of designating land use plan that specifies restricted zones for various functions and "gray" area with mono-functions, the Structure Plan has a mixed–use area that considers the essence of Bhutanese life – the 'Dharma.' These are achieved through designating more than twenty different 'precincts' arrived at through a detailed analysis of the existing scenarios. These precincts facilitate and promote various activities that make up the residents' daily lives, and are sanctified as sacred places for all affairs and activities. The precincts also provide spaces for religious functions and other residential activities to be carried out without disruptions from the industrial, commercial, and retail activities.

The Structure Plan also recognizes that the city must be planned for future residents who have no "voice" in the preparation of the plan. The components of the plan in the TSP are designed to cater to the needs of the future population, more than the present ones. These plans will affect the citizens of Bhutan who own the capital as an image of their "nationhood," more than the owners of the shops and plots in the city today. This aspect of the planning process is non-negotiable. The strategy is to design houses that are affordable and located in compact and walkable neighbourhood. The Plan also sets aside spaces for social services and amenities to allow city dwellers to access to basic health care and educational facilities. It has provision to facilitate distribution of potable water, electricity, and communications networks.

The TSP is a good example of the kind of mixed land use planning that would increase the Energy Efficiency of the city and its citizens. If implemented in Thimphu and replicated in other cities, the TSP will go a long way in ensuring an energy efficient future for the country.

These strategic interventions are also evident by the baseline scenario developed in the previous section. The details of each of these strategic interventions are discussed in the following section.

4.1. Public Transit

The provision of new and improved public transport is essential to reduce energy consumption and emissions of greenhouse gases. Public transport in Bhutan would be provision of efficient bus system. Attractive, accessible and reliable public transport systems can provide the basis for alternative mode use in cities. The two key options to improve public transport are the expansion of systems or services and improvements to the operation of systems and services. The expansion of services can include fixed guide ways, express bus services, local bus services, or services which extend the geographical coverage of bus network. System/service and operational improvements may include splitting routes, transfer improvements, co-ordination of schedules, through ticketing, and increased vehicle frequency. Services may also be improved through the provision of passenger amenities (e.g., bus shelters, station improvements, safety and security enhancements, vehicle comfort improvements, signage and elderly/mobility impaired access), as well as full integration of public (and other) transport systems, both regarding physical infrastructure and fare systems.

The extent to which increased transit investment reduces motor vehicle energy consumption depends on the extent to which transit causes shifts in mode of travel, and the extent to which any increase in transit energy consumption offsets these reductions.

For the **inter-district** movement across Bhutan, an organized bus system is an immediate need. Currently, the inter-district bus services are the domain of private operators who focus on serving only profitable routes, leaving large parts of the country not connected by transit services. People rely on expensive taxis to fill the gap, making mobility unaffordable to a large section of population. This will disable economic growth. An organized inter-district bus system needs to be put together under a Road Transport Authority. The buses may or may not be owned by the State, but route licences, schedules and fares need to be regulated across the country.

Case study - Introduction of Airport bus service

To promote public transport system in Bhutan, as discussed under the planning strategies a small study was carried out to gauge the Energy Efficiency of bus service between Paro airport and Thimphu in lieu of taxis and private cars. Initiating this bus service makes logical sense considering the limited number of flights to Bhutan and major destination of flight passengers being Thimphu city. In order to estimate the quantum of vehicle flow, a survey of vehicle movement was carried out between Thimphu city and Paro airport, and between Paro city and Paro airport. The number of vehicles coming from Thimphu to Paro was counted between 5 am to 5 pm. Vehicles entering the airport and those which kept driving to Paro were differentiated. Besides that, the number of vehicles coming from Paro and entering the airport was also counted. It was observed that an average of 361 cars/SUVs/taxis and 46 tourist buses (Hiace /Tourist Bus) entered the airport. As per Annual InfoComm and Transport Statistical Bulletin March 2014, the total number of passengers (Domestic and International) carried by Druk Air and Bhutan Airlines at Paro airport is 192,810, which led to an average figure of 500 passengers on a typical day. Assuming the average occupancy of a car/SUV/taxi as 1.2 (based on the experience of similar projects), the maximum number of cars/SUVs/taxis required is 417 approximately. From the survey average, the number of cars/SUVs/taxis was 361 implying that the remaining passengers arrived or departed in groups using tourist buses. If only 25% or 50% of these passengers shift to bus service, then 3 or 6 buses (30 seater diesel fuel buses) are required respectively. **In both the cases one bus can replace 25 cars/SUVs/taxis, thus saving Nu. 643,039 per year, 226.02 GJ of energy per year and 16.11 tCO_2 amount of emission reduction per year.** There will be certain employment loss because of shift of passengers from taxi's to buses which can be checked by providing the employment opportunities to taxi drivers in the operation and maintenance of the bus service.

Therefore, it is recommended to initiate bus service between Paro airport and Thimphu. However, the scheduling and frequency of the buses has to be dynamic as the schedule of flights is varying throughout the year. Thus, it should be linked to flight schedule on day to day basis.

For **Intra city** movement, especially in the cities of Thimphu, Phuentsholing, Gelephu and Samdrup Jongkhar, reliable city bus services need to be organized. Currently intra city buses are run in Thimphu and Phuentsholing by the Royal Bhutan Post. Though the services are currently being availed by many commuters, the absence of and operational plan and organizational capacity does not allow for the service to be scaled up. For Thimphu and Phuentsholing, one option to improve public transport is the implementation of 'Bus Rapid Transit' (BRT) systems. BRT systems have most notably been implemented in Bogotá (Colombia) and Curitiba (Brazil), and others including Beijing (China), Jakarta (Indonesia), León (Mexico), and Seoul (South Korea), with projects underway in cities like Cape Town (South Africa), Dar es Salaam (Tanzania), Hanoi (Vietnam), Lima (Peru), Mexico City (Mexico), and Johannesburg (South Africa). A study of introduction of bus services, especially BRT for the cities of Thimphu and Phuentsholing has already been carried out (refer System Selection and Eco-Friendly (SSEF) feasibility report volume 1 and 2). This needs to be updated and implemented. A BRT system, however, requires an even higher order of organizational and planning capacity.

Experience with good public transit systems across the world shows that they can contribute to reducing energy consumption and emissions. Congestion problems are reduced substantially through increases in patronage (mode shift from private vehicles), and increasing fuel economy when efficient buses are used. Additional co-benefits are likely, such as improved local air quality (reductions of SOx, NOx, PM, and CO emissions), and improved public transport.

4.2 Non-Motorized Transport

The encouragement and facilitation of increased levels of walking and cycling is essential in any successful sustainable transport strategy. Cycling and walking as modes do not directly consume energy or produce any direct emissions. As energy consumption from motorised transport are highest at cold start of the engine, short trips are disproportionately polluting. These shorter trips are most suitable for shift to non-motorised modes.

Transport authorities face difficulties when trying to achieve a mode shift to cycling and walking, as they are often viewed as unattractive alternatives to motorised transport, primarily due to the inconvenience and safety concerns experienced in developing country cities (World Bank, 2004). Lack of protection from the weather, dress codes in Bhutan, the topography in Bhutan, the health and physical fitness of the intended cyclists, and road safety and security (e.g., fear of bicycle theft) in general also add to the perceived unattractiveness of walking and cycling.

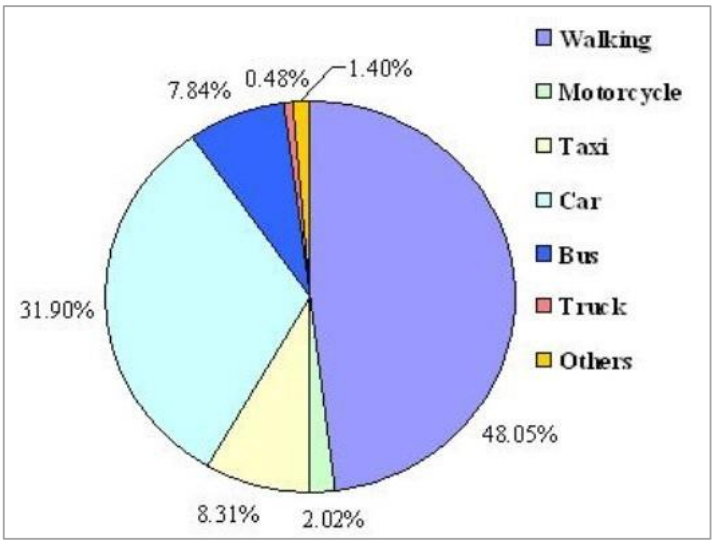
There are a number of improvements that can be made to encourage cycling and walking. These include the following:

- the construction of continuous bicycle networks i.e., painted bicycle tracks, safe bicycle crossings at intersections, bicycle route maps for ease of access of daily commuters, NMT only zone like major commercial streets;
- integration with other transport modes;
- Employers and educational facilities also have a role to play in encouraging walking and cycling, and may wish to consider the provision of facilities such as lockers (for storing cycling/walking equipment), bicycle racks, and showers.
- Construction of new foot paths and improvement of existing foot paths.
- Planting of trees to provide shades along the foot paths

A key instrument in encouraging a mode shift to walking and cycling is the use of awareness campaigns and information, which may also include the development of cycling and walking routes and maps (Sloman, 2003; Hook and Wright, 2002). However, in case of cities in Bhutan segregated cycle lanes may not be required considering the narrow road widths, slow traffic in core areas, and mostly walking distance destinations.

The share of walking is high in Bhutan. While it would be very high in the rural areas, it is also as high as 48% in the most motorized cities of the country – Thimphu and Phuentsholing.

Figure 19: Mode share of Thimphu city



Source: Data Collection Survey on Urban Development and Environment in the Kingdom of Bhutan, Japan International Cooperation Agency (JICA) Study Team, 2013

While footpaths are seen in the core areas of Thimphu, they are missing in the other parts of the city and, in fact the entire country (refer Figure 20, Figure 21 and Figure 22). The structure plans of Thimphu, Phuentsholing and other Thromdes make explicit mention of the need for walking paths. Thus, it is necessary to construct state of art footpaths especially in Thimphu and Phuentsholing.

Figure 20: Road without walking facility in Thimphu

Source: Photographs during Primary Survey

Figure 21: Road with on street parking and high stairs but no place to walk, Phuentsholing

Source: Photographs during Primary Survey

Figure 22: Road without walking facility in Punakha

Source: Photographs during Primary Survey

4.3 Electric Vehicles

The Energy Efficiency of electric vehicles during operation is much higher than that of conventional cars and they do not emit CO_2 or other pollutants while driving. At the local level, improved air quality and reduced noise are major advantages of electricity as a fuel. Although there are environmental advantages associated with electric vehicles, there are challenges involved in managing the shift. Electric propulsion using batteries as the power source is still hampered by the problem of storing sufficient on-board energy. With the existing battery technology, the range of such cars is at present mainly limited to urban areas. To promote electric cars, Beijing, Shanghai and Tianjin have recently introduced charging stations. Another disadvantage of electric vehicles, is the need for a proper, ubiquitous electricity grid.

With the available technologies, electric cars can still only make a limited contribution to energy-efficient urban transport. However, it might be technology for the future. Already today, electric scooters and bikes are an option in urban areas. For example, there are already more than 120 million electric two-wheelers in China. Especially in large cities, the number of electric bicycles has increased tremendously in recent years (Associated Press 2009; Cherry et al., 2007; Financial Times Deutschland 2009).

Bhutan produces hydroelectric power and has to import petroleum fuel for vehicles, it would seem sensible to electrify the entire set of transport vehicles. However, given the above discussion, this is easier said than done. A separate study has been carried out to assess the feasibility of introducing electric vehicles in Bhutan.

The fuel efficiency of different vehicles (obtained from primary survey) in Bhutan has been listed in annexure 1.

4.4 Fuel or Energy Taxes

Bhutan is completely dependent on import of petroleum fuel from India and its energy security is linked to it. It becomes critical for the country to ensure that the fuel is being used to ensure the economic growth of all, not facilitate the luxury of a few. In a country where the private vehicles are consuming a large chunk of the fuel imported, high taxes on fuel and the use of the money to provide public transit and NMT will ensure that the fuel pays for inclusive mobility. Fuel taxes increase the price of travelling and thus have an indirect effect on individual travel behaviour and decisions. Fuel taxes are a way of charging the users of transport infrastructure relative to individual use. Fuel taxation raises the price of travel per km. This action can lead to drivers trying to reduce the number of vehicle kilometres travelled.

Again, fuel price is currently a highly sensitive issue in the country. A need for viable policy option needs to be in place before the private vehicles may be taxed on consumption of the fuels. As the use of electric vehicles increases and the supportive structures for promoting them are in place, one may explore necessary taxes on conventional fuels in near future.

Arguments against fuel subsidies

Governments in developing countries argue that fuel prices have to be low to promote economic growth and social equity. Consequently, many developing countries lack a proper fuel taxation policy, or they have subsidised fuel prices. However, there are disadvantages to such policies:

1. Low fuel prices result in higher fuel consumption due to growth in vehicle travel and trend for larger vehicles like SUVs;
2. Fuel taxation is essential if a State is to expand and maintain a nationwide infrastructure network. In the long run, subsidised fuel prices hamper economic growth;
3. Middle- and high-income motorists profit from fuel subsidies, not the poor. The lowest-income groups account for just a very small proportion of the total fuel consumed;
4. Low fuel prices lead to more traffic, with knock-on effects such as land use dispersion, pollution, congestion and accidents.

To conclude, it is recommended to reduce overall fuel costs by effective land use planning to reduce trip distance, provision of convenient infrastructure for walking and cycling for short trips and to establish affordable public transport options which provide poor people with the transport services they need.

4.5 Eco driving training

The way in which a vehicle is driven or maintained has a direct impact on fuel consumption, and subsequently operating costs and emissions. Through the provision of 'Eco-Driving' education and training, driver behaviour may be altered to achieve greater fuel efficiencies. Estimates show that average fuel savings (and emission reductions) are in the range of 10% to 15%. Individual fuel saving potential may be even up to 25%. Key methods for improving fuel efficiency can relate to driving style/behaviour (speed, braking and acceleration, engine idling, carrying capacity and cold starts) and vehicle condition (maintenance-engine, tyres, oil and air filter, and vehicle age).

Avoiding unnecessary braking and clutch management: Having better traffic management and better roads can eliminate unnecessary heavy braking, consequently reducing gear changes, shifting load and other fuel drawing exercises. Again, it is advisable to use exhaust braking system instead of the foot brake which not only saves fuel but it also extends the life of brakes.

Avoid idling the vehicle: 'Idling' the vehicles refer to keeping the engine running when the vehicle is not moving as it usually happens when the vehicles are stopped at traffic signals or public vehicles wait for passengers. Idling vehicles do consume fuel. Hence, it is useful to inculcate the habit of turning off the vehicle until absolutely necessary or for short waits (usually less than 10 seconds).

Overfilling and overweighing: Overfilled fuel tanks might overflow on heating which is not only risky but also wasteful. It is important to note that heavier the vehicle more effort is required by the engine to pull the vehicle consequently consuming more fuel.

These features can be incorporated in the public awareness programmes and can be directly brought to effect through monitoring and capacity building. Driver training is particularly effective

when regulated fleet of commercial vehicles, such as bus, are included. The potential fuel savings can significantly contribute to (fuel) cost savings and constitute a strong incentive for eco-driving.

4.6 Recommendations to achieve the impact of strategic interventions

The following table presents the various set of recommendations necessary to support the strategic intervention discussed in the previous sections.

Table 4: Strategies and recommendations for impacts on Energy Efficiency

Strategies	Recommendations	Impact on EE (Direct/Indirect)	Explanations
Public Transport	[1] Ensure public transport vehicles and associated infrastructure (public transport stations/hubs) are accessible (low floor vehicles, step-free buildings), and attractive (safe, lighting, waiting areas, information provision, etc.).	Indirect	[1] To give users incentives to shift from cars to public transport, thus reducing fuel consumption and traffic congestion.
	[2] Ensure that public transport provision has the appropriate level of service and coverage to meet potential user demand.	Direct	[2] Extending the coverage of public transport, and providing adequate level of service will attract captive car users - reducing fuel consumption and traffic congestion.
	[3] Use appropriate fare structures to ensure adequate levels of patronage.	Indirect	[3] Traveling by bus should be cheaper than traveling by private modes or taxis making it a choice if the service is good. This would ensure lower per capita fuel used for mobility.
	[4] Ensure appropriate priority measures for public transport, cyclists, and pedestrians.	Indirect	[4] This would ensure that commuters, using transit or walking, should reach destinations faster (in terms of travel time) making them use transit thereby reducing fuel consumption and traffic congestion.
	[5] Ensure provision of relevant passenger travel information (timetables, format of information, advertising).	Indirect	[5] Giving people travel information can make them rationalise their travel, and so decrease the energy they use. It can attract non-public transport users by providing them information which could interest them.
	[6] Consider integration with other modes, e.g., integration between City and regional bus services (e.g. common fare, timetable), bus and cycling (allow transport of cycles, provide parking infrastructure) to encourage their use.	Direct	[6] This will make the overall public transport more efficient. Making it more attractive, avoiding waste of users' time, and avoiding car use which may currently compensate for the lack of public transport integration/connectivity.

Strategies	Recommendations	Impact on EE (Direct/Indirect)	Explanations
Non-Motorized Modes	[1] Ensure that cyclist and pedestrian facilities in Thromdes are attractive to existing and potential users. This includes considering safety (adequate lighting, separate from traffic where necessary), and accessibility (direct routes, connectivity)	Direct	[1] Such attraction will increase the use of these modes of transport, and so decrease fuel consumption.
	[2] Aim to create partnerships with local shopkeepers, employers and businesses, encouraging the implementation of additional ancillary facilities for cyclists and pedestrians, such as lockers/storage facilities, showers, bicycle racks, etc.	Indirect	[2] Such implementation will set up non-motorised facilities in strategic locations, and will make non-motorised modes of transport more attractive. Thereby leading to less petroleum fuel consumption.
Electric buses	[1] Electric buses can be controlled by the National and city governments for organized inter-city and intra-city transit systems in the country.	Direct	[1] The positive effects would be: decrease in energy consumption leading to reduced air pollution and petroleum fuel import from India.
Electric cars	[1] Electric cars for private ownership can be introduced in the country.	Direct	[1] This may not contribute substantially to EE. A user based study in the country asking people if they will shift to electric vehicles shows that only 25% of responded are willing to shift to electric cars. The major reason for not opting for electric vehicles for private mode of transportation are absence of well-established technology and the cost of electric cars is much more than the conventional petrol car.
Electric bike	[1] Making available paddle assist bicycles in the country will encourage cycling (using e-bikes) for short distance commutes.	Direct	[1] Considering warnings in previous sections, positive effects would be: decrease in fuel consumption, air pollution and petroleum fuel import.
	[2] Raise awareness through use of information instruments of the benefits of cleaner fuel use.	Indirect	[2] Making people aware of cleaner fuel technology may give them incentives to change according to it.
	[3] Consider the adverse effects of new technologies (such as when implementing bio-fuels).	Direct	[3] Electric technologies have a reverse effect (on environment, etc.) to be taken into account.
Driver Behavior Training and Education / Eco-Driving	*Public Authorities:* [1] Early provision of cycle training (for children) may encourage long term travel behaviour change towards more sustainable modes.	Indirect	[1] This has an indirect short-term impact, but a direct long-term impact on Energy Efficiency.

5. Quantification of Energy Efficient Strategies – The CBA

The strategies discussed in the previous section (for Energy Efficient Transport Strategies) have been quantified (selected/quantifiable strategies) in this section. The quantification is done in two categories: (i) monetary savings; and (ii) emission savings.

The strategies selected for quantification are as follows:

1. The Public Transport Introduction – Mode shift to PT;
2. Construction of footpaths – Mode shift to NMT;
3. Eco driving training for bus drivers.
4. Improving road conditions by constructing well paved carriage ways

This section further presents the Emission Reduction and Energy Savings for all interventions proposed above.

5.1 The PT introduction – Mode shift to PT

The Public Transport (PT) introduction scenario has its genesis in the Public Transport planning strategy discussed in the previous section. PT introduction here means addition of new buses (only conventional diesel buses are considered for the purpose of this study) for public transport system in Bhutan. It would induce the mode shift from private cars and SUVs to buses especially in the urban areas. As most of the private cars and SUVs (80% approximately) are registered in the Thimphu and Phuentsholing region, it is safe to assume that mode shift from private cars to buses would happen swiftly in these two regions. The calculations of addition of number of buses is done based on the assumption of 10% (conservative figure as compared to the calculated mode shift in the SSEFF report through TDM model) mode shift in Thimphu and Phuentsholing regions from cars to buses. The cost benefit analysis of the PT intervention is presented in the Table 5.

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Table 5:Cost benefit analysis of PT introduction scenario - Addition of buses

Mode shift to PT	**Unit**											
Investment in Diesel Buses	Nu (Million)	1,025.10										
Total Loan		768.83										
Loan Repayment Schedule												
Description	**Unit**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**
Initial down payment		256.28										
Opening Balance	Nu	768.83	733.59	693.76	648.76	597.91	540.45	475.52	402.14	319.23	225.54	119.67
Interest	Nu	99.95	95.37	90.19	84.34	77.73	70.26	61.82	52.28	41.50	29.32	15.56
Repayment	Nu	135.19	135.19	135.19	135.19	135.19	135.19	135.19	135.19	135.19	135.19	135.19
Closing Balance	Nu	733.59	693.76	648.76	597.91	540.45	475.52	402.14	319.23	225.54	119.67	0.04
Operational cost of running a diesel bus												
Description	**Unit**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**
Initial down payment		256.28										
Differential fuel Cost	Nu	202.60	247.82	276.81	306.41	336.50	366.97	397.74	428.72	459.81	490.96	522.09
Maintenance Cost of diesel bus	Nu	7.13	7.58	8.02	8.45	8.87	9.27	9.66	10.04	10.42	10.78	11.13
Loan Interest	Nu	99.95	95.37	90.19	84.34	77.73	70.26	61.82	52.28	41.50	29.32	15.56
Depreciation	Nu	153.77	130.70	111.10	21.78	35.17	33.17	33.47	33.42	33.43	33.43	33.43
Depreciated value of buses	Nu	871.34	740.64	145.18	234.50	221.10	223.11	222.81	222.85	222.85	222.85	222.85
Net Present Value of Investment												
Description	**Unit**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**
Cost of Diesel Buses	Nu	1025.10										
Differential Fuel Cost	Nu	202.60	247.82	276.81	306.41	336.50	366.97	397.74	428.72	459.81	490.96	522.09
Maintenance cost	Nu	7.13	7.58	8.02	8.45	8.87	9.27	9.66	10.04	10.42	10.78	11.13
Repayment	Nu	135.19	135.19	135.19	135.19	135.19	135.19	135.19	135.19	135.19	135.19	135.19
Depreciation	Nu	153.77	130.70	111.10	21.78	35.17	33.17	33.47	33.42	33.43	33.43	33.43
Net cash flow	Nu	-811.06	235.75	244.70	184.55	227.62	255.68	286.36	316.90	347.63	378.42	409.20
NPV	**Nu**	**454.67**										

Sources: Developed on Primary Survey Results (Please refer to attached Excel sheet on Cost Benefit Analysis on Bhutan EE for the calculations)

Note: The set of reference unit values used calculations are listed in Table 12 in annexure 2.

It can be seen in Table 5 that NPV for the introduction of PT scenario has positive value of Nu. 23.54 million, which indicates that introduction of new buses for public transport will be financially beneficial even if the mode shift happens only in the major urban areas i.e., Thimphu and Phuentsholing.

5.2 Construction of footpaths – Mode shift to NMT

The mode shift to NMT is discussed in the previous section along with the planning strategies for Energy Efficiency in Transport Sector. In NMT mode shift only walking as NMT mode is considered in this scenario as it was observed during the field visit that cycling as daily commute is not popular among the residents. Further, urban areas like Thimphu and Phuentsholing has the short distance trips which can be easily made by walking if the proper infrastructure for walking is available in the cities. It is assumed in this scenario that 10% of motorised trips done by private cars in Thimphu and Phuentsholing region would shift to walking if the state of the art walking facility is available in the city (The cost of constructing footpaths includes street lighting, tactile paving to provide barrier free walking to all, standard ramps where ever needed, necessary shifting of utility lines or retrofitting required). This varies from baseline year to year 2025 (12,058.80 km multiplied by the number of private cars shift (10%) in a particular year t. As most of the private cars and SUVs (80% approximately) are registered in the Thimphu and Phuentsholing region, it is safe to assume that mode shift from private cars to walking would happen swiftly in these two regions. The cost benefit analysis for the NMT interventions in presented in the Table 6.

Table 6: Cost benefit analysis of mode shift to NMT – Construction of footpaths

Mode shift to NMT	**Unit**											
Investment in constructing footpaths	Nu (Million)	2,446.00										
Total Loan	Nu (Million)	1,834.50										
Loan Repayment Schedule												
Description	**Unit**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**
Initial down payment		611.50										
Opening Balance	Nu	1,834.50	1,750.40	1,655.37	1,547.98	1,426.63	1,289.51	1,134.56	959.47	761.61	538.04	285.40
Interest	Nu	238.49	227.55	215.20	201.24	185.46	167.64	147.49	124.73	99.01	69.95	37.10
Repayment	Nu	322.59	322.59	322.59	322.59	322.59	322.59	322.59	322.59	322.59	322.59	322.59
Closing Balance	Nu	1,750.40	1,655.37	1,547.98	1,426.63	1,289.51	1,134.56	959.47	761.61	538.04	285.40	-0.08
Net Present Value of Investment												
Description	**Unit**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**
Repayment	Nu	323	323	323	323	323	323	323	323	323	323	323
Fuel Cost Saved	Nu	225	254.13	283.71	313.89	344.55	375.60	406.94	438.47	470.11	501.79	533.45
Net cash flow	Nu	-97.293215	-68.45	-38.88	-8.70	21.97	53.02	84.35	115.88	147.52	179.21	210.86
NPV	**Nu**	**68.10**										

Sources: Developed on Primary Survey Results

Note: The set of reference unit values used calculations are listed in Table 12 in annexure 2.

It can be seen in the Table 6 that NPV for the mode shift to NMT scenario has high positive value of Nu. 68.10 million, which indicates that construction of state of the art footpaths in urban areas to induce NMT mode shift will be financially beneficial even if the mode shift happens only in the major urban areas i.e., Thimphu and Phuentsholing.

5.3 Eco driving training for bus drivers

The scenario of training drivers with Eco Driving lesson is the important and quantifiable part of Information strategy discussed in the previous section. Introduction of Eco Driving Training here means giving training to drivers for improving the driving skills of bus drivers to achieve higher fuel efficiency. The training would include regular sessions for the drivers and monitoring of driving skills on every day basis. In the first month, all the drivers would be trained and afterwards every month bottom 10% of performers including drivers who had performed less than their own last month's performance will be selected to repeat the training. This is a self-sustainable model of training, if done for large number buses (more than 100). The cost of training would be generated from the cost of fuel saved by Eco Driving methods. The eco driving training model also includes incentivizing the drivers to encourage them to adapt to energy efficient driving skills. The cost benefit analysis of the Eco Driving Training is presented in Table 7.

Table 7: Cost benefit analysis of the Eco Driving Training

Eco Driving Training	**Unit**											
	Nu (Million)											
Net Present value with incentive to bus drivers												
Description	**Unit**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**
Fuel Cost Saved	Nu	1.68	1.89	2.10	2.31	2.52	2.74	2.96	3.18	3.40	3.62	3.83
NPV	**Nu**	**12.86**										
Net Present Value without any incentive to bus drivers												
Description	**Unit**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**
Fuel saving by eco driving training	Nu	14.32	16.06	17.85	19.66	21.50	23.35	25.21	27.08	28.94	30.80	32.66
Training and monitoring cost	Nu	8.40	11.47	12.75	14.05	15.36	16.68	18.01	19.34	20.67	22.00	23.33
Net Cash Flow	Nu	5.91	4.59	5.10	5.62	6.14	6.67	7.20	7.74	8.27	8.80	9.33
NPV	**Nu**	**32.88**										

Sources: Developed on Primary Survey Results

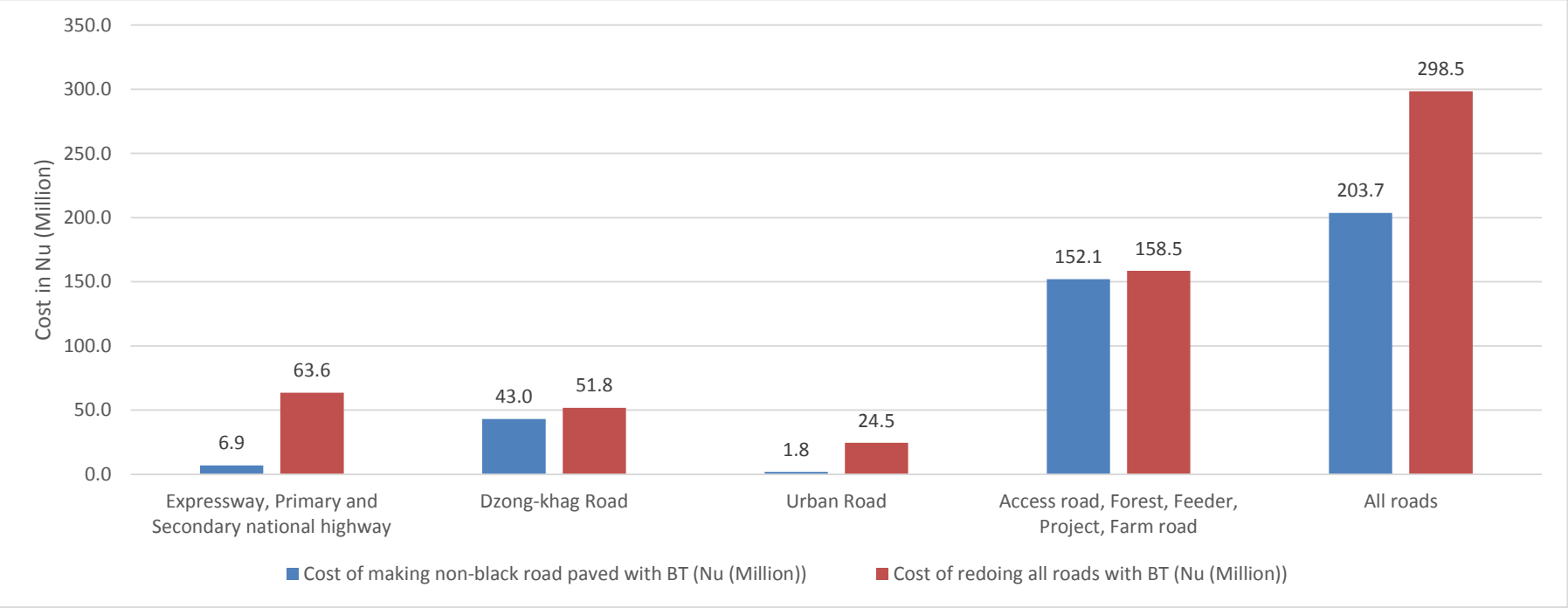
Note: The set of reference unit values used calculations are listed in Table 12 in annexure 2. In addition, the cost of training is taken in terms of fuel which is converted in monetary terms afterwards for NPV calculations. The cost is based on the PT expert (Mr. Prashant Bachu, Freelance consultant with Embarq India) calculations, based on a similar exercise done in Andhra Pradesh. The total fuel saving per bus per day is 6 litres of fuel out of which 2.5 litres would be the cost of training and monitoring and remaining 3.5 litres would the savings. Out of this 3.5 litres, 3 litres may be given to drivers as incentive (the monetary equivalent of 3 litres of fuel) and 0.5 litres will be the benefit to the government.

It can be seen in the Table 7 that NPV has a high positive value Nu. 12.86 million even in the case of net fuel saved after removing the incentives given to the driver for eco driving (incentive cost is taken from saved fuel cost of eco driving) which indicates that Eco Driving would be financially beneficial even after giving high incentives to the drivers (the amount of incentives given to the drivers is upon the government and can even be reduced from the current assumption).

5.4 Improving road conditions by constructing well paved carriage way

Improving road conditions by laying bituminous road may include two possible interventions. First, laying bituminous road on the existing unpaved/non-black top roads and second could be laying the whole surface of roads with bituminous surface to achieve consistent quality. The figure 23 provides the cost of laying bituminous surface on different types of roads for both interventions.

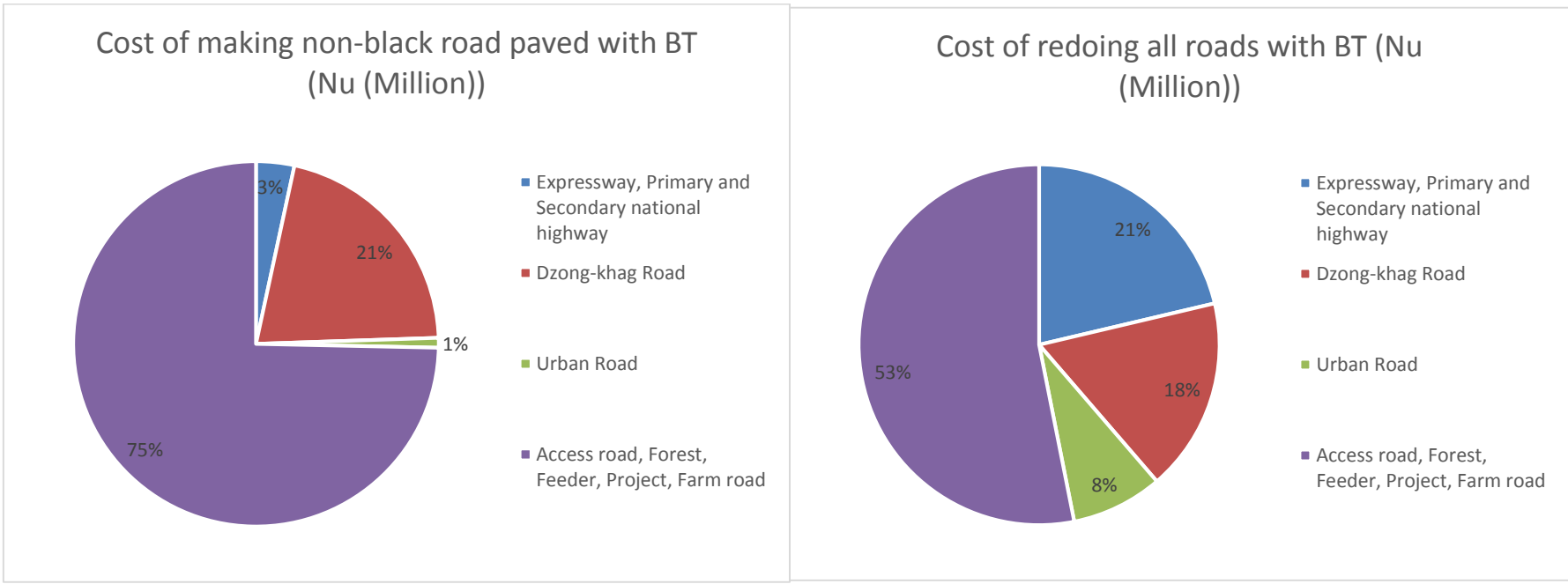
Figure 23: Cost of laying bituminous road



Source: Developed on Primary Survey Results

It is evident from the figure below that major portion of laying bituminous surface is of access, forest, feeder, project and farm roads. If a nation-wide data set on average trip distances per year on different types of road can be collected, it can be used to prioritise the bituminous surface laying process.

Figure 24: Percentage share of laying bituminous surface on different types of roads



Source: Developed on Primary Survey Results

However, the findings of fuel efficiency experiment conducted using one vehicle (refer section 3.9 Road condition and Energy Efficiency, Table 2) is extrapolated and applied to the whole universe i.e., all cars, SUVs and taxis registered in the country, then the assumption in change in fuel efficiency would be same i.e., 1 km per litre for all these cars, SUVs and taxis and it will cover same average trip distance as of a typical car in a year, then accordingly the monetary and energy savings can be calculated. These are represented in the following table.

.

Table 8: Potential benefits of improved road conditions

Average saving of fuel by one car in a year by running on well paved roads (Litre)	74.3
Fuel consumed by one car in a year by running on not well paved road (Litre)	1,189.0
Total fuel saving by vehicles running on well paved roads (kl)	685
Total fuel consumed by vehicles in a year by running on not well paved road (kl)	10,962
Percentage savings in fuel	6%
Fuel saved by registered vehicles annually in monetary terms by running on well paved road (Nu. Million)[4]	47
Percentage cost (laying BT road) can be recovered by fuel efficiency enhancement	16% to 23%

Source: Developed on Primary Survey Results

Note: The figures represented in the table above have set of limitations and assumptions;

1. The basic assumption for calculating the change in fuel efficiency adopted from the experiment conducted with only one car. This may not be true in the case of whole set of cars, SUVs and taxis registered because experiment was conducted using specific car (Toyota Prado manufactured in year 2008) and driven by a specific driver. Therefore, the extrapolate figure will be scientifically correct only if the same experiment is repeated on different types of roads with different vehicles driven by different drivers.
2. Another underlying assumption is that all the savings from the fuel efficiency change could be transferred to government. However, there is no proven implementation or regulatory structure existing which can ensure that user fuel savings (vehicle driver/owner will be directly benefited by the improved fuel efficiency of the vehicle) could be successfully transferred to concerned government authorities. Even, if it is assumed that government will be benefitted in terms of importing less petroleum fuel, it will be virtually impossible to establish mechanism to keep track of individual user fuel/energy savings.
3. There are set of external factors like fuel/energy to be used laying the BT roads, fuel/energy required to transport the raw material to different sites, etc. These energy factors will negate the fuel/energy saving showed in the above table.

It can be seen in the table above that by improving road conditions fuel efficiency may improve but the savings are marginally, especially if the cost of laying bituminous road is compared with (maximum 23% of cost can be adjusted against the potential savings). Therefore, laying of bituminous surface may be considered as least priority intervention to develop the energy efficient transport system in Bhutan.

[4]Refer to tab 'BT Road' in the excel sheet CBA for EE Bhutan_v3

5.5 Emission Reduction and Energy Savings for all interventions

In addition to the real time monetary benefits of the interventions discussed in the previous sections, there would be emission reductions because of these interventions which are presented in Table 9. The emission reductions have been taken out on the basis of savings in fuel consumption by the means of mode shift from private cars to public transport, walking, use of electric cars, bikes and buses, and use of eco driving training model for enhancing the efficiency of public transport.

Table 9: Reduced Emission calculations for various strategies

	Strategies	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	Total	% share
Emission Savings (Thousand tCO_2)	**Mode shift to PT**	9.21	9.74	6.05	6.35	6.64	6.92	7.19	7.46	7.72	7.98	**75.26**	15.01%
	Mode shift to NMT	10.24	10.83	11.41	11.97	12.51	13.04	13.56	14.06	14.54	15.02	**127.16**	25.36%
	Eco Driving Training	0.91	0.97	1.02	1.07	1.12	1.17	1.21	1.26	1.30	1.34	**11.36**	2.27%
	Introduction of Electric Buses	0.10	0.20	0.29	0.39	0.48	0.75	1.02	1.28	1.53	1.78	**7.82**	1.56%
	Introduction of Electric Cars	5.49	10.84	16.05	21.11	26.04	30.84	35.51	40.06	44.49	48.79	**279.23**	55.69%
	Introduction of Electric Bikes	0.02	0.03	0.04	0.05	0.06	0.07	0.07	0.08	0.08	0.08	**0.57**	0.11%
	Total	25.97	32.61	34.85	40.93	46.84	52.79	58.57	64.19	69.67	74.99	**501.41**	**100.00%**

Sources: Developed on Primary Survey Results

Note: The set of reference unit values used calculations are listed in Table 12 in annexure 2.

It can be seen in Table 9 that largest emission reduction would be in case of shift to EVs but it is dependent on the acceptance of the EVS by the market. The substantial amount of emission reductions is being achieved by PT introduction and NMT scenario which can be easily implemented and monitored

by the government, and it has less externality. Thus, it is strongly recommended to strengthen the Public transport system by addition of more buses and followed by driving skill improvement training.

The energy savings in case of the various strategies have been presented in Table 10. It can be clearly seen from Table 10 that the maximum energy savings are in the case of electric cars followed by PT and NMT mode shift strategies. However, the realization of energy savings from introduction of electric cars and bike is dependent on the residents' willingness to buy these EVs. On the other hand, the realization of energy savings from Mode shift to PT and NMT is much more realistic for government to implement, especially considering the inadequate PT system and NMT facilities in the country at present.

Table 10: Energy savings by various strategies

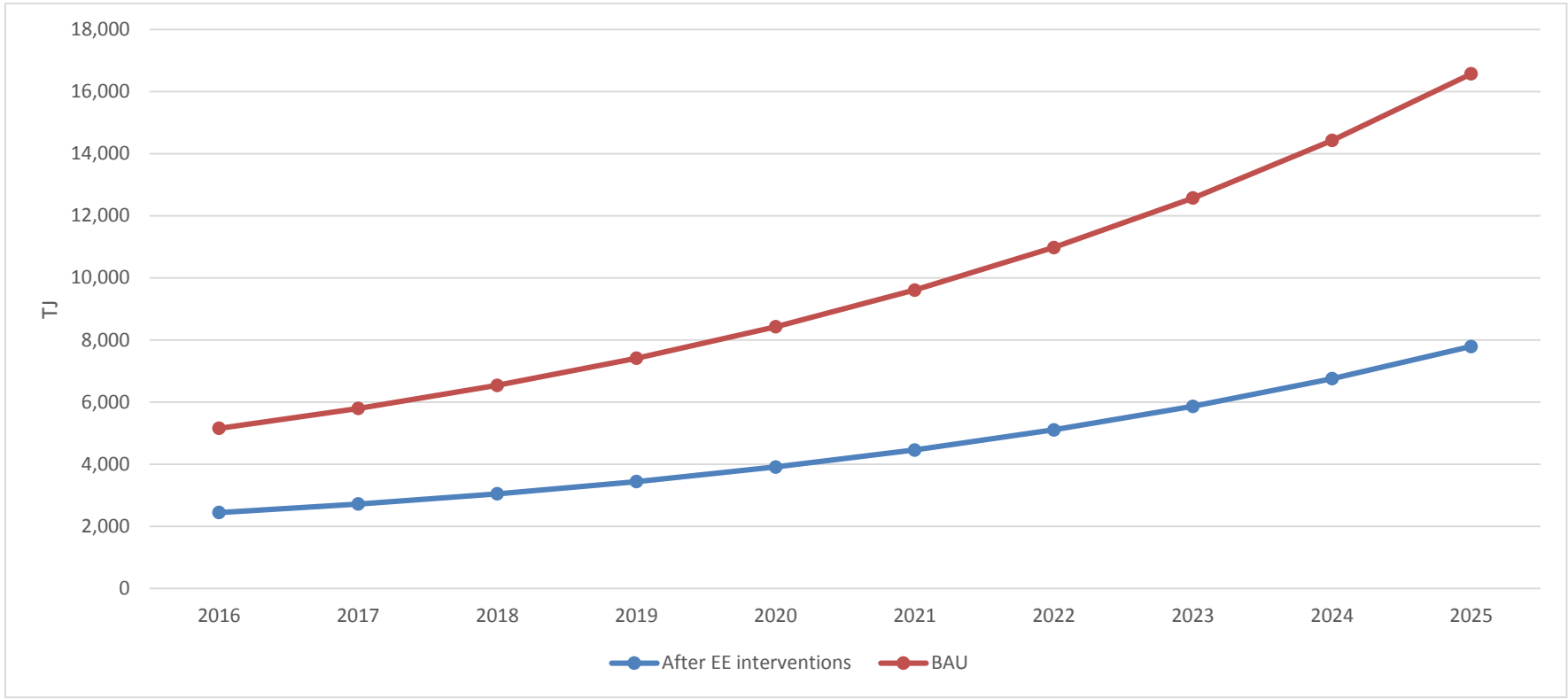
	Strategies	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	Total	% share
Energy Savings (Thousand GJ)	**Mode shift to PT**	110.8	117.3	123.6	129.8	135.7	141.6	147.2	152.7	158.1	163.3	**1380**	20.11%
	Mode shift to NMT	116.8	123.6	130.3	136.7	143.0	149.1	155.1	160.9	166.5	172.0	**1454**	21.18%
	Eco Driving Training	1.1	1.1	1.2	1.3	1.3	1.4	1.4	1.5	1.5	1.6	**13**	0.19%
	Introduction of Electric Buses	0.3	0.6	0.9	1.2	1.4	2.3	3.1	3.8	4.6	5.3	**23**	0.34%
	Introduction of Electric Cars	78.4	154.8	229.1	301.4	371.8	440.3	507.0	571.9	635.1	696.6	**3986**	58.07%
	Introduction of Electric Bikes	0.2	0.4	0.5	0.6	0.7	0.8	0.9	0.9	1.0	1.0	**7**	0.10%
	Total	0.3	0.4	0.5	0.6	0.7	0.7	0.8	0.9	1.0	1.0	**6865**	**100.00%**

Sources: Developed on Primary Survey Results

Note: The values used for conversion of Fuel into Energy are 31.85 and 37.63 GJ/kl for petrol and diesel respectively. And 1 kWh *= 3.6 MJ for electricity. These values are calculated from IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2. The set of reference unit values used calculations are listed in Table 12 in annexure 2.*

The figure below shows the change in energy consumption pattern as compared to energy consumption in Business As Usual scenario.

Figure 25: Energy consumption in BAU and EE scenario



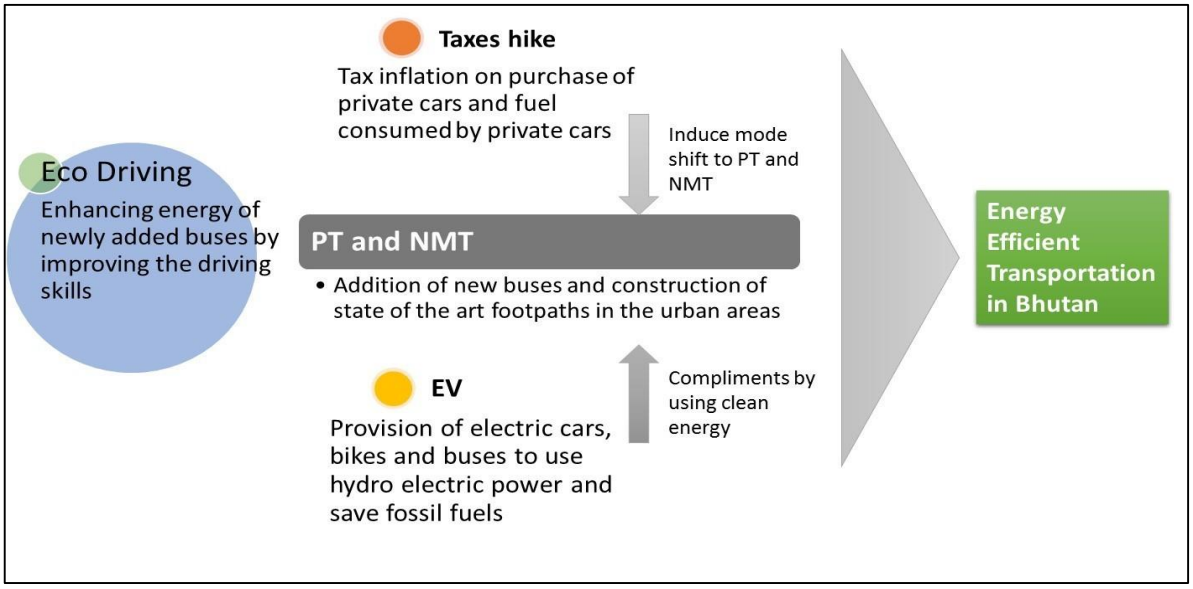
Sources: Developed on Primary Survey Results

Note: Only actionable energy consumption transportation segments (refer Table 9) are considered for building the BAU and EE scenario.

5.6 Conclusions

It can be concluded that the various interventions discussed in Energy Efficient Transport Strategies in section 4 and quantified in section 5 to gauge the associated costs, benefits and emission reduction will be highly beneficial for the country. In order to achieve this positive impact/benefits these interventions have to be implemented all together because these are complimentary between themselves. The relationships between the interventions are explained in Figure 26.

Figure 26: Relationship between energy efficient interventions



Thus, it is necessary to have public transport system for medium and long distance trips and NMT infrastructure for walking for short trips in place, before the taxes increase take place. Addition of new buses will motivate the residents to use PT and provide them affordable and sustainable mode for commuting. This will be further strengthened by the eco driving training to improve fuel efficiency of new buses and incentivize the drivers to drive in an energy efficient manner. Further benefits can be achieved by change of technology from conventions fossil fuel cars, bike and buses to electric vehicles. The strategies with direct Energy Efficiency benefits have been quantified in this report; however, it is critical that the larger National Policy Level addresses the other proposed interventions (discussed in the section 4 of this report) involving multiple stakeholders to ensure a low carbon energy efficient future for the country.

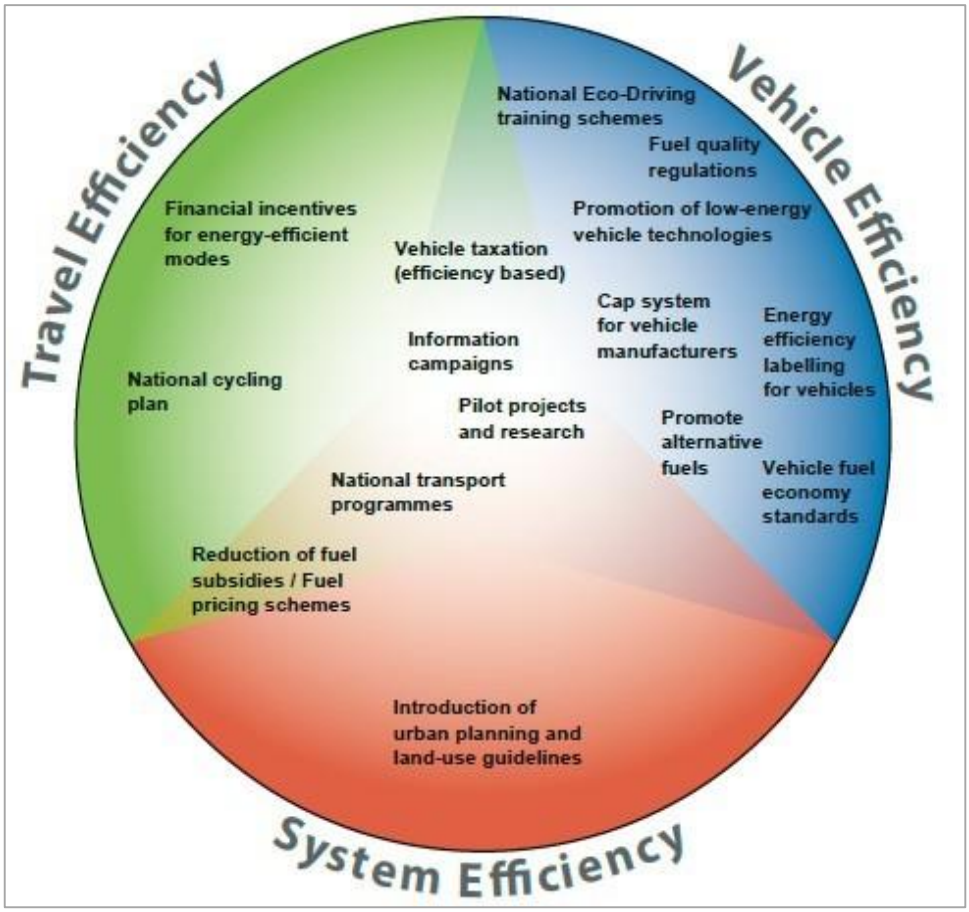
6. Strategies for a Comprehensive EE approach

The policy instruments presented in the previous section are most successful in reducing greenhouse gas emissions and achieving other co-benefits, when implemented as a package of measures. While Bhutan has taken some steps like the ban of second hand car import and not allowing use of PT and taxi that are more than 10 years old etc. This section focuses on the various combinations of measures and on a more comprehensive approach.

Evidence suggests that a comprehensive sustainable urban transport approach that takes advantage of a variety of instruments will have a larger impact on emission reductions and will result in more co-benefits through the improvement of local transport systems. Taking a comprehensive approach will typically include, e.g., the provision of cycling and walking facilities, attractive and reliable alternatives to the private vehicle; it will make use of measures that restrict the use of the car; it will help establish of good land use planning practices; it will promote technological improvements such as cleaner fuels; and it will set (monetary) incentives by applying appropriate economic instruments. The level and intensity of intervention will differ from instrument to instrument. Some will be voluntary, some will work on an incentive basis, and others will establish binding legal restrictions.

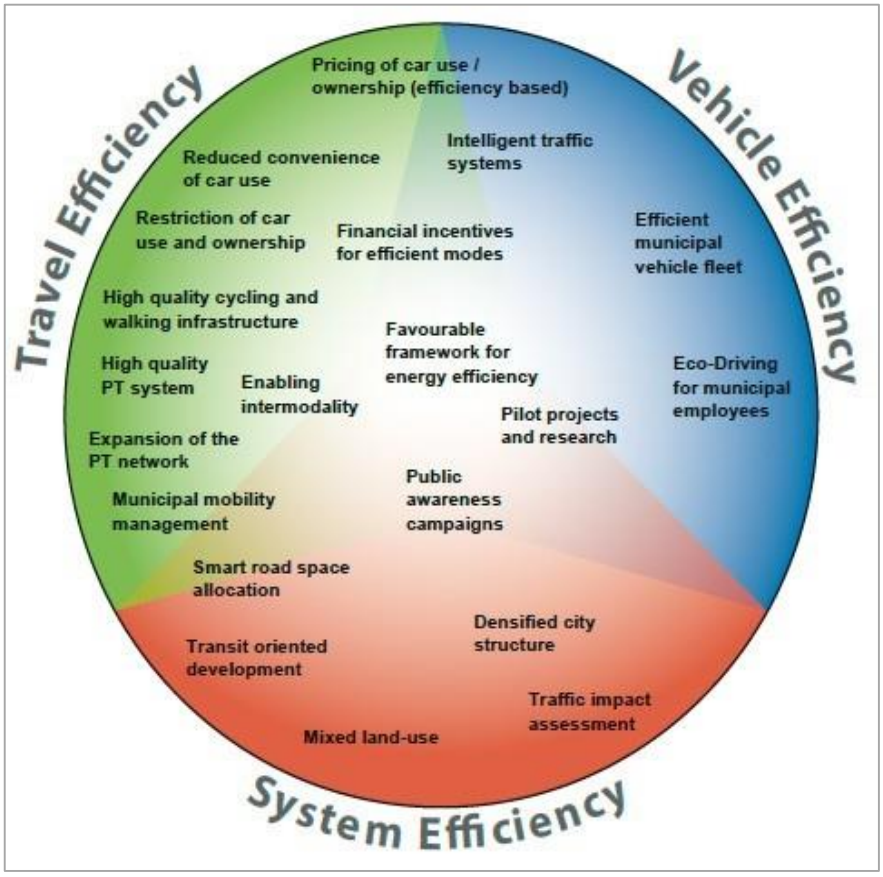
A successful policy mix or package for increasing Energy Efficiency of transport can be put together to gain travel efficiency, system efficiency and vehicle efficiency. This mix is presented in Figure 27, Figure 28 and Figure 29 below based on the different levels of stakeholders.

Figure 27: Energy efficiency navigator for National Governments



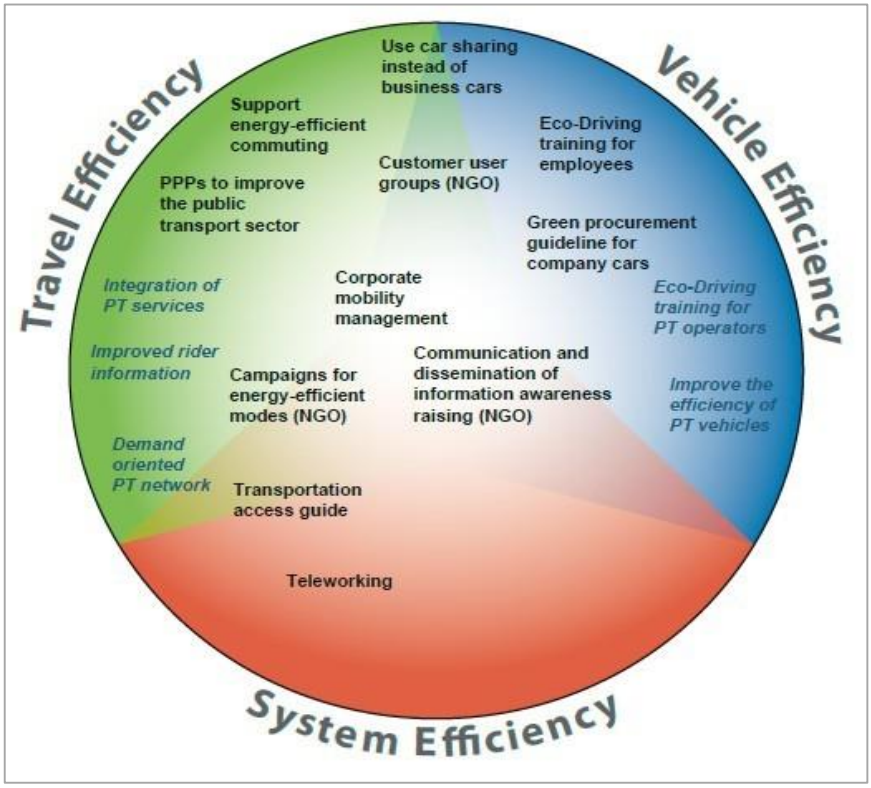
Source: Report on Climate Change, GIZ

Figure 28: Energy efficiency navigator for Thromde and Local Authorities



Source: Report on Climate Change, GIZ

Figure 29: Energy efficiency navigator for Local companies and organizations



Source: Report on Climate Change, GIZ

6.1 Bundling for increased efficacy

Projects such as NMT are often too small in size and scope to be attractive for funding. Also, they are difficult to implement without intervening with other systems. However, these are sustainable and increase efficiency of larger projects. These can be bundled with other larger projects to make them financially attractive and implementable. Some of the projects that can be combined are:

- **Public Transit Projects**: The high implementation cost of building BRT and bus systems can easily absorb the costs of providing better access facilities (which would be a small percentage of the total project cost) to transit like investment in good sidewalks, cycling infrastructure and parking for NMV modes. This can be easily carried out in Thimphu and Phuentsholing while investing in public transit systems.
- **Heritage and tourist area plans**: Walking and cycling infrastructure have a symbiotic relationship with heritage and tourist areas, as a lot of domestic and foreign visitors walk and cycle in these areas. Additionally, there is focus on public spaces and green areas which makes it perfect for walking and cycling. The areas around the Dzongs in Bhutan can be pedestrian and cycle friendly.

6.2 Prioritization of projects

If a country does not invest in sustainable transport facilities, it will cost much more in the future to the country. Phasing of interventions and prioritizing should be based on scrutiny list. The prioritisation of projects into immediate, short term, medium term and long term can be done using the following criteria:

	Criteria	**Impacts**	**Potential Energy Efficiency**
Immediate and short-term measures	Improving the safety and accessibility of pedestrians, cyclists and public transport users.	↑ Non-motorised modes and public transport can become more attractive. Users can shift from cars to these modes.	Decrease in accidents. Decrease in fuel consumption. Decrease in congestion. Decrease in air pollution.
	Improving area level traffic circulation plans.	↑ This will regulate and smoothen traffic.	Decrease in fuel consumption. Decrease in congestion. Decrease in air pollution.
	Implementing measures like traffic signals.	↓ The number of car stops will increase.	Increase in fuel consumption. Increase in congestion Increase in air

			pollution.
Medium-term measures (Halting the decrease in the city's public transport and non-motorised transport users)	Corridor-level projects: like implementing cycle tracks and mass-transit corridors.	 Non-motorised modes (NMT) and public transport can become more attractive. Users can shift from cars to these modes.	Decrease in accidents. Decrease in fuel consumption. Decrease in congestion. Decrease in air pollution
	City level initiatives: like public transport fleet improvement, provision of bus stops and efficient scheduling. Pilot project for electric buses.	 Public transport can be more energy efficient, and more attractive for people.	Decrease in fuel consumption. Decrease in congestion. Decrease in air pollution
	Developing area level cycle networks and Public Bicycle Sharing (PBS) schemes, parking policy development and implementation in the city. Regular maintenance of tracks and footpaths.	 NMT would become a preferred option for intra city trips	Decrease in fuel consumption and emissions. Decrease in congestion.
	Provision of large number of charging stations for EV private cars.	 Increase use of private cars	Reduce fossil fuel consumption. Decrease in air pollution.
Long-term measures (Implementing the overall vision of City Structural plans and mobility plans.)	Developing city level networks for walking and cycling, bus systems, mass-transit networks and integrating with better urban/land use planning to reduce trip distances.	 Car usage and ownership will start declining. Congestion and parking pressure will ease. Cities in Bhutan will become more equitable and inclusive.	Decrease in fuel consumption and emissions. Increase in energy security due to decreased dependence on imported fossil fuels.

	Parking regulation measures and pricing strategies as a demand management tool. Levying private car ownership tax	Car usage will decline. Public Transport and NMT will become an economical choice for commuting.	Decrease in fuel consumption and emissions. Increase in energy security due to decreased dependence on imported fossil fuels.
	Improving the overall road network, design to provide adequate accessibility for existing developed areas and new ones as the city grows.	Road network improvements could increase the number of private vehicles. Besides, it can increase the number of public transport users.	Decrease in fuel consumption.
	Centralised control measures for traffic signal systems and public transport operations.	This will rationalise systems and operations, through traffic management.	Decrease in fuel consumption. Decrease in congestion. Decrease in air pollution.

Positive Impact Negative Impact

An additional set of criteria for prioritising projects can be as following:

- Balance between improving existing infrastructure and creating new infrastructure in upcoming areas of development;
- Costs versus project's benefits measured in terms of mobility and accessibility, safety, energy, environment and CO_2 mitigation;
- These project ideas can be presented to the stakeholders in order to get their feedback on both the projects and their prioritisation. Multi Criteria Assessment (MCA) technique can be used to evaluate alternate options using stakeholder feedback. The final list of identified projects can then undergo detailed studies on implementation, cost estimates and likely funding agencies.

6.3 Consensus building to maximizing impacts

Maximum impact can be created by building commitment at all levels and among all stakeholders. The following strategies can help in creating maximum impact:

- **Creating High Level Political Commitment to boost sustainable transport shares:** To be successful, politicians must be able to clearly express their cycling vision and its benefits, while at the same time offering solutions to deal with the possible disadvantages. Many politicians have been inspired to support cycling in their city, once they see that cycling works in other cities. Well-developed cycling cities like Copenhagen, Amsterdam, Munster or Nantes serve as showcases for different levels of cycling culture; they are usually very welcomed by visitors and also cities are proud to showcase their cycling culture;
- **Creating Commitment across fields and political parties**: the NMT policy is not a single issue of transportation, but widespread across almost all policy fields and political parties. With broad commitment from the various policy departments, NMT initiatives can more easily be integrated into long term political ambitions to raise air quality, reduce traffic congestion, reduce carbon emissions, improve public health and increase liveability and the general feeling of safety by having more people on the streets;
- **Ensuring Senior Executive support for making it Happen**: Strong senior political and executive support is necessary in order to build an environment that can meet the sustainability objectives of a city. Well-educated and experienced leaders understand the political logic of how a city works and how it can be translated into the professional tool box of the civil servants. They understand the variety of terms and conditions that are closely linked to cycling and how to create and work with an administrative structure and staff that will be supportive and able to respond to change.

Engaging citizens through user/stakeholder participation is the key to success. The benefits of their consensus are:

- It smoothens the execution of interventions since fewer objections/court cases from citizens will occur and wider acceptance is secured;
- It improves the quality of the decisions since local know-how and experiences of users and professional expertise can be combined, as the users are often in the best position to identify urgent priorities;
- Potential future problems might be identified earlier and solved quicker since there is wider support;
- Involvement of the private sector in the sharing of responsibility and costs solves the financial and organisational burden of the government and private parties become more pro-active actors.
- Some of the strategies to promote sustainable transport among different user groups using following campaigns:
    - **Tourists** - Establish NMT friendly tourism routes, guest houses/hotels to supply free bikes for the duration of the stay, establish a programme to train local guides that can run bicycle tours;
    - **Urban Scholars/ Students** - Promote cycling to school and initiate safety awareness training;
    - **Urban Commuters** – Provide information to them about shorter and safer paths for walking and cycling;

- **Promote cycle subsidization programmers with large employers** - Businesses / co-ops / factories, etc. Encourage businesses / co-ops / factories etc. to provide showers, bicycle parking and storage facilities.

6.4 The Policy Matrix for an Energy Efficient Bhutan

The Policies proposed for Bhutan in this document are summarized below:

Policies	Key rationale	Who will implement?	How will it be implemented? (Regulatory, Institutional, Financing)	Implementation time frame
Improving public transport				
Promoting Organized Bus Transit systems (with emphasis on introducing electric buses)	[1] A skeletal bus system of 32 buses on 13 routes operates in Thimphu City, and 2 buses run in Phuentsholing. They are well patronized. especially in peak hours [2] These buses are currently run by Bhutan Post, who has the mandate but not capacity or interest to run the buses. The Intra-city bus systems are making losses [3] Intercity bus services are run by private operators [4] City bus services need to be organized with high frequency services to contend with the growing motorization [5] Introduction of electric/hybrid buses needs to be considered	A special purpose vehicle (SPV) formed by a Bhutan Post and/or private operator with performance monitoring by Thromde, RSTA, DRE and Bhutan Post (or Ministry of Information and Communications)	[1] Preparation of a detailed project report for bus transit system and operations in Bhutan (intra-city and intercity services); [2] Development of a SPV model for operations and maintenance of the bus system with a financial viability model; [3] Explore feasibility of electric buses for the intra-city services; [4] Station area design interventions with non-motorized access to Bus stations; [5] Development of Bus Stations, Terminals and Interchange Stations, Signal systems, Bus Stations and Maintenance facilities. [6] Pilot electric bus to demonstrate viability of electric bus and build public confidence on this technology.	Medium term (3-5 years) in Thimphu and Phuentsholing and longer term plan for other cities as they grow – especially, Gelephu and Samdrup Jongkhar
Improving Taxi servicing vehicle ownership				
Organizing the taxi services (with emphasis	[1] Increasing number of taxis run in Thimphu City and other cities. They are registered and well patronized. especially in peak hours; [2] They are run by private operators and fare, stands and	RSTA, DRE, Thromde, Taxi Associations	[1] Preparation of a Demand estimation and operational model for taxi services in the cities, including location of taxi stands and fares; [2] Study feasibility of electric taxis for the intra-city services; [3] Preparation of a subsidy model for purchase of electric taxis	Medium term (3-5 years) in Thimphu and Phuentsholing and longer term plan for other

on introducing electric taxis)	other operational characteristics are not structured; [3] Taxi services need to organized with high frequency services and fare meters to contend with the growing motorization; [4] Introduction of electric taxis needs to be considered as the second step towards electrification of the vehicle fleet.			cities as they grow – especially, Gelephu and Samdrup Jongkhar
Reducing vehicle ownership				
Policy for reducing vehicle ownership and wiser use of automobile	[1] Influences shift to public transport and walking.	RSTA, MOIC, Thromde	[1] Progressive increase (with rising income level) in the tax on auto ownership (only after augmenting PT system; [2] Introducing number plate bidding system only after augmenting PT system; [3] Regulating entrance to the city centre; [4] Introducing a parking policy and augmenting parking fee system; [5] Introducing travel awareness initiatives for wise use of automobiles.	Short term (0-3 years)
Congestion tax	[1] Reduces urban congestion; [2] Influence shift to public transport;	RSTA, MOIC, Thromde	[1] Introduce a Decree on introducing congestion tax by RSTA that should contain formulae and mechanism to compute the tax and the institutional mechanism to enforce and monitor; [2] Use collected tax to subsidize low emission vehicles or alternative energy use in vehicles; [3] Implement congestion tax in cities with populations of over 100,000 or mode share of private cars of more than 5% (whichever comes first in the development of the city).	Long term (5-10 year)

<table>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Differential taxation based on engine capacity</td><td>[1] Tax on engines with higher capacity already exists in Bhutan. It is significantly high for higher CC vehicles. This was a major reason for reduction in import of vehicles compared to years before 2012. However, this tax structure needs updating with time once the EV implementation is in place.</td><td>MOIC, RSTA, Ministry of Revenue and Customs</td><td>[1] Although the tax on vehicles (based on engine capacities) is already in place, the same needs to be updated from periodically especially after significant EV penetration in the country. Higher taxes need to be imposed on vehicles whose engine capacity is high and mileage is low.
<table>
<tr><th rowspan="2">Vehicle's Engine Capacity and Country of Origin</th><th colspan="4">Existing Tax Rates (%)</th></tr>
<tr><th>CD</th><th>ST</th><th>GT</th><th>Total</th></tr>
<tr><td>Less than 1500CC (imported from India)</td><td>0</td><td>45</td><td>10</td><td>55</td></tr>
<tr><td>Less than 1500CC (imported from third countries)</td><td>45</td><td>45</td><td>10</td><td>100</td></tr>
<tr><td>1500cc – 1799cc</td><td>50</td><td>50</td><td>15</td><td>115</td></tr>
<tr><td>1799cc – 2500cc</td><td>50</td><td>50</td><td>20</td><td>120</td></tr>
<tr><td>2500cc – 3000cc</td><td>50</td><td>50</td><td>25</td><td>125</td></tr>
<tr><td>More than 3000cc</td><td>100</td><td>50</td><td>30</td><td>180</td></tr>
</table>
Source: Ministry of Revenue and Customs</td><td>Long Term (5 - 10)</td></tr>
<tr><td colspan="5">Improving conditions of walking and cycling</td></tr>
<tr><td>Improving conditions of pedestrians</td><td>[1] Pedestrians form more than 50% of mode share but this is declining;
[2] Few places have adequate footpaths and well-designed crossings;
[3] Pedestrian access to public transit is necessary for the bus services to be effective.</td><td>Thromdes, Ministry of works and Human Settlements (Dept. of Road and Dept. of Urban Development)</td><td>[1] Preparation of an NMT Master plan for all the cities to be linked to the city development plan (including civil infrastructure, street lighting, civic amenities etc.).
[2] Phase-wise pedestrian infrastructure plans to be included in annual municipal budget and road budget.</td><td>Ongoing (starting from next year)</td></tr>
</table>

Introduction of Electric Public bike sharing system in cities	[1] Majority of trips are short as cities are small; [2] Electric bikes make it easy to negotiate the gradients; [3] This will discourage purchase of conventional two-wheelers or use of cars for short trips.	Thromde, DRE, Dept. of Urban Development	[1] Preparation of a detailed project report for bike-sharing in Thimphu city with financial plans, location and demand estimation.	Short term (0-3 years)
Lowering emission from Vehicles				
Stricter enforcement of auto fuel quality norms and emission standards	[1] Reduced local pollution – SOx, NOx, PM; [2] Improved well-being and reduced health hazards.	National Environment Commission, RSTA	[1] Mandatory testing of SOx, NOx and PM apart from CO/CO_2 for vehicle fitness certificate renewal [1] Review of Auto Fuel Roadmap (EURO standard) in view of the present compliance status, local survey on sources of pollution and future challenges in meeting the norm; [2] Progressively higher registration tax for EURO II vehicles; [3] Mandatory phase out of EURO II vehicles (fixing deadline through all-stakeholder consultation); [4] Tax rebate for EURO IV vehicles; subsidized loan or grant to bus and truck owners for conversion into EURO IV vehicles; [5] Testing facility to check import of inferior quality vehicles; [6] Stringent punitive actions for non-compliance; setting penalty and legal provisions for criminal actions; [7] Introduce fiscal measures: -Differential vehicle fees and taxes: Tax or registration fee based on engine size, efficiency, CO_2 emissions; -Higher fuel taxes. [8] Consumer awareness programme:	Short term (0-3 years)

			-Fuel economy/ GHG emission labels in the car; -Awareness programme for taxi, bus, truck drivers to change the driving behaviour. [9] Establish vehicle inspection and testing facilities to check inferior quality of imports from India.	
Compact city development and Sustainable urban planning				
Adoption of compact city policies at the planning stage of all the new cities (focus on walking and transit oriented development	[1] Bhutan is rapidly urbanizing. Growing urbanization and unplanned urban growth increases congestion and environmental pollution.	Department of Urban Development, Dzonkhag, Thromde	[1] Mixed land-use policy for new cities; [2] Regulation of ratio of spatial distribution of build-up land to open land; [3] Mode split with appropriate walkable and cycle routes; [4] Planning of green infrastructure: -Density regulation through effective FSI; -Passive solar architecture; -Regulations and limits on urban sprawls. [4] Implementing building code for all buildings in the new cities; [5] Incentives are specific to: -Community Amenities: A density bonus of two square feet for every one square foot of open space, plazas, childcare, eldercare, or community meeting rooms; -Pedestrian Enhancements: special street lighting, special street trees, special paving/amenities, bicycle storage facilities through joint public private efforts; -Funding/Reduced Costs: For Bus systems, if the bus station is an environmentally disadvantaged area, developers may be eligible for redevelopment, block grant, or housing funds; or tax abatements, increment financing, and tax credits from the Thromde in the context of a joint development partnership. Developers may also be exempt from Thromde fees, and delays for service connections may be avoided;	Short-Medium term (implementation of these planning and policy measures should be mainstreamed immediately in urban planning so as to avoid infrastructure “lock-in” effect)

			-Density Incentives: Reduced parking, land assembly, provision of housing and combined hearing processes may permit the developer to build at higher densities than normal. [6] Vendor development for supplying green building and construction materials and appliances; [7] Capacity building for builders, Thromde, Dzongkhag and Dept. of Urban Planning. [8] Dedicated parking for EV and Electric bikes with charging station.	

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8. Annexures

8.1. Annexure 1- Data from Survey

Table 11: Fuel efficiency and make of vehicles plying in Bhutan

Make	Model	Model CC	Mileage, km/l	Number of Vehicles
FUEL TYPE - Diesel				
AMW	1618TP	5883	4	13
AMW	2518TP	5833	4	4
AMW	2523TP	5883	3	5
ASHOK LEYLAND	U2518 IL T		3	3
ASHOK LEYLAND	LEYLAND-2012		2	1
ASHOK LEYLAND	7.5 T		7	2
ASHOK LEYLAND	1113		8	2
ASHOK LEYLAND	1212LE		6	2
ASHOK LEYLAND	1616		3	3
ASHOK LEYLAND	25180IL		3	3
BEML	2006		22	3
BOLERO	PIKUP 4X4	2523	12	2
BONLUA	BL-120		1.5	1
BONLUA (VIETNAM)	BL-120		1	1
CAT	CAT-2011		21	1
CAT	320B		18	4
CHINESE COASTER	COASTER-GZ6590	2800	7	1
DCM TOYOTA	DYNA	2336	8	2
DOOSAN	PC225		18	1
DOOSAN	DX 225LCV		13	4
EICHER	DCM-EICHER	5883	5	13
EICHER	EICHER 20-16	3298	4	1
EICHER	10.75H	3298	8	6
EICHER	10.95	3298	7	6
EICHER	EICHER 2011	4948	5	2
FORD	FORD-60	2195	1.5	1
HYUNDAI	SANTA FE	2199	12	4
HYUNDAI	SANTRO LX	1086	16	2
HYUNDAI	TUCSON TRD	1975	14	7
JCB	3DX-SUPER		7	1
JCB	JCB -2011		5	1
KIA	SORENTO	2359	12	2
KOBELCO	SR115		15	1
KUBOTA	L3301	1647	10	1
KUBOTA	B241	1123	10	1

KUBOTA	2004		1	1
KUBOTA	500 KG TYPE		2	10
MAHINDRA	575DI	2730	10	1
MAHINDRA	BOLERO	2523	9	2
MAHINDRA	BOLERO PICKUP	2523	10	6
MAHINDRA	CAMPER	2523	10	1
MAHINDRA	PICKUP 2.5 TURBO	2523	12	3
MITSUBISHI	SHORT BODY	2299	10	1
NISSAN	TERRANO XL	1461	15	4
TATA	1618	5883	4	3
TATA	207	2956	7	2
TATA	CITYRIDE 16	2956	10	1
TATA	INDICA	1405	18	1
TATA	LPK1613	5675	5	2
TATA	LPK1618	5675	4	2
TATA	LPK2518	5675	4	2
TATA	LPT809	3783	8	2
TATA	LPT913	5675	8	4
TATA	PICKUP	2956	10	1
TATA	SK1613	5883	5	17
TATA	SK407	2956	8	2
TATA	TRIPPER	5883	3	5
TATA-VISTA	VISTA	1248	19	1
TIREX	760		8	1
TOYOTA	COASTER	4164	8	1
TOYOTA	CORNONA	1899	15	4
TOYOTA	COROLLA	1798	15	7
TOYOTA	HILUX	2366	10	13
TOYOTA	PRADO	2982	15	6
FUEL TYPE - ELECTRIC				
MARUTI SUZUKI	CELERIO LXI	998	85km/charge	1
FUEL TYPE - PETROL				
BAJAJ PULSAR	180 DTS-I	180	35	4
BAJAJ	BIKE	150	35	1
BAJAJ	BIKE-2002	150	22	1
BAJAJ	BIKE-CALIBER	112	30	1
BAJAJ	BIKE-PULSAR	150	40	6
BAJAJ	CHETAK	145	25	3
BAJAJ	DISCOVER 125 M	125	35	1
BAJAJ	DISCOVER-250	250	45	1
BAJAJ	LEGEND	145	30	3

BAJAJ	LEGEND SCOOTER	145	35	3
BAJAJ	MOUNTAIN TRIAL	135	45	1
BAJAJ	PULSAR	150	25	34
BAJAJ	SCOOTER	150	25	17
BAJAJ	SCOOTER -LEGEND	145	30	1
BAJAJ	SUPERBAJAJ	150	36	2
CHEVROLET	AVEO UVA	1149	15	2
ENFIELD	ROYAL ENFIELD	500	45	1
FORD	FIGO	1196	15	6
HERO	KARISMA350CC	350	40	1
HONDA	BIKE	125	25	6
HONDA	BRIO	1198	16	2
HONDA	CIVIC	1798	22	2
HONDA	LIRE	1498	13	1
HYUNDAI	ACCENT	1495	18	4
HYUNDAI	A-STAR	998	18	2
HYUNDAI	EON	998	25	7
HYUNDAI	ERA	814	14	2
HYUNDAI	GETZ	1341	17	5
HYUNDAI	GETZ PRIME	1341	14	1
HYUNDAI	GRAND I10	1086	16	1
HYUNDAI	GRAND I10 MAGNA	1086	19	1
HYUNDAI	HYUNDAI-2008	1396	16	1
HYUNDAI	I10	1086	17	14
HYUNDAI	I10 ERA	1086	20	4
HYUNDAI	I10-IRDE	1086	15	1
HYUNDAI	I20	1396	15	8
HYUNDAI	SANTRO	1086	18	11
HYUNDAI	SANTRO XING	1086	15	24
HYUNDAI	SANTRO ZING ERLX	1086	20	10
HYUNDAI	SPARK	955	14	2
HYUNDAI	TUCSON TRD	1975	10	1
KINETIC	BIKE	165	30	4
MARUTI SUZUKI	100	100	18	2
MARUTI SUZUKI	A STAR VXI	998	20	2
MARUTI SUZUKI	ALTO	796	19	58
MARUTI	ALTO K10	998	18	2
MARUTI	A-STAR	998	17	12
MARUTI	CAR-800	800	13	2
MARUTI	CELERIO	793	17	4
MARUTI	CELERIO LXI	998	16	5

MARUTI	EECO	1196	13	7
MARUTI	EECO-VAN	1196	11	4
MARUTI SUZUKI	ESTELO LXI	1061	13	2
MARUTI SUZUKI	EURO3	206	20	5
MARUTI	K10	998	18	3
MARUTI	MARUTI 800	800	16	16
MARUTI	MARUTI-K10	998	19	1
MARUTI	OMNI	796	13	32
MARUTI	SWIFT	1197	14	3
MARUTI	SWIFT-DZIRE	1248	14	8
MARUTI SUZUKI	SX4	1248	17	1
MARUTI	WAGONR	998	13	31
ROYAL ENFIELD	ROYAL ENFIELD	500	30	3
SUZUKI	VETARA	2393	12	2
MARUTI SUZUKI	EECO	1196	12	1
TOYOTA	CORNONA	1899	20	1
TOYOTA	ETIOS CROSS V-D	1197	15	1
TOYOTA	ETIOS VX	1197	20	1
TOYOTA	LAND CRUISER	3999	10	4
TOYOTA	LAND CRUISER GX	4499	10	7
TOYOTA	RAV4	1998	15	2
TOYOTA	YARIS	1258	17	1
YAMAHA	100CC	100	25	1
YAMAHA	FAZER	125	35	7
YAMAHA	RX-100	100	35	1
YAMAHA	RX125	125	30	3

Source: Primary survey

8.2. Annexure 2: Reference unit values for PT introduction scenario

Table 12: Reference unit values for PT introduction scenario

Parameter	Value	Units	Source
Average run of a bus	100.93	km/day	Primary survey
kms run by a bus in a year in baseline	30,277.52	Kms	Primary survey
Efficiency of diesel bus	8.00	Km/litre	Primary survey
Diesel consumed by 1 bus in a year	3,784.69	litres	Calculated based on primary survey data
Cost of 1 electric bus	50,00,000.00	Nu	First-hand information based on the discussion of iTrans with Mahindra and Mahindra (minimum order of 100 buses)
Cost of 1 diesel bus	36,85,080.00	Nu	Primary survey
Diesel emission factor	2.68	tCO_2/kl	Calculated from IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2
Maintenance cost of electric bus	1%		First-hand information based on the discussion of iTrans with Mahindra and Mahindra (minimum order of 100 buses)
Maintenance cost of diesel bus	1.09%		Calculated based on primary survey data
Maintenance cost of electric bus	50,000.00	Nu/year	Calculated by iTrans
Maintenance cost of diesel bus	40,000.00	Nu/year	Primary survey
Average run of a car	46.38	km/day	Primary survey
Kms run by a 4-wheeler in a year in baseline	12,058.80	Kms	Primary survey
Efficiency of petrol car	17	Km/litre	Primary survey
Petrol consumed by 1 car in a year	630	litres	Calculated based on primary survey data
Petrol emission factor	2.27	tCO_2/kl	Calculated from IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2
Electricity emission factor from Bhutan	--	tCO_2/kWh	Hydro power is assumed to be CO2 free

Diesel emission factor	2.68	tCO_2/kl	Calculated from IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2
Mileage of a diesel car	16	Km/litre	Primary survey
Diesel consumed by a car in one year	670	Litres	Calculated based on primary survey data
Maintenance cost of petrol car	15,528.00	Nu/year	Primary survey (increment of 5% y-o-y)
Maintenance cost of diesel car	16,522.00	Nu/year	
Cost of Debt	0.13	%	http://drukpnbbank.bt/loan-interest-rates/
Debt Equity Ratio	75:25		
Cost of Equity	0.16	%	
Loan Repayment Year	5.00		
Depreciation rate	0.15	%	India -Income Tax Act 1961
Cost of capital	0.15	%	Calculated
SSEFF calculated mode shift to PT as per TDM	18%		In case of PT shift scenario conservative figure of 10% mode shift have been taken.
Length of road in Thimphu and Phuentsholing	244.60	km	Statistical Yearbook of Bhutan 2014 Note: Only Urban roads in Thimphu and Phuentsholing. (Chhukha) region are considered for construction of footpaths. As it constitutes of 70% of the total length of Urban roads in Bhutan. It is assumed that 10% of Private car short trips in these two cities will shift to NMT. It is assumed that 10% of Private car short trips in these two cities will shift to NMT.
Per unit cost of construction of footpath	100,00,000.00	Nu/Km	iTrans Note: It includes street lighting, tactile paving to provide barrier free walking to all, standard ramps wherever needed, necessary shifting of utility lines or retrofitting required.