



Ea Energy Analyses

**Bhutan:**

**A national strategy and action plan  
for low carbon development**

**FINAL REPORT**

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## **References**

## **Abbreviations**

## **Annex 1 – Stakeholder consultation**

## **Annex 2 – Scenario model training**

### **Separate deliveries:**

- Scenario model (Excel based tool)
- Scenario model user guide (document)

## **Preamble**

Environment a top priority

Bhutan has always placed great emphasis on the protection of its rich natural environment. Even while pursuing economic development environment has always been an integral part of its development strategy and is one of the four pillars of its philosophy for balanced and equitable sustainable development called “Gross National Happiness”. Green growth is being encouraged in industrial and private sector development. However, according to the draft Second National Greenhouse Gas Inventory the sink capacity is being challenged by the economic development of the country.

Challenges

Emissions of greenhouse gases are rapidly growing from increasing use of fossil fuels for energy and industrial processes. Ambient air and water quality is still very good to excellent but there are urban and industrial areas where air and water quality is increasingly becoming a major concern. The National Environment Commission (NEC) is also receiving increasing numbers of applications for environmental clearances for new industrial and infrastructure development projects – some with proposals for use of fossil fuel as a source of energy. Waste management is becoming a major concern with changing consumption patterns and increase in population.

Technical assistance

The Danish Ministry of Foreign Affairs therefore invited Ea Energy Analyses and COWI to bid for consulting services for a short term Technical Assistance (104.Bhutan.806-200). The task was to assist the NEC in making recommendations to the Royal Government of Bhutan on options for pursuing green growth. More specifically the objective of the assignment was to develop a long-term national strategy and short-term action plan for low carbon development to enable Bhutan to fulfil its commitment of remaining carbon neutral.

The technical assistance was financed by DANIDA and carried out in the period 1<sup>st</sup> August – 31<sup>st</sup> November 2011.

Stakeholder consultation

During the first mission 5-14 September 2011 numerous stakeholders were solicited for existing information and suggestions for interventions. Then a scenario model was prepared as a means to illustrating the consequences of various intervention options. During the second/final mission 31<sup>st</sup> October – 3<sup>rd</sup> November 2011 baseline results showing the challenges associated with pursuing a sustainable economic development of the country was presented and based on this, preliminary recommendations for interventions were discussed with key stakeholders. Furthermore, interested stakeholders took

part in training on scenario modelling, data development and the use of the scenario model together with NEC staff. Finally, a draft strategy and action plan report was circulated among stakeholders for commenting, after which it was finalised and handed over to NEC together with the scenario model.

The long-term national strategy and short-term action plan for low carbon development feeds in to the work of the 11<sup>th</sup> five year plan (2013-2018).

We wish to take this opportunity to express our gratitude to all stakeholders for their valuable contributions without which the work would not have been possible.

Ea Energy Analyses and COWI  
January 2012

# 1 Executive summary

The national strategy and action plan for low carbon development shall enable Bhutan to fulfil its commitment of remaining carbon neutral meaning that national emissions of greenhouse gasses (GHG) will not exceed the national sequestration. The strategy comprises various scenarios analysing development paths until the year 2040. As a supplement to the scenarios the action plan presents a number of short- and medium-term interventions to achieve carbon neutrality while still pursuing sustainable economic development.

The analysis starts by defining a baseline, i.e. development path under a business-as-usual regime. The data for the baseline is delivered by the National Environment Commission (NEC) and the National Statistics Bureau supplemented by information from a large number of ministries and other stakeholders involved. A core element is also the energy data directory 2005.

Bhutan's sequestration capacity is in the analyses assumed constant over the period until 2040 while emissions are analysed in more detail.

All projections of the present study are made from 2005 until 2040. In line with the methodology applied for the national GHG inventory, prepared by NEC, projections are made on a sector level and emissions categorised as energy related (residential, commercial, and industrial energy consumption as well as transport) and non-energy related (industrial processes, agriculture, land use and forestry, and municipal waste).

Today Bhutan has low carbon intensity on 0.15 kg CO<sub>2</sub>e/USD of GDP power-purchase-parity compared to an average among developing countries of 0.46 kg CO<sub>2</sub>e/USD. However, the low intensity reflects the high rate of carbon neutral hydro power in Bhutan. Another hydropower based country like Nepal has an intensity of 0.12 but also a lower GDP/capita. Bangladesh, which has no hydropower and a low GDP/capita, has an intensity of 0.22.

For projection of the *energy related* carbon emissions it is assumed that an increase in economic growth (GDP or GDP/capita) leads to an increased demand for energy services (light, heat, transport, etc.) and consumption of final energy (fuel wood, kerosene, diesel, etc.) resulting in increasing carbon emissions. Energy related emissions can be reduced by improving the energy efficiency of appliances producing energy services and/or by changing the

source of final energy from fossil fuels to renewable energy sources. Three different scenarios of energy related emissions have been analysed to show the possible impact of energy efficiency and renewable energy on the emission levels.

For projections of the *non-energy related* carbon emissions it is assumed that an increase in GDP leads to an increase in demand for final products resulting in increasing carbon emissions. Non-energy related emissions can be reduced by improving carbon intensity in the production process and/or reducing the production of for example municipal waste.

### **Baseline development**

NEC has estimated the 2009 carbon emission level to around 2.1 million t CO<sub>2</sub>e which is about one third of the estimated sequestered 6.3 million t CO<sub>2</sub>e. Emission from agriculture is a major source with half of the emissions while emissions from energy and industry count for a quarter each. The high share of emissions from the agricultural sector compared to other countries reflects the high rate of carbon neutral hydro power in Bhutan compared to the high dependence on fossil fuel for power generation in many other countries.

The baseline projection shows that in 2040 the emissions will be 4.7 million t CO<sub>2</sub>e or more than double the level in 2010 (see Figure 1), but still below the expected sequestration of 6.3 million t CO<sub>2</sub>e. The projections are made using the official population and GDP forecasts.

The energy related emissions will increase with almost 90% during the period 2010-2040 while the non-energy related emissions will increase with almost 110%. The main increase is expected in the industrial processes with emissions in 2040 that are almost four times the emissions in 2010.

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

Figure 1: Baseline projection of carbon emissions from energy related and non-energy related emissions (kt CO<sub>2</sub>e). Note: International aviation is not included in the numbers.

### Alternative energy scenarios

An overview of the results of the three modelled scenarios for *energy related* carbon emissions is presented in Figure 2 below. No scenarios were designed for the *non-energy related* emissions.

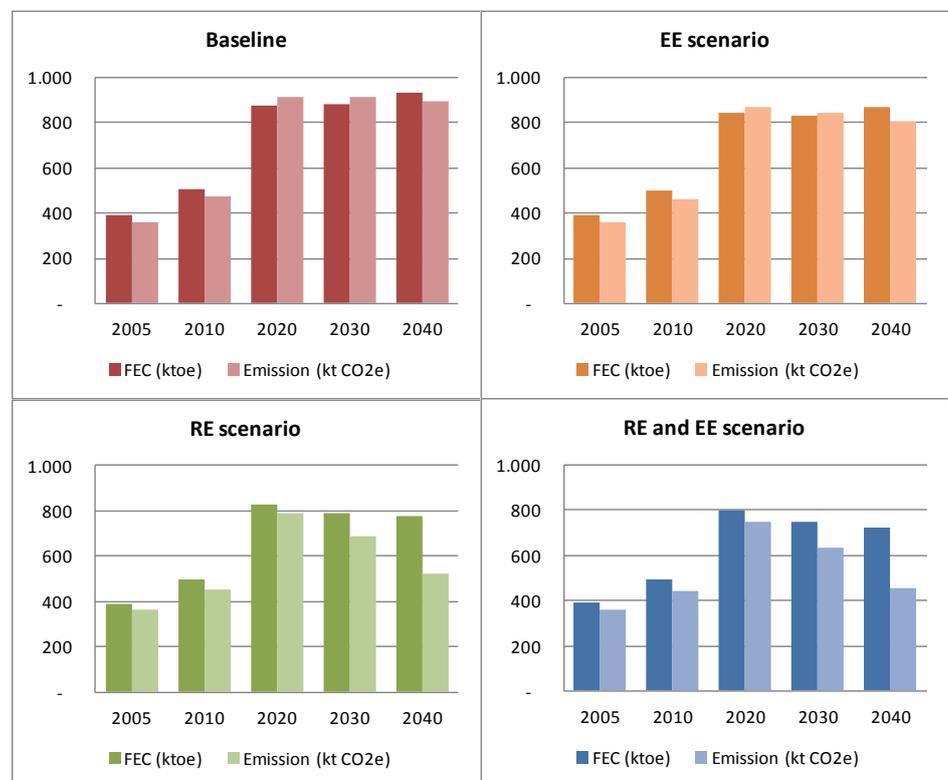


Figure 2: Development in final energy consumption (ktoe) and energy related carbon emissions (kt CO<sub>2</sub>e) of the four modelled energy scenarios 2005-2040. EE = energy efficiency; RE = renewable energy. Note: Non-energy related emissions are not included.

In the baseline projection energy related carbon emission increases by a factor 2.5 from 2005 to 2040. A focused effort to improve energy efficiency in all sectors could bring about a 10% reduction in 2040 compared to the baseline. A focused effort to increase the share of renewable energy has a much more significant impact and could result in a 42% reduction in 2040 compared to the baseline development. A combined pursuit of energy efficiency and renewable energy will have a slightly larger impact, namely 49% reduction in 2040 relative to the baseline level.

Bhutan has a large hydro power potential and exploitation of this resource is gradually increasing with the construction of new large scale hydro power plants. In 2009, the total hydro power production was 6,925 GWh (installed large hydro capacity 1,480 MW) of which 78% was exported to India. The carbon emission level of the marginal production in the Indian electricity system is 1.0 tCO<sub>2</sub>e/MWh. In other words, the electricity exported to India in 2009 represents about 5.4 million t CO<sub>2</sub>e avoided carbon emission. Bhutanese hydro power production thus not only benefits Bhutan but also the regional carbon balance. The 2009 amount of avoided carbon emissions in India due to import of electricity from Bhutan exceeds the total expected 2040 amount of carbon emissions in Bhutan.

### **Interventions**

A number of potential interventions/mitigation actions have been identified based on reviews of existing documents and consultations with stakeholders. An overview is presented in Figure 3. Assessments of abatement costs and benefits are merely qualitative. Further specific and detailed studies are required in order to quantify the abatement costs.

The criteria applied for selection of interventions include volume, costs, non-economic barriers (i.e. conflicts between sector policies), sustainability benefits (such as improved employment, reduced congestion in traffic and health improvements), and the specific 'window of opportunities' of using state of the art technology in an expanding economy. There are many opportunities for implementing interventions with low economic and non-economic costs. However, the large emitters of carbon also represent the largest economic and non-economic barriers.

Immediate term (1-2 years)	Medium term (2-5 years)
<b>Energy intensive industry</b>	
Further investigations on how international standards can be applied to Bhutan to reduce emissions and increase sustainability benefits.	Combine licensing with obligations that limit carbon emissions and increases benefits (energy efficiency standard, data for carbon footprint, energy management, employment of local work force, training, etc.).
<b>Crop production</b>	
The Royal University of Bhutan already has undertaken studies of new rice farming systems. The experience from this research is being tested and should be expanded during the next years in combination with awareness campaigns and training.	
<b>Livestock raising</b>	
Both identified mitigation options – improved breeding and manure management – are already under preparation and implementation by the Ministry of Agriculture. The efforts should be further pursued during the next years in combination with awareness campaigns and training.	
<b>Municipal solid waste</b>	
Establish system of composting of market waste (as in Thimphu) and municipal waste collection in all urban areas.	Feasibility study of biogas possibilities in the largest cities and if relevant pilot test.
<b>Road transport</b>	
<p>Parking fees and tax revision with elimination of tax exemption on import of cars could increase government revenue which could be earmarked for a modal shift.</p> <p>Improvement of public transport offer.</p> <p>Promotion of walking and bicycling for short journeys. Fully integrating transport issues in urban planning work.</p>	Pilot testing of electric vehicles.
<b>Residential sector</b>	
<p>Energy efficiency requirements in the building regulation and enforcement of the regulation. Provision of training of construction workers and enforcers.</p> <p>Test and adaptation of solar water heating and solar space heating technologies to the Bhutanese needs and build local production, installation, and maintenance capacity of these technologies.</p>	<p>Enforce minimum energy efficiency standards on electric appliances and cooking stoves.</p> <p>Information campaign to sensitise the population and businesses to energy efficient purchase and use.</p>
<b>Data on sequestration</b>	
Complete the already planned and partially initiated National Forest Inventory to enable the assessment of current and future sequestration capacity and measures to realise this. Establish monitoring system and organisation.	Information campaign and education program targeting the rural population and those employed in the agricultural and forestry sectors.
<b>Data on carbon footprint</b>	
<p>Devise mapping system and conduct pilot test of carbon footprint data system.</p> <p>Further analysis of the interventions of the short-term action plan among other with the aim to determine costs and specific impact targets.</p>	Establish sample data collection routines and test for selected sectors a data reporting obligation.

Figure 3: Recommended short- and medium-term actions.

The cement, ferro-silicon and calcium carbide industries produce a huge amount of carbon due to the use of reducing agents in the processing of raw material. As part of the industrial policy of Bhutan these industries are in the baseline projection expected to increase significantly resulting in a more than 400% increase in carbon emissions in 2040 compared to 2010. These industries represent a large potential for carbon emission reductions but the barriers are high. There is very little information on the costs of improving the efficiency in these industries. The industries are located in Bhutan because of the availability of resources and cheap power. There may be conflicts between climate policy and economic and industrial policy and there may be high abatement costs related to reductions in this sector. The proposed actions recommend a controlled development allowing further investigations on how to ensure employment opportunities and development of local capacity to exploit a larger share of the value chain and to reduce environmental impacts from mining and processing. It is recommended to further investigate how international standards can be applied to Bhutan to reduce emissions and increase sustainability benefits.

Another important area of intervention will be to increase the sequestration of carbon. National Forest Inventory initiated by the Department of Forestry Services will estimate carbon stocks for Bhutan in detail.

### **NAMAs**

There exist a number of financing mechanisms under the international climate regime. National Appropriate Mitigation Actions (NAMA) is a new mechanism and though modalities and procedures for NAMAs are still evolving many developing countries have pledged NAMAs. However, these NAMAs are often held at the level of aggregate targets and do not include much detail. NAMAs can consist of specific project based actions like CDMs and/or refer to broader policies or targets. Specific actions can consist of only one measure, a set of measures, or implementation of a holistic action plan. On 5<sup>th</sup> February 2010, the Royal Government of Bhutan registered in the NAMA pipeline<sup>a</sup> a NAMA with a nationwide approach and carbon emission target to remain carbon neutral as emission reduction goal.

One of the requirements to the NAMAs is that the actions must be embedded in the broader national sustainable development strategy and must be measurable, reportable and verifiable. With this study and the previous work

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<sup>a</sup> UNEP Risoe NAMA pipeline

and legislation prepared by the Royal Government of Bhutan mitigation actions have been embedded in a broader context. What remains is to gradually improve the basis for informed decision-making i.e. the data on various statistical topics including energy consumption and carbon foot print information.

### **Conclusion**

There is a room for increasing emissions within the present level of sequestration if the assessment is reliable. Should the sequestration be less than anticipated there is a risk that the present consumption of fuel wood is not sustainable and thus not carbon neutral. This would change the situation. Therefore it must be a high priority to complete the sequestration inventory already initiated by Department of Forestry.

The mining based industries are the main emitters of carbon and the proposed investigation of how international standards can be applied in Bhutan must have high priority.

There is a huge potential for reducing the energy related emissions. A combination of both energy efficiency and renewable energy efforts constitutes a sound strategy to limiting emissions and therefore development opportunities should be further investigated.

Finally, the agriculture sector comprises opportunities for increasing yield and thus rural welfare without increasing carbon emissions.

The current drive for economic development and purchase of energy consuming goods together with the building boom, provide a 'window of opportunity' to mitigate carbon emission cost-effectively seen from a long-term societal perspective – in particular within building construction, transport, and intensive industries. However, resolute and immediate action is required and is not a small task for anyone.

## 2 Introduction – the challenge of sustainable growth

### Carbon neutrality

During the UNFCCC 15<sup>th</sup> Session of Conference of Parties (COP15) in Copenhagen, the Royal Government of Bhutan committed to remain carbon neutral – in other words to ensure that the country's greenhouse gas (GHG) emissions do not exceed the sequestration capacity of its forests. The term “carbon” here refers to the green house gasses CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O and is measured in CO<sub>2</sub> equivalents (CO<sub>2</sub>e).

The economic development policy of 2010 states that green growth will be encouraged in promoting industrial and private sector development. However, with economic development carbon emissions are growing.

The National Environment Commission (NEC) is charged with the responsibility to make recommendations to the Royal Government of Bhutan on options for pursuing green growth so that the goal of remaining carbon neutral is achieved.

This report presents a long-term national strategy and action plan for low carbon development to enable Bhutan to fulfil its commitment of green growth and carbon neutrality.

### A long-term national strategy

The function of the long-term national strategy for low carbon development is to underpin the realisation of the ambitious vision of the Kingdom of Bhutan for economic development of the nation in a balanced and equitable sustainable manner. The main principles upon which the long-term national strategy for low carbon development is formulated are consistent with the values guiding the economic development vision. The long-term national strategy sets a target for the period until 2040 and describes a strategy for how this target may be achieved, with intermediate targets for 2020 and 2030.

### Action plans

The stepwise implementation of the long-term strategy will be coined in a number of action plans of which the first is part of this report, namely a short-term action plan for the near term period.

## 2.1 Bhutan in brief

Bhutan is unique in its mix of natural resources and its commitment to national happiness and sustainable development. Bhutan is explicitly striving to uphold Buddhist belief while balancing the development vision of a green and self-reliant economy sustained by an IT enabled knowledge society (Economic development policy of the Kingdom of Bhutan, 2010).

Gross national happiness

Progress is measured in “Gross National Happiness” and the guiding philosophy emphasises:

- Sustainable economic development;
- Preservation and promotion of culture and tradition;
- Conservation of environment;
- Good governance.

Major carbon sink

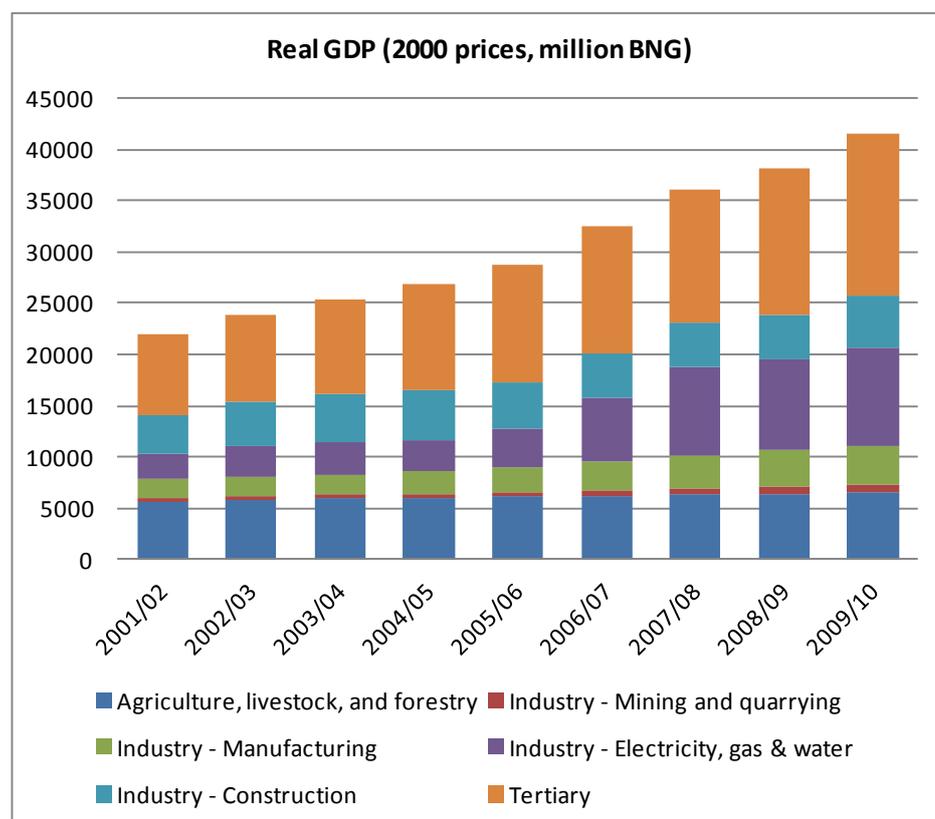
Forests and forest shrubs currently cover more than 72% of the 38,000 km<sup>2</sup> nation and the Constitution mandates a minimum 60% country under forest cover. Parks and protected areas make up half of the area of Bhutan. The forests thus constitute a major green house gas sink while at the same time providing biomass for energy and an important income potential from tourism industry.

Electrification

In 2005, rural residents constituted 69% of the total population. Electrification has been an ongoing project for many years and the aim is to achieve 100% electrification (“Electricity for All”) by 2013. In 2009 the electrification rate was 50% for rural households and 90% for urban households. Electricity is provided almost entirely by hydro power, while biomass is dominant for cooking and heating. The transport sector and non-electrical industrial processes relies completely on petroleum products that are imported since Bhutan does not possess any such resources. The remote location of a number of the households makes electrification difficult and expensive and off-grid hydro and solar energy systems are alternatives connection to the main grid.

Main economic sectors

The main economic sectors excluding the tertiary sector are 1) energy due to large scale hydro power export to India, 2) agriculture, livestock, and forestry, and 3) construction due to road and energy system construction work. In 2009, the hydro power sector contributed about 40% of government revenues, 45% of export earnings, and 25% of the gross national product. As can be seen in Figure 4 the energy industry has grown significantly over the past ten years as has the tertiary sector.



	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10
Agriculture, livestock, and forestry	5649	5791	5917	6012	6120	6221	6269	6374	6514
Industry - Mining and quarrying	389	405	392	414	489	591	715	753	752
Industry - Manufacturing	1838	1911	2011	2135	2342	2778	3218	3465	3705
Industry - Electricity, gas & water	2373	2887	3096	3119	3786	6186	8585	9002	9627
Industry - Construction	3895	4389	4634	4760	4474	4357	4238	4341	5228
Tertiary	7762	8409	9260	10455	11631	12454	13120	14310	15808
<b>Real GDP at factor cost</b>	<b>21905</b>	<b>23791</b>	<b>25310</b>	<b>26895</b>	<b>28842</b>	<b>32586</b>	<b>36145</b>	<b>38245</b>	<b>41634</b>

Figure 4: Sector specific contribution to the national revenue – real GDP in 200 prices (million Nu.) (NSB, 2010).

## Hydro power capacity

The total hydro power production in 2009 was 6,925 GWh (installed large hydro capacity 1,480 MW) of which 78% was exported to India whose green house gas balance is improved by the import of clean electricity. The average emission of Indian electricity production is 0.82 tCO<sub>2</sub>e/MWh and the emission of the marginal production is 1.0 tCO<sub>2</sub>e/MWh<sup>b</sup>. In other words, the 78% exported electricity represents somewhere between 4,400 and 5,400 kt CO<sub>2</sub>e avoided emission in India depending on the choice of method.

The installed capacity by December 2010 was 1,505 MW<sup>c</sup>. The estimated economically feasible potential is about 10,000 MW and four new projects of a combined capacity of 3,024 MW are to be commissioned in the period 2010-

<sup>b</sup> CO<sub>2</sub> Baseline Database for the Indian Power Sector, User Guide Version 5.0, Central Electricity Authority, Ministry of Power, Government of India, November 2009.

<sup>c</sup> Source: NEC, 2012.

2020 – all with strong involvement of the Government of India. These projects in turn require expansion of the transmission capacity. At present the storage capacity is limited (due to run-of-river plants) and during December-March there is shortage of supply (Bhutan: Energy sector, august 2010, ADB). During the shortage period residential consumers are given preference over industrial plants, and among other diesel is used to temporarily supplement electricity production.

Power Generation Data	2004	2005	2006	2007	2008	2009
Generation Output (GWh)						
Chukka HPP ( 336 MW)	1,928	1,831	1,878	1,788	1,802	1,808
Basochuu HPP (64 MW)	131	304	327	314	336	323
Kuruchuu HPP ( 60 MW)	345	366	365	380	386	370
Tala HPP ( 1,020 MW)		164	1,080	3,919	4,611	4,396
Mini Hydro	20	17	20	21	23	25
Diesel Plants	1	1	1	2	1	
Power Imports (GWh)	2	2	3	3	3	3
Total Power Supply (GWh)	2,427	2,685	3,673	6,427	7,162	6,925
Power Exports to India (GWh)	1,759	1,777	2,903	5,453	5,922	5,405
Power Sales to BPC (GWh)	680	708	715	947	1,125	1,414
Exports as a % of total generation	73.2%	66.7%	79.0%	84.8%	82.7%	78.1%
Power Sales to BPC as a % of Generation	28.0%	26.4%	19.5%	14.7%	15.7%	20.4%

BPC = Bhutan Power Corporation, gWh = gigawatt hour, MW = megawatt.  
Source: Independent Evaluation Department staff estimates.

Figure 5: Energy balance for Bhutan power sector 2004-2009 (ADB, Bhutan energy sector august 2010)

Projects	Output (GWh)	Cost (\$ million)	Financing Modality <sup>a</sup>	Construction Schedule
Dagachhu HPP 114 MW		201	Joint venture (Tata Power and DGPC) debt-equity 70: 30 and ADB OCR loan and Austrian export credit	2008–2014
Punatsangchhu –I 1,200 MW	5,700	850	Government of India financing (60% loan at 10% interest rate and 40% grant financing)	2008–2016
Punatsangchhu –II 990 MW	4,150	1,215	Government of India financing (70% loan at 11% interest rate and 30% grant financing)	2012–2019
Mangdechhu 720 MW	2,920	875	Government of India financing (70% loan at 11% interest rate and 30% grant financing)	2012–2019

<sup>a</sup>The financial structure of Punatsangchhu-II HPP and Mangdechhu HPP are indicative and subject to finalization. ADB = Asian Development Bank, DGPC= Druk Green Power Corporation, HPP = hydropower plants, MW = megawatt.  
Source: IED Staff estimates.

Figure 6: Details on hydro power projects to be commissioned 2010-2020 (ADB, Bhutan energy sector august 2010)

Item	2004	2005	2006	2007	2008	2009
<b>Low Voltage Consumers (Nu/kWh)</b>						
Block 1 (up to 80 kWh)	0.60	0.60	0.60	0.70	0.75	0.75
Block <sup>1</sup> II (80 kWh–200 kWh)	0.90	0.95	1.10	1.20	1.25	1.35
Block III (above 200 kWh)	1.00	1.20	1.25	1.45	1.55	1.70
<b>Medium VoltageV Consumers (6.6/11/33 kV)</b>						
Energy Charge (Nu/kWh)	0.95	0.95	1.10	1.25	1.30	1.43
Capacity Charge (Nu/kW)		54	54	54	65	75
<b>High Voltage Consumers (66 kV and above)</b>						
Energy Charge (Nu/kWh)	0.90	0.90	1.05	1.20	1.29	1.40
Capacity Charge (Nu/kW)		54	54	54	65	75
<b>Av. Electricity Tariff (Nu/kWh)</b>	0.94	0.97	1.12	1.23	1.47	1.56

kV = kilovolt, kW = kilowatt, kWh = kilowatt-hour.  
Source: Bhutan Power Corporation.

Figure 7: National electricity tariff 2004-2009. Nu = Bhutanese currency Ngultrum.

Transport infrastructure	One of the preconditions for socio-economic development is sufficient, timely and safe transport possibilities for transporting of goods and persons. Here transportation infrastructure planning and deliberate fiscal instruments for public, commercial and private transport are key to steering the development in an energy efficient direction. So far there has not been any domestic airport. However domestic airport services were commenced just recently – Yonphula (Trashigang) and Batpalathang (Bumthang) domestic air services started 17 <sup>th</sup> December,2011 while Gelephu Airport (Sarpang) is under still under construction and expected to come into operation in 2012.
Local farming and Brand Bhutan	The potential for improvement of local farming techniques to further organic farming is significant as is the potential to increase energy efficiency in the use of biomass (SHARE International Conference, May 2009). “Brand Bhutan” is intended to help further local business development based on natural resources and culture as is the aim for attracting low-impact high-value tourism. Brand Bhutan is an umbrella brand for a strategy to position Bhutan’s special qualities and products as leverage for economic development in line with the gross national happiness philosophy.
Economic development policy	The objectives of the economic development policy of Bhutan are to achieve economic self-reliance by 2020 and achieve full employment. The strategies outlined to achieve these objectives are presented below.

Economic development policy 2010:

- Development objectives
  - Achieve economic self-reliance by 2020
  - Full employment (97.5%)
- Strategies
  - Diversify economic base with minimal ecological footprint
  - Harness and add value to natural resources in a sustainable manner
  - Increase and diversify exports
  - Promote Bhutan as an organic brand
  - Promote industries that build the Brand Bhutan image
  - Reduce dependency on fossil fuel especially in respect to transportation
- Policy objective
  - Create an enabling environment for investment

RGoB aims to achieve a minimum economic growth rate of 9% annually and become a middle-income nation<sup>d</sup> by 2020 (RGoB, Economic development policy, 2010, p. 2).

Compared to its immediate neighbours Bangladesh, Nepal and India, Bhutan has a relatively high purchasing-power-parity (see Figure 8). Bhutan's purchasing-power-parity is also higher than the overall development of "Developing Asia".

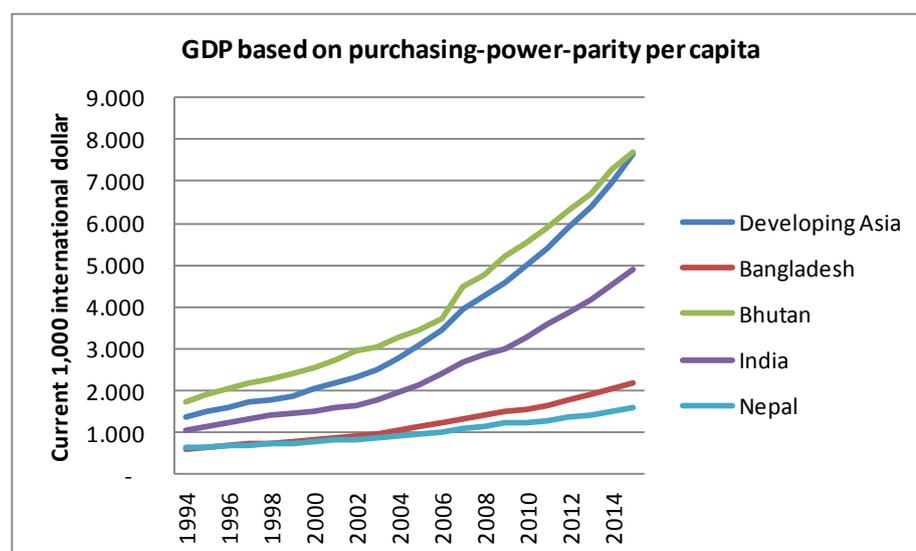


Figure 8: GDP based purchasing-power-parity per capita (Extract from IMF WEO database). The category "Developing Asia" is composed of 26 countries: Republic of Afghanistan, Bangladesh, **Bhutan**, Brunei Darussalam, Cambodia, China, Fiji, India, Indonesia, Kiribati, Lao People's Democratic Republic, Malaysia, Maldives, Myanmar, Nepal, Pakistan, Papua New Guinea, Philippines, Samoa, Solomon Islands, Sri Lanka, Thailand, Democratic Republic of Timor-Leste, Tonga, Vanuatu, and Vietnam.

At present, the Bhutanese economy has a relatively low carbon intensity. According to U.S. Energy Information Administration, Bhutan's CO<sub>2</sub> intensity<sup>e</sup> per unit of GDP in 2009, valued at purchasing-power-parity, constituted 0.108 t of CO<sub>2</sub> per thousand 2005-USD of GDP which is well below the world average of 0.464 t of CO<sub>2</sub> per thousand 2005-USD of GDP. This places Bhutan on the 29<sup>th</sup> place out of 48 least-developed countries and close to Nepal (see Figure 9 below).

<sup>d</sup> World Bank definition of middle income nation using the Atlas method: Lower middle income nation has a gross national income of 1,006-3,975 USD/capita and a higher middle income nation 3,976-12,275 USD/capita. Bhutan's 2010 gross national income =1,920 USD/capita.

<sup>e</sup> According to IEA's list of countries by ratio of GDP to carbon dioxide emissions, October 2010, Bhutan's CO<sub>2</sub> intensity<sup>e</sup> per unit of GDP in 2006, valued at purchasing-power-parity, constituted 0.146 tonnes of CO<sub>2</sub> per 1,000 USD of GDP which is well below the world average of around 0.4 tonnes of CO<sub>2</sub> per 1,000 USD of GDP.

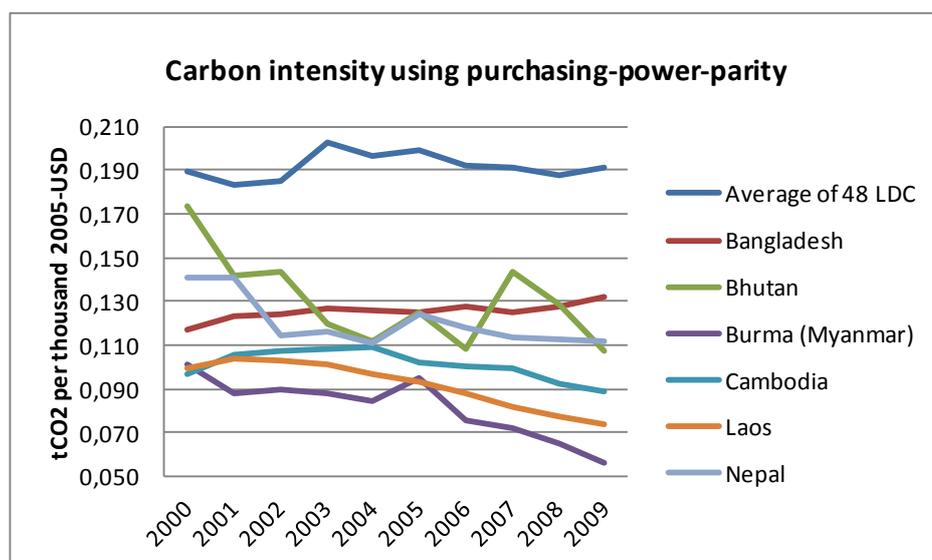


Figure 9: Comparison of carbon intensity using purchasing-power-parity (tCO<sub>2</sub> per thousand 2005-USD) ([www.eia.gov](http://www.eia.gov)).

The intended economic growth will among other inevitably bring about a larger demand for energy. Targeted energy efficiency efforts and low-carbon solutions can limit the extent of the increase in demand for non-renewable energy. Hydro power is highly sought after on the international market as it can supplant fossil fuel based production as well as compensate for fluctuations in other types of renewable energy production such as wind provided that there is sufficient water at the time in question. (It should, however, be noted that in general there are some cases where exploitation of hydro power potentials may cause local environmental problem.)

## Economic trends

There are economic trends in Bhutan which will drive the economic development over the next decades:

- The promotion of Gross National Happiness is expected to comprise economic growth in rural as well as urban areas.
- During the last decade there has been an increasing migration from rural to urban areas. In 2005 around 30% of the population were living in urban areas and in 2015 this share is expected to be close to 50%.
- Increasing unemployment among young men and women while the number of youth finishing higher education is increasing. Such unemployment is estimated to have risen from 4% to 15% during the last six years. At the same time labour is imported on a large scale for tasks particularly in the construction sector.

- There is a strong focus on greening the economic development by supporting sustainable tourism and eco-farming.
- Bhutan as a mentioned earlier has a large potential for hydro power generation and a large international market for export of non-fossil based electricity. During recent years the investment in hydro power plants and the generation of electricity from these plants have formed a major share of the increasing GDP.

## Organisation

Of the ten government ministries the following are per November 2011 particularly relevant to the development of a low carbon strategy

- MoAF – Ministry of Agriculture and Forests
- MoEA – Ministry of Economic Affairs
  - Departments of Energy, Geology and Mines, Industry, and Trade
- MoF – Ministry of Finance
- MoIC – Ministry of Information & Communication
  - Road Safety and Transport Authority
- MoLH – Ministry of Labour and Human Resources
- MoWHS – Ministry of Works and Human Settlement
  - DUDES – Department of Urban Development & Engineering Services

Also the Tourism Council of Bhutan (formerly a department under the MoEA) plays an important role.

## GNHC

The Gross National Happiness Commission (GNHC) is charged with ensuring that GNH is mainstreamed into the planning, policy making and implementation process by evaluating their relevance to the GNH framework of 1) developing a dynamic economy as the foundation for a vibrant democracy; 2) Harmonious Living – in harmony with tradition and nature; 3) Effective and good governance; and 4) The people: investing in the nation’s greatest asset.

## NEC

The National Environment Commission (NEC) is a high level multi-sectoral body, and the highest decision making and coordinating body on all the matters relating to the protection, conservation and improvement of the natural environment. The mandate of the NEC includes among other to:

- Develop, review and revise environmental policies, plans and programmes
- Formulate, review and revise environment related Laws/Acts and monitor enforcement of the same.
- Mainstream environment into the country’s developmental policies, plans and programmes

The Climate Change Division at NEC Secretariat is responsible for implementing the NEC's mandate of climate change. A Multisectoral Technical Committee on Climate Change (MSTCCC) also supports the NEC in coordinating climate change activities in Bhutan in a technical and advisory role.

The National Environment Commission is the national focal agency for climate change in Bhutan and also the National Focal Agency for the UN Framework Convention on Climate Change. The NEC is the also the Designated National Authority under the Kyoto Protocol for the Clean Development Mechanism.

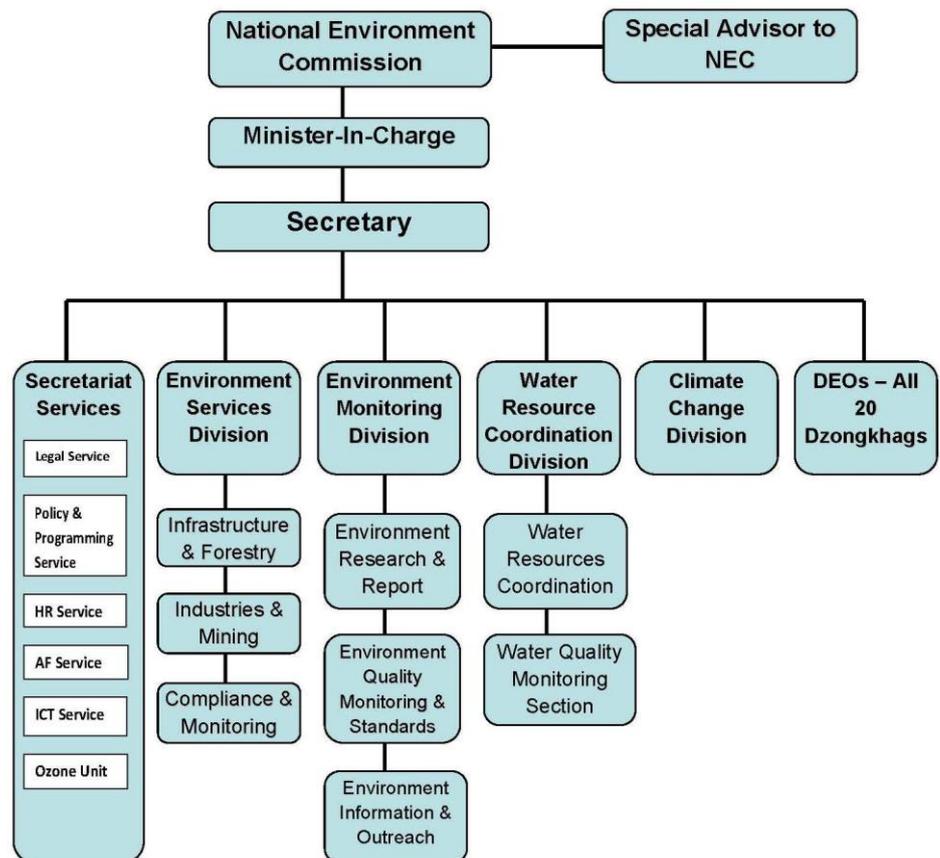


Figure 10: Organisation of NEC (NEC website).

## 2.2 UNFCCC GHG inventory

Bhutan is a UNFCCC Non-Annex I Party<sup>f</sup>. All Parties to the UNFCCC must submit national reports on the implementation of the Convention to the Conference of the Parties based on the principle of "common but differentiated responsibilities". Annex I Parties must submit an annual inventory of their GHG emissions, which is subsequently reviewed by international review teams. Non-Annex I Parties such as Bhutan must report in more general terms on their actions to address climate change and to adapt to its effect.

Bhutan submitted its first GHG inventory to the UNFCCC in 2000 presenting an inventory for 1994. The second inventory with a status for 2000 was submitted in November 2011 as part of its Second National Communication.

The GHG inventories operate with two main categories of emissions namely energy related emissions and non-energy related emissions, as shown below in Figure 11. The categories marked in grey – railways, national navigation, pipeline transport, and international marine bunkers – are not relevant in Bhutan's case. However, please note, that railway connection to a few border towns are being considered according to the Policy & Planning Division of MoIC, January 2012 – a fact that was not available at the time of the preparation of the analyses presented in this report.

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<sup>f</sup> Parties to UNFCCC are classified as: Annex I countries) Industrialized countries and economies in transition; Annex II countries) A sub-group of developed countries which pay for costs of developing countries; and Non Annex I countries) Developing countries.

Categories	Subcategories		
Energy related fuel combustion	Energy industries		
	Manufacturing industries and construction		
	Transport	Domestic aviation	
		Road	
		Railways	
		National navigation	
		Pipeline transport	
	Other sectors	Commercial / institutional	
		Residential	
		Agriculture / forestry / fishing	
	Other		
	Energy related fugitive emissions from fuel	Solid fuel	
		Oil and natural gas	
Memo items	International marine bunkers		
	International aviation bunkers		
	CO2 emissions from biomass		
Non-energy related	Industrial processes		
	Solvent and other product use		
	Agriculture		
	Land use change and forestry		
	Waste		
	Other		

Figure 11: GHG emissions categories (UNFCCC). Grey categories are not relevant in Bhutan's case. Please note, that railway connection to a few border towns are being considered according to the Policy & Planning Division of MoIC, January 2012 – a fact that was not available at the time of the preparation of this report.

Looking at the data that NEC has collected for the period 1995-2009 it is evident that the GHG emissions from the energy sector and the industrial sector are growing significantly although agriculture still constitutes the largest emitter of the sectors (primarily due to CH<sub>4</sub> emissions from enteric fermentation and manure).

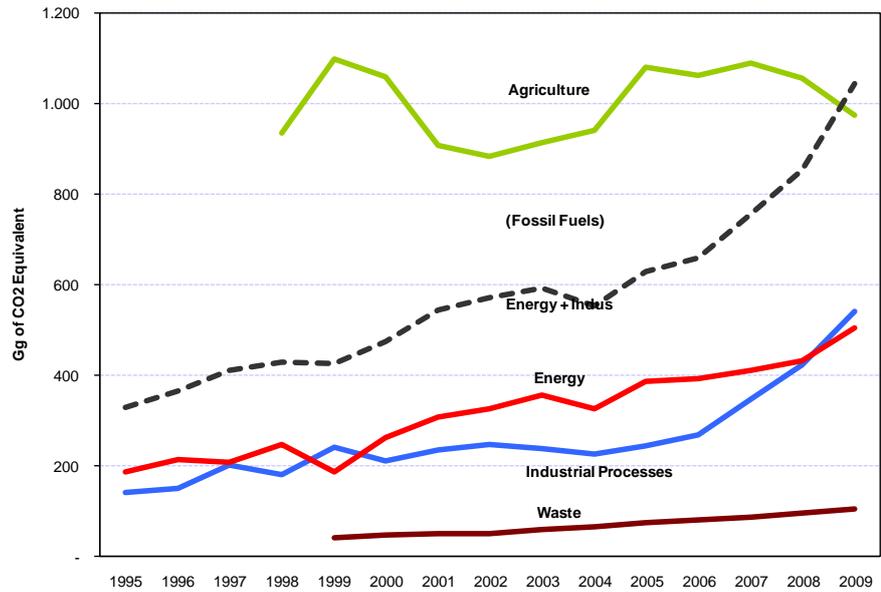


Figure 12: Development in GHG 1995-2009 for each main sector (ref: Draft 2nd GHG inventory).

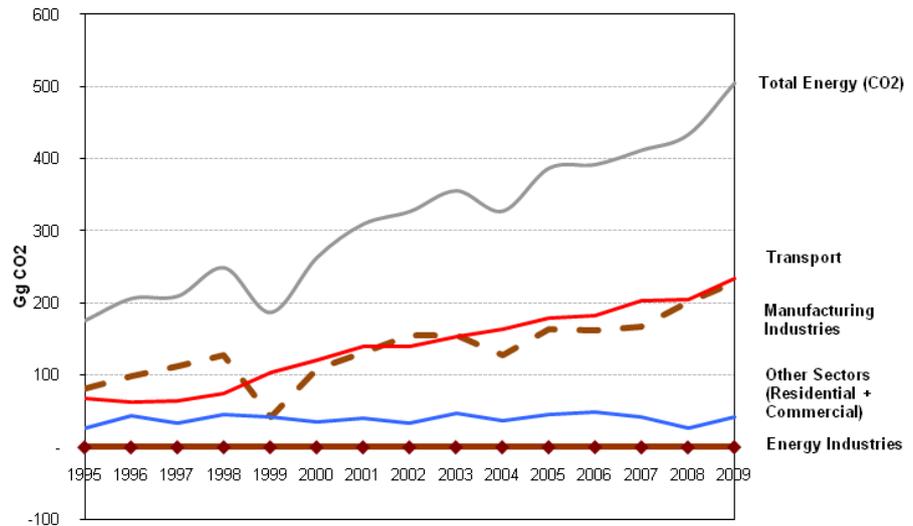


Figure 13: Development in energy-related GHG 1995-2009 for each main sector (ref: Draft 2nd GHG inventory). Transport emissions are represented by the bright red line and manufacturing industries by the dotted line.

A low net level of CO<sub>2</sub>e can be achieved by expanding the capacity for uptake (so-called sequestration) or/and limiting the emissions. The emissions sequestration in 2009 is estimated by NEC to be approximately 6,300 kt CO<sub>2</sub>e while the emissions constitute 2,100 kt CO<sub>2</sub>e, leaving a margin of two thirds of the sequestration.

Achieving the right balance

In conclusion, the challenge facing Bhutan is to achieve the right balance between economic development and carbon neutrality whilst increasing the degree of economic self-sufficiency but retaining an open exchange with the international world both in terms of services and goods but also cooperation to mutual climate benefits.

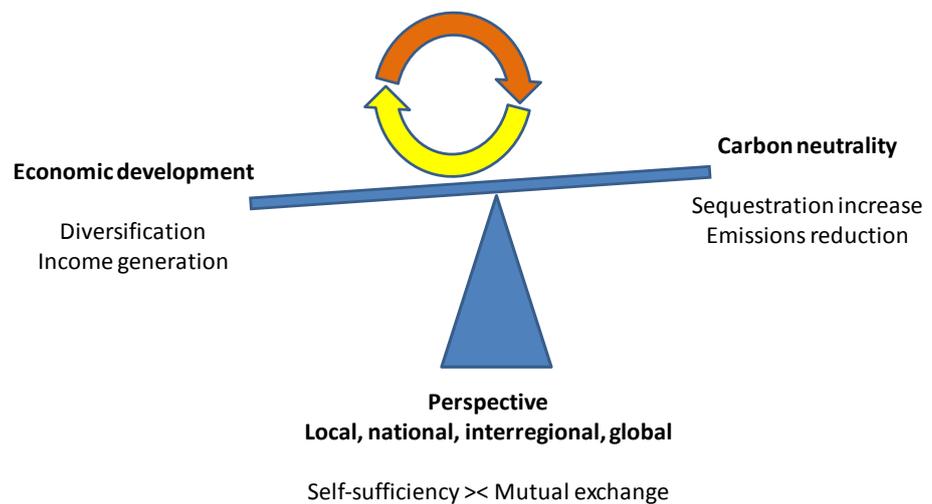


Figure 14: Achieving the right balance between economic development and carbon neutrality.

Economic development

The national economic development requires energy and will be restrained by insufficient energy supply. Access to cost-effective renewable energy is thus imperative to sustainable development of the economy. Waste management also poses challenges to sustainability and emissions reductions.

The recent status and projections of the second UNFCCC GHG inventory shows that the most significant growth in carbon has been within the energy and industry sector and it is a serious challenge to decouple economic growth from excessive energy consumption and carbon emissions.

### 2.3 Methodological approach

Scenario analysis is a useful tool to visualise and test robustness of various strategies and identify projects that are of critical importance to achieving long-term development objectives. A scenario approach was therefore used to explore potential carbon emission futures 2020, 2030 and 2040 under different assumptions – scenarios – building on stakeholder consultation and work already carried out in relation to historical carbon inventories and recent sector specific strategic plans and studies on intervention options. The scenario analyses allowed pinpointing areas which contribute significantly to

the future carbon emissions and may need intervention if targets are to be upheld in the long-term.

Sequestration capacity has not been analysed but instead taken as given. Part of the reason for this choice is that sequestration in forestry and agriculture is a complex matter that requires more detail and the National Forest Inventory initiated by the Department of Forestry Services will estimate carbon stocks for Bhutan in much greater detail.

### Data and modelling logic

In line with IPCC guidelines both energy-related and non-energy-related emissions are considered in the scenario analyses.

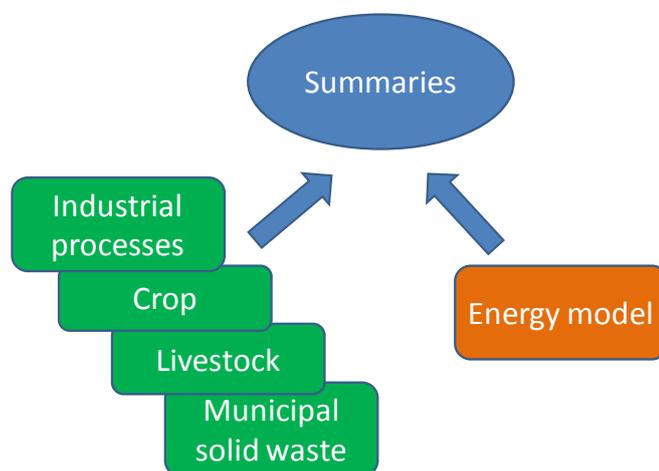


Figure 15: Model structure.

First baseline assumptions are defined and a baseline developed. Then a number of variations are modelled in the form of four scenarios.

Start year 2005

The scenario model has its starting point in 2005 and projects the future development for the years 2020, 2030, and 2040. It is worth stressing that the model is not developed for making precise forecasts but to explore the consequences of different future development paths.

The year 2005 was selected as base year since this is the most recent year for which there is a reasonable selection of data for all relevant sectors. This means that in some cases the projected figures deviate from actual historical data from the period 2006-2010 (production levels, emissions, population, energy consumption, etc.). No attempt has been made to rectify this since the main concern has been the long-term results (2020, 2030 and 2040).

Please note that projections made in other contexts – as for example the ‘Bhutan Transport 2040 Integrated Strategic Vision’ – may differ in assumptions and thus ultimately also in results.

#### NSB core reference

Where possible, data from the National Bureau of Statistics (NSB) is used so as to ensure highest possible consistency in the data. The NSB is the central agency for the collection, production and dissemination of official statistics while the respective line ministries and agencies are responsible for primary and secondary data collection on areas directly related to their areas of authority. There are other sources that use different data and thus comparison of results across reports may be difficult.

#### Main data sets

The main data sets used are:

- GHG Inventories and explanatory notes prepared by NEC.
- Historical and forecast population figures from ‘Population Projections Bhutan 2005-2030’, NSB, July 2007.
- Historical and forecast GDP figures 2001-2020, Ministry of Finance, originally produced by NSB.
- Final energy consumption figures from the ‘Energy Data Directory 2005’ and the ‘Integrated Energy Management Master Plan’, prepared by TERI for the Department of Energy, Ministry of Economic Affairs, 2005.

### **Modelling energy related carbon emissions**

The applied approach for projection differs for energy-related and non energy-related emissions.

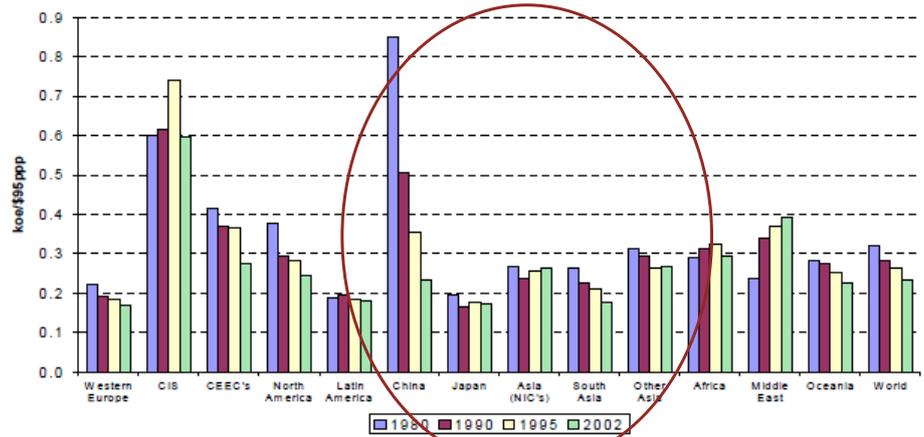
For projection of the energy-related carbon emissions the core assumption of the model is that changes in GDP or GDP/capita (current 2000 prices) leads to changes in energy *service demand* (e.g. the need for space heating, light, cooked food, transport services, etc). As will be explained later, the *energy service demand* is provided through conversion of an energy carrier like firewood, gasoline, electricity etc. to the energy service in question. Often statistical information is connected to the energy carrier and not the basic energy service demand, making it necessary to make best estimates of the conversion efficiencies.

In some cases there are special restrictions on the development of a sub-sector of the economy (e.g. availability of mineral resources) and these then overrule the link between GDP and energy service demand.

Elasticity

The link between GDP (and GDP/capita) and energy *service demand* is described using an elasticity factor. The elasticity factor expresses to which extent a change in GDP results in a change in energy service demand. The elasticity is 1 when the demand for energy is growing with the same rate as the economy (GDP or GDP/capita). The aim is to reduce the elasticity which means that the economy is growing faster than energy consumption.

**Figure 2.1: Primary energy intensity by world region**  
*Intensité énergétique primaire par région du monde*



Source: ENERDATA.

Figure 16: Primary energy intensity by region. Bhutan is counted in 'Other Asia' (ref: Energy efficiency: A world wide review; World Energy Council & Ademe, July 2004).

Ideally, this elasticity factor would be derived using historical energy *consumption* data for Bhutan but it has not been possible to establish a clear trend due to limited data and the special structure of the Bhutanese economy. Instead the elasticity factor has been decided based on international findings.

Main sector	Sub Sector	2010	2020	2030	2040
Agriculture and forestry	All primary sector	0,4	0,4	0,4	0,4
Industries	Energy intensive industries	0,8	0,8	0,8	0,8
Industries	Other industries	0,8	0,8	0,8	0,8
Tertiary	All tertiary subsectors	0,8	0,8	0,8	0,8
Residential	Rural	0,8	0,8	0,8	0,8
Residential	Urban	0,8	0,8	0,8	0,8
Transport	Aviation	0,8	0,8	0,8	0,8
Transport	Road transport	0,8	0,8	0,8	0,8

Figure 17: Applied elasticity factors.

The development in the energy *service demand* is projected using GDP (and GDP/capita) projections and the abovementioned elasticity. Thereafter the energy *service demand* is multiplied by the efficiency of the technology involved to arrive at the final energy *consumption*.

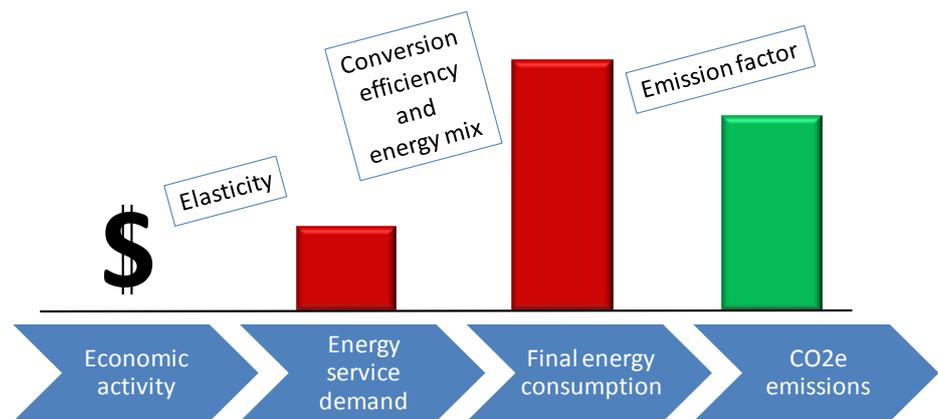


Figure 18: Sketch of relation between economic activity, energy service demand, final energy consumption, and CO<sub>2e</sub> emissions. 'Energy service demand' is also by some referred to as 'useful energy'.

The technological conversion efficiencies of for example pumps and cars do not remain constant over time. Neither does the mix of energy chosen to meet an energy service demand – if for example a household gains access to electricity then it becomes possible to use electric lighting and cookers. These changes are addressed explicitly in the model for each end-use.

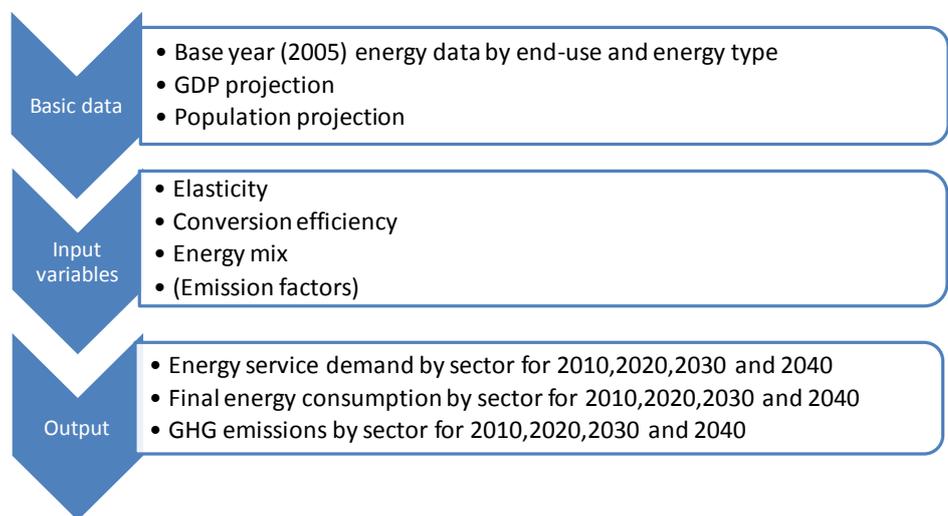


Figure 19: Logic of the energy module.

### Modelling non-energy related carbon emissions

In the case of non-energy related carbon emissions the change in GDP or GDP/capita (current 2000 prices) is linked to a development in production of e.g. clinker or amounts of waste.

## Population and GDP projections

The population and GDP projections made for the long-term national low-carbon strategy are presented below in Figure 20. The projections have been developed using an approximation of historical trends and forecasts prepared by NSB.

The average annual national GDP growth over the period 2010-2040 is 5.7% per year relative to the previous year while the average population growth is 1.1%. This leads to an average annual growth in GDP/capita of 4.5%.

The GDP of the industrial sector is greatly influenced by the large hydro power projects and the energy intensive industries (cement, ferro-alloy and carbide). The consequence of this is that in some cases the sector specific GDP rather than the national GDP should be used as driver for the energy development of the sector in question. However, due to data uncertainties sector specific GDP developments are not applied although the model permits doing so.

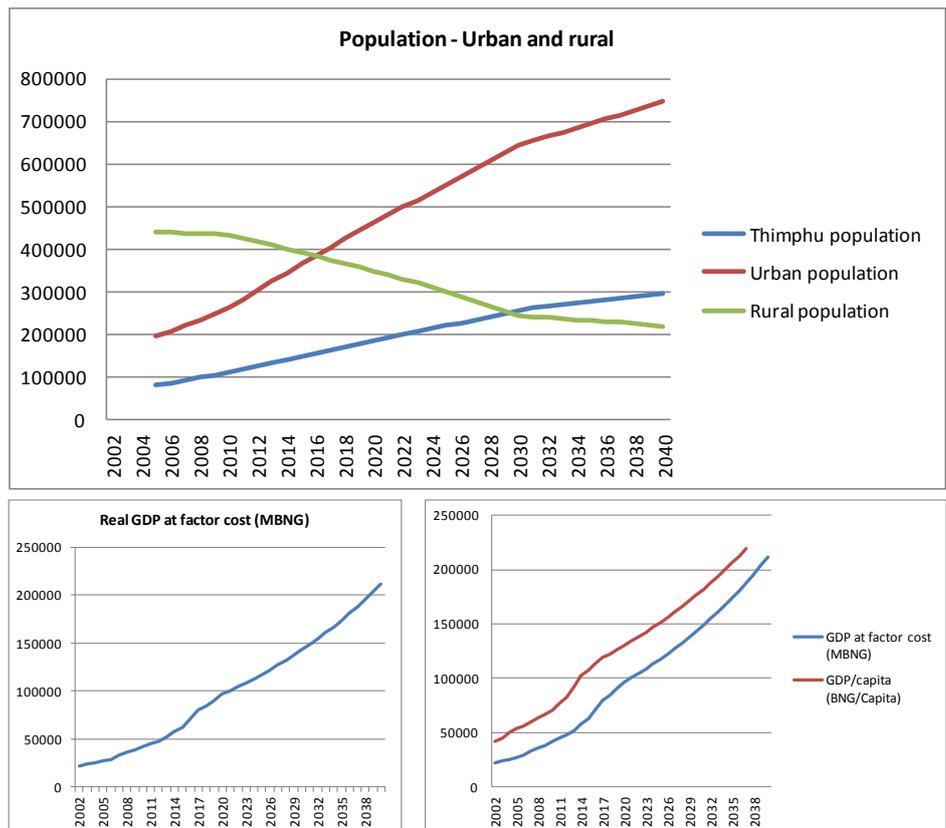
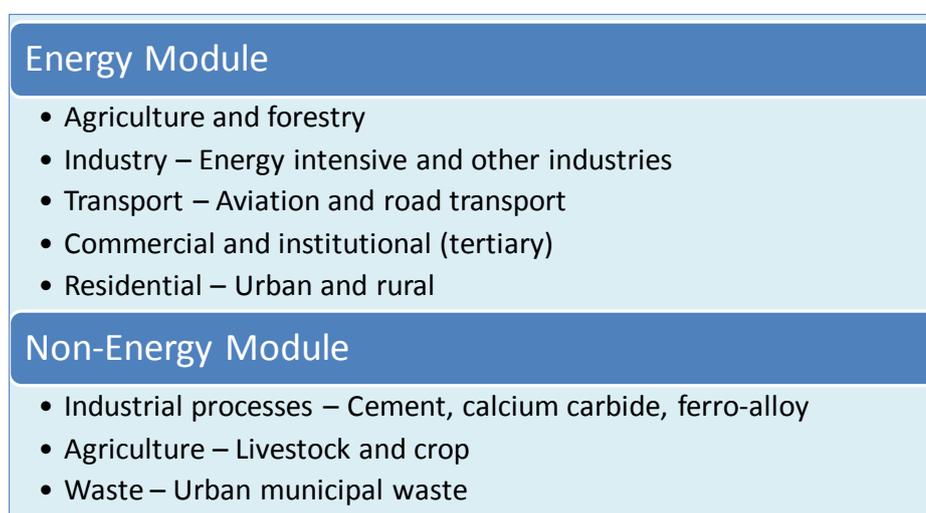


Figure 20: Projected population and GDP.

It is worth noticing that GDP and GDP/capita are expected to grow with a factor 8 from 2005 to 2040 which indicates major increases in carbon over the period.

### **Selected sectors**

The level of detail in the modelling varies across the various sectors. Emphasis has been placed on areas with a high volume of emissions and/or a significantly increasing volume of emissions. The modelled sectors are shown in the figure below. Little information for example exists about the consumption pattern in industries and tertiary sector while more information is available for road transport and households. This difference is reflected in the degree of detailing in the model for each sector.



*Figure 21: Modelled sectors.*

### **The modelling tool**

The function of the model is to portray the energy related and non-energy related carbon emissions by main sectors of economy in accordance with UNFCCC practice.

The performance of the model can be improved in the future as needs arise and more detailed data becomes available.

### **No new empirical data**

The model work has been based on existing data and documents as well as dialogue with NEC and other stakeholders. It has not been within the scope of the present Technical Assistance to collect new empirical data and no new detailed studies were undertaken. It is recommended that new and improved data be applied as it becomes available.

Excel based

The model is made in Excel to ensure mainly to ensure flexibility towards future enhancements. In addition user friendliness, transparency, and consistency with the work of the NEC in relation to the national GHG inventory was important in choice of model base.

The details of the scenario analyses carried out can be found in chapter 2. A separate document describes the developed model and functions as a user guide.

### **Limitations and omissions**

Data limitations

The most comprehensive data set for energy consumption by sector and sub-sectors is from 2005, namely the 'Energy Data Directory 2005' and the 'Integrated Energy Management Master Plan'. The values are however flawed by uncertainty – Lack of access to certain energy types at certain times of the year or all year round and lack of affordability of energy colours the historic consumption patterns. When making projections based on historical data, there is a risk that these limitations are not fully corrected for.

Omissions

Fuel prices are not explicitly included in the model. Changes in relative prices may affect real choices and priorities made by the local actors and hence the energy mix in sectors and in the country as a whole.

The scenario model does not include an economic module that allows assessments of costs and benefits related to the interventions. There is limited access to detailed data and therefore assessments of costs and benefits are qualitative statements based on available studies.

Limiting emissions

The long-term national strategy for low carbon development presented in chapter 6 is primarily concerned with limiting the emissions (rather than increasing sequestration) and focuses on areas with a high volume of emissions and/or a significantly increasing volume of emissions – the latter not only hints towards a potential future problem but also indicates a 'window of opportunity' to leverage the natural drivers for achieving sustainability and carbon goals. Other sectors are given a more cursory review. The threats and opportunities to sequestration capacity are, however, equally relevant.

## 3 Baseline scenarios

### 3.1 Energy intensive industries

Government body

Department of Industry under the Ministry of Economic Affairs is the governmental body with responsibility for industrial development. The Secretariat of the National Environmental Commission has duties and functions in relation to the Environmental Assessment Act of which the mandate to issue license to industries is an important function.

Governing regulation

The overall development targets for industrial development are outlined in Vision 2020<sup>8</sup> and substantiated in the Industrial Development Plan.

Supporting legislation:

- Industries and Investment Act
- Foreign Investment Promotion Act.

Natural resource based processing industries has increased their production during the last years and captured large markets in India. Bhutan is known to possess deposits of lead, zinc, copper, tungsten, graphite, iron, phosphate, pyrite and gold, although the commercial value of these deposits has in most cases not yet been assessed. According to U.S. Geological Survey July 2011 the main industrial mineral products include cement, dolomite, granite, marble and sandstone.

The new industries are mainly energy-intensive industries that take advantage of the cheap hydro power and the presence of mineral resources. Dungsam Cement is expected to start operation in the beginning of 2012 with a production capacity of one million tonnes per year. Several applications (18) for licenses for ferro-alloy plants are currently under consideration. If these are granted operating license and each have an average emission from production processes equivalent to the existing ferro-alloy plants, then they will have a significant impact on the national emission level.

#### Energy related baseline

The analysis distinguishes between energy intensive industries and other industries. Only cement, ferro-alloy and carbide industries are counted in the category 'Energy intensive industries'. Any other possibly energy intensive industries are counted under 'Other industries'.

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<sup>8</sup> Vision 2020 – Bhutan 2020: A Vision for Peace, Prosperity and Happiness, Part I and II, Planning Commission, RGoB, May 1999.

For the energy intensive industries the energy service demand is linked directly to assumptions about production levels and establishment of new production units.

For both energy intensive and other industries a fuel switch gradually takes place from fuel wood to electricity so that so that in 2040 about 80% of energy service demand in energy intensive industries is satisfied by electricity, 10% by coal, and the remainder by other energy.

No detailed information on the composition of the various technologies applied in the industries and their conversion efficiencies exists. It is therefore assumed that the conversion efficiency is 75% for electricity, 25% for fuel wood and 50% for all other fuel types. Efficiency gains as result of replacing existing equipment with equipment of higher efficiency are assumed to be 10% over the period until 2040.

An overview of the assumptions is presented below in Figure 22.

	Energy service demand (toe) 2005	Conversion efficiency 2005	Conversion efficiency gain 2005-2040	Fuel mix 2005	Fuel mix 2040
Coal	13,101	50%	10%	24%	10%
Electricity	23,622	75%	10%	43%	80%
Fuel wood	14,881	25%	10%	27%	0%
Gas/diesel oil	889	50%	10%	1.6%	6.6%
Kerosene	242	50%	10%	0.4%	0.4%
Residual fuel oil	1,638	50%	10%	3.0%	3.0%
<b>Total</b>	<b>54,373</b>			<b>100%</b>	<b>100%</b>

Figure 22: Final energy consumption 2005 by fuel and applied conversion efficiencies, efficiency gains, and fuel mix for **energy intensive industries**.

Figure 23 shows that the energy baseline development for the energy intensive industries shows an increase in energy service demand by a factor 4 (while the GDP growth factor is 8). This is due to the fact that it is assumed that production of the energy intensive industries reaches its limit in 2020 – see more on this in the section “Industrial processes” further ahead.

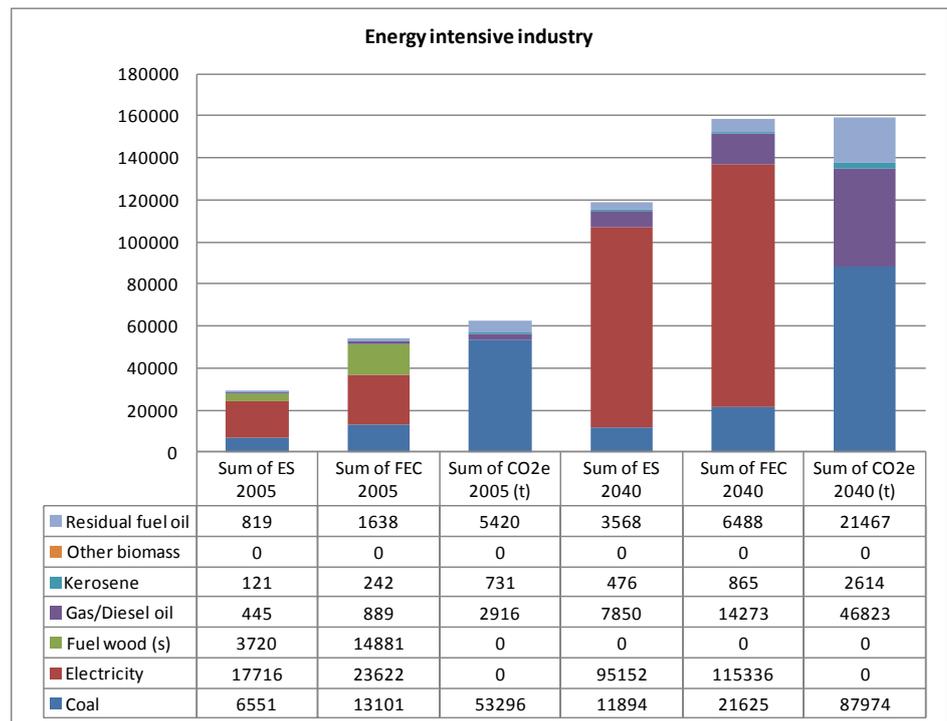


Figure 23: Energy service demand (toe), final energy consumption (toe), and CO<sub>2</sub>e emissions (t) 2005 and 2040 for **energy intensive industries**.

The assumed phase out of fossil fuels and greater electrification of the energy intensive industries increase the total energy efficiency and impacts the emission level significantly (see Figure 24).

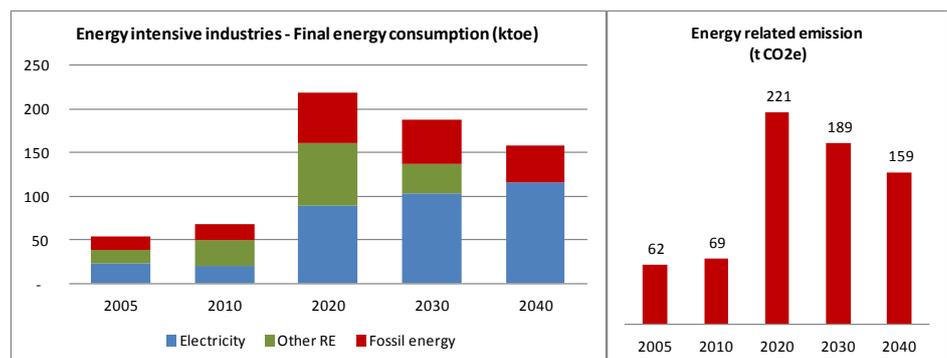


Figure 24: Development in final energy consumption (ktoe) and energy related CO<sub>2</sub>e emissions (kt) 2005- 2040 for **energy intensive industries**.

## Industrial processes

Emissions from physical and chemical processes that transform industrial materials are considered by IPCC as process emissions under the industrial processes sector. These processes produce greenhouse gases such as carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>) and nitrous oxide (N<sub>2</sub>O).

## Cement

Globally, cement production is the most important source of process CO<sub>2</sub>e emissions in the industrial processes sector (IPCC 1996). Calcium carbonate (CaCO<sub>3</sub>) from limestone is transformed into clinker (the major raw material in cement) through the application of high-temperature heat in kilns. The end-product is lime or calcium oxide (CaO) and carbon dioxide (CO<sub>2</sub>). This lime is then mixed with other materials to form cement. The default emission factor is 0.507 t CO<sub>2</sub>e/t cement not including possible energy related emissions from producing the high-temperature heat.

Since 2000 economic growth and large infrastructure projects have been the major driver for the growth in cement production in Bhutan. While there is still expectations of more infrastructure projects the future demand for cement production is expected to depend more on demand from the export market.

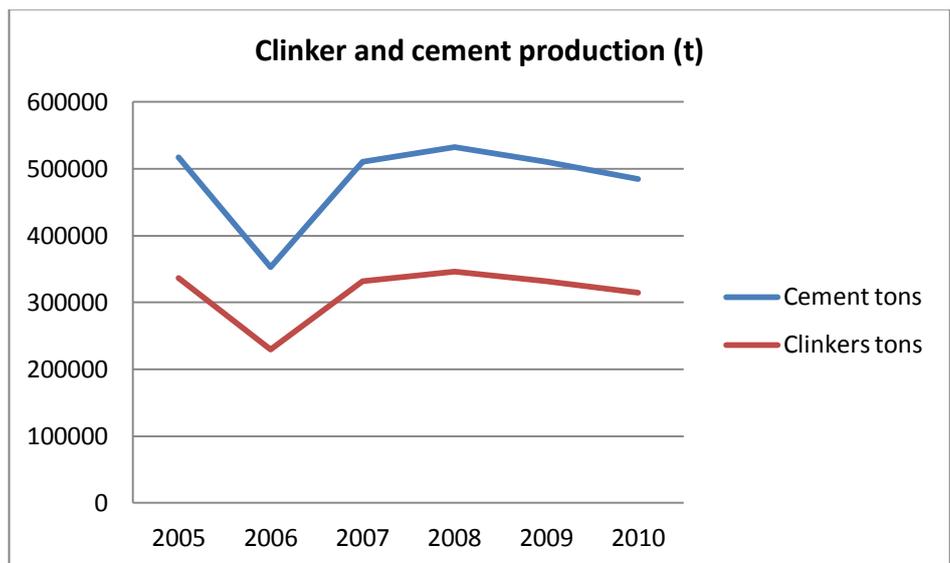


Figure 25: Historical development in cement and clinker production.

There are only three major cement plants producing clinkers from locally sourced limestone: Penden Cement Authority Ltd, Druk Cement Pvt Ltd, and Lhaki Cement. By 2012 Dungsam Cement is expected to start production with an expected annual production of 1.36 million tonnes cement annually.

## Calcium carbide

Bhutan Carbide & Chemicals Ltd (BCCL) was founded as a joint venture between the Royal Government of Bhutan and Tashi Commercial Corporation. In the 1990s the Royal Governments sold its share to Bank of Bhutan, Royal Insurance Company of Bhutan and others.

The main raw materials used to manufacture calcium carbide are limestone and carbonaceous materials such as charcoal, petroleum coke, low ash metallurgical coke and coal. Manufacture of calcium carbide takes place in a three phase submerged electric arc furnace imported from Norway.

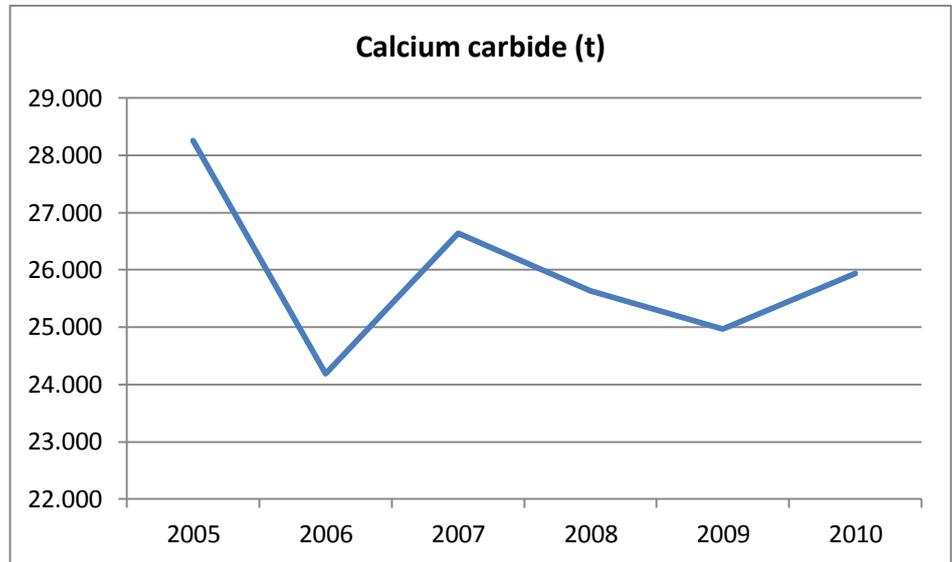


Figure 26: Historical development in calcium carbide production.

## Ferro-silicon

The production of ferro-alloys results in emission of greenhouse gases. In ferro-alloy production raw ore, carbon materials and slag forming materials are mixed and heated to carbon sources. Since charcoal and wood are based on renewable sources, they are not accounted for as an emission source. Ferro-alloys are most commonly produced by electric submerged arc furnaces. Typical reducing agents are coal and coke. Primary emissions in covered arc furnaces consist almost entirely of carbon-monoxide (CO)<sup>h</sup>. Data available for the national GHG inventory are national ferro-alloy production statistics and default emission factors.

Bhutan Ferro Alloys Ltd. (BFAL), which is a joint venture of the Government of Bhutan, Marubeni Corporation of Japan, and Tashi Commercial Corporation, produces ferro-silicon and magnesium-silicon with micro-silicon as a by-product. A new furnace was installed in 2006 to increase production to 35,000 tonnes of ferro-silicon annually. Bhutan Ferro Alloys imports 90% of its raw material (quartzite, LAMC, charcoal, wood chips, mill scale and coal) from India. Only quartzite is produced in Bhutan. Almost 90% of the products are exported to Indian companies like TATA Steel and Mittal Steel, while the remaining is exported to Japan.

<sup>h</sup> Greenhouse gas emissions from ferro-alloy production. Lindstad, Olsen, Tranell, Færden and Lubetsky, 2006 IPCC Guidelines for National Greenhouse Gas Inventory, Volume 3.

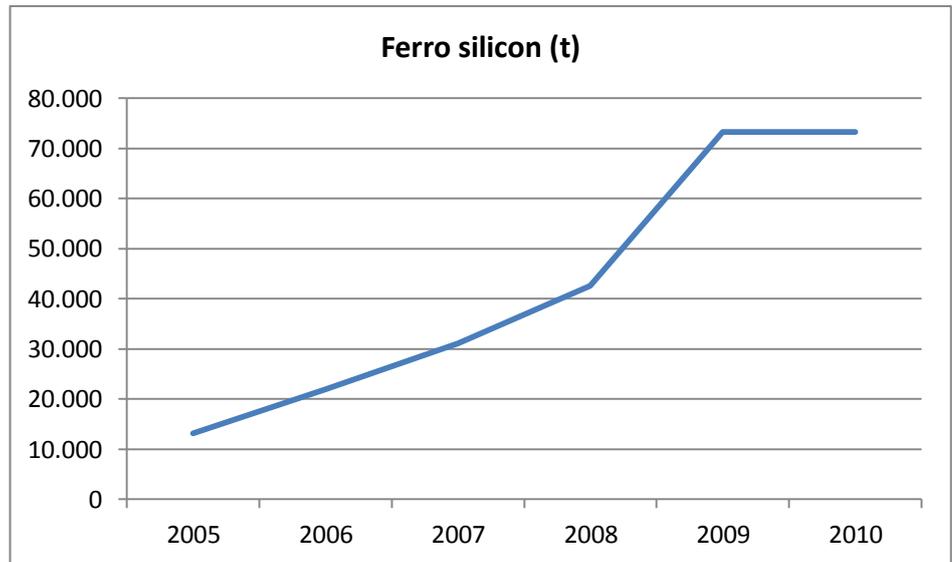


Figure 27: Historical development in ferro-silicon production.

However, there are different types of ferro-alloy production based on different compositions of reducing agents resulting in different amounts of emissions.

### **Baseline for non-energy related emissions**

A calculation of baseline carbon emissions is based on the projected demand for the final products multiplied by a default emission factor. Final products are export oriented.

The baseline demand is partly demand driven and partly driven by environmental regulation. The availability of natural resources and the access to cheap electricity will attract energy intensive industries and industrial development is critical for employment generation and economic development. However, exploitation and processing of many natural resources puts a pressure on the local and regional environment and causes large emissions of carbon. Therefore the baseline is designed in a pace that can be politically acceptable with reference to availability of resources and the environment and social impacts (see Figure 28).

Sub sector	Assumptions
Industrial process general	Production increase directly related to establishment of new production capacity <sup>j</sup>
Cement industry	Dungsam Cement starts production in 2012 with an annual production of 1.37 million tonnes cement. No further capacity increase but existing capacity remains constant until 2040
Calcium carbide	No further increase in capacity due to resource and environmental constraints but existing capacity remains constant until 2040
Ferro-silicon	NEC has received a number of applications for new production. Capacity is increased by 30,000 tonnes per year until 2020 and then constant until 2040

Figure 28: Baseline assumptions by subsector.

Total non-energy related emissions are expected to increase from around 500 kt in 2010 to around 2,000 kt in 2040 as shown in Figure 29 below.

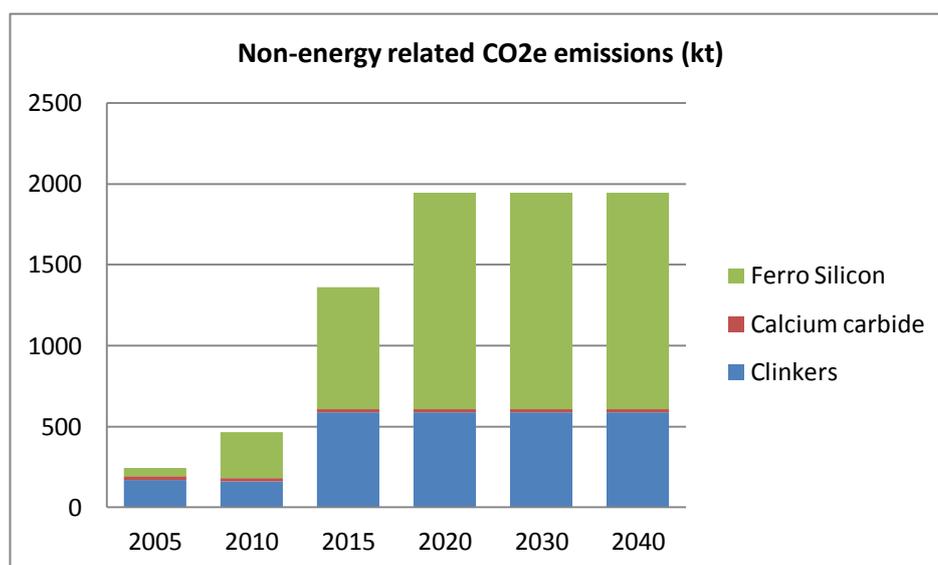


Figure 29: Baseline projection of non-energy related CO<sub>2</sub>e emissions (kt) for **energy intensive industries**.

### 3.2 Other industries

Energy intensive industries dominate in size while other industries dominate in number. Some of the industries have been established in industrial estates among other to allow access to necessary facilities, minimise environmental

<sup>i</sup> The limitations in production are very rough assumption not based on studies and needs to be adjusted by relevant authorities

impact and further clusters of industries which may be linked by commonalities or may complement each other. Medium and small scale industries include for example food processing, textile, paper, and resin and turpentine industries. Many industries are so-called "cottage industries". Fuel wood, electricity and coal are the main sources of energy in other industries.

### Energy related baseline

The energy service demand of other industries is assumed to follow GDP development with an elasticity of 0.8.

It is assumed that a fuel switch gradually takes place from fuel wood to electricity so that so that in 2040 the energy service demand is satisfied by 50% electricity, 25% fuel wood, 20% coal, and 5% other energy.

No detailed information on the composition of the various technologies applied in the industries and their conversion efficiencies exists. It is therefore just as for the energy-intensive industries assumed that the conversion efficiency is 75% for electricity, 25% for fuel wood and 50% for all other fuel types. However, it must be stressed that *conversion efficiencies* only have an effect for the end-results in sectors where fuel switching take place. Where little fuel switch takes place over the years, *energy efficiency gains* are likely to have a higher impact on the development. Efficiency gains are results of replacing existing equipment with equipment of higher efficiencies and are in the other industries sector assumed to be 10% over the period until 2040.

An overview of the assumptions is presented below (Figure 30).

	Energy service demand (toe) 2005	Conversion efficiency 2005	Conversion efficiency gain 2005-2040	Fuel mix 2005	Fuel mix 2040
Coal	14,397	50%	10%	31.2%	20%
Electricity	12,783	75%	10%	27.7%	50%
Fuel wood	15,437	25%	10%	33.4%	25%
Gas/diesel oil	3,550	50%	10%	7.7%	5%
<b>Total</b>	<b>42,617</b>			<b>100%</b>	<b>100%</b>

Figure 30: Final energy consumption 2005 by fuel and applied conversion efficiencies, efficiency gains, and fuel mix for **other industries**.

The bar diagram in Figure 31 shows the change from 2005 to 2040 for three indicators, namely the energy service demand (ESD), the final energy

consumption (FEC), and the CO<sub>2</sub>e emission (CO<sub>2</sub>e). The first three bars show the situation in 2005, the final three bars the situation in 2040. The difference between energy service demand and the final energy consumption expresses the efficiency of the conversion of energy. The difference between the final energy consumption and the CO<sub>2</sub>e emission reflects the choice of energy type and the associated emission. Is the final energy consumption fully based on renewable energy sources, then the CO<sub>2</sub>e emission is zero.

As shown in Figure 31 below, the baseline development for other industries experiences an increase in both energy service demand and the final energy consumption by a factor 5. The fuel shift trend is assumed to be less strong in other industries than in energy intensive industries and fuel wood is not completely phased out in the baseline scenario. The development in CO<sub>2</sub>e emissions is a factor 3 from 2005 to 2040. Reason for the lower factor relative to energy service demand and final energy consumption is that fuel wood is assumed to have zero CO<sub>2</sub>e emissions.

Total emissions thus increase from around 70 kt in 2005 to 208 kt in 2040 as can be seen in Figure 32.

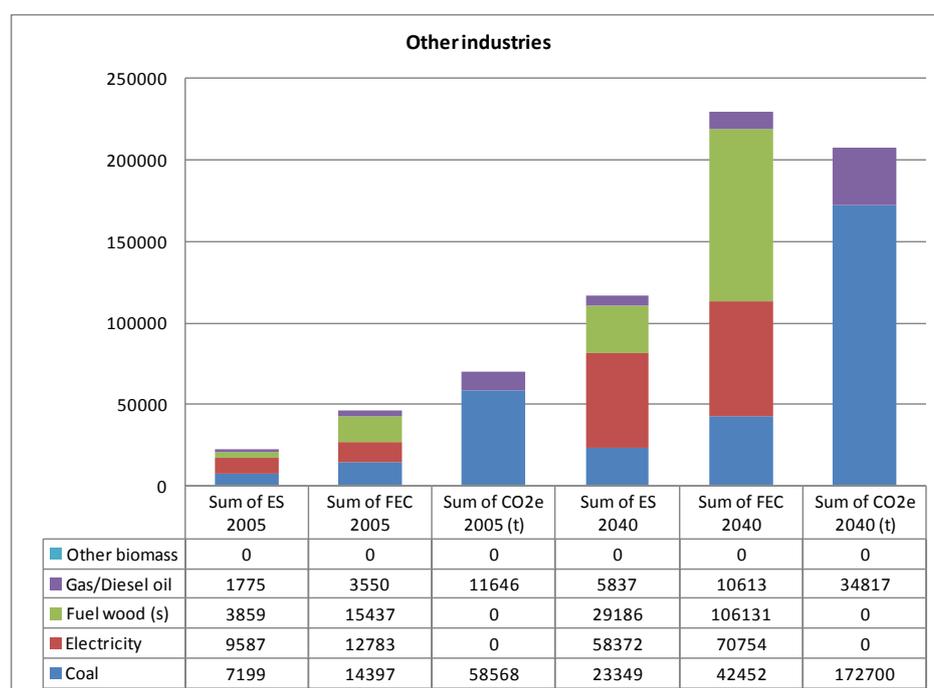


Figure 31: Energy service demand (toe), final energy consumption (toe), and CO<sub>2</sub>e emissions (t) 2005 and 2040 for other industries.

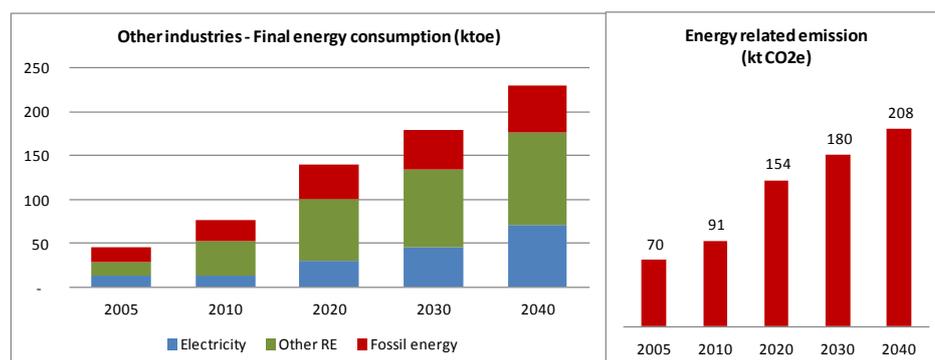


Figure 32: Development in final energy consumption (ktoe) and energy related CO<sub>2</sub>e emissions (kt) 2005-2040 for **other industries**.

### 3.3 Domestic aviation and international aviation bunkers

Until recently Bhutan has only had one international airport and limited flights. With the launch of domestic airports and services the fleet of domestic and international helicopters and airplanes will increase. The domestic airports are intended for both passenger and cargo transport.

Domestic air travel is counted in the GHG inventory while international aviation (“bunkers”) are merely a memo item based on IPCC guidelines.

#### Energy related baseline

The energy service demand for international air traffic is assumed to follow GDP development with an elasticity of 0.8 until 2020 where after the demand remains unchanged. A fuel shift towards 5% biofuel in international air traffic is expected to take place.

Domestic aviation is assumed to stabilise in 2020 at a level equal to half the 2005 level for international air traffic, which was 957 toe<sup>j</sup>.

The conversion efficiency of the various air planes and helicopters are as a whole assumed to be 30% and the energy conversion efficiency gains 10% over the period until 2040<sup>k</sup>. In this sector only the efficiency gains have influence on the end results because no major fuel switching is taking place.

<sup>j</sup> toe = tonne oil equivalents.

<sup>k</sup> The IEA has carried out a study of scenarios and strategies for technology development. In their baseline development scenario for the development from 2008-2025 and 2025-2050 the IEA assumes a 0.8% and 7% per year improvement, respectively, in technological energy efficiency due to the inherent competitiveness of the aviation industry (Energy Technology Perspectives 2008: Scenarios and Strategies to 2050, IEA, p457-458). An estimate of the gains due to improved operational efficiency and load factor is also made but this is judged irrelevant to the situation of Bhutan where there is climate, terrain, and modal-shifting constraints that limit the options available.

International aviation is not counted towards the national CO<sub>2</sub>e emissions balance and is mentioned here only for the sake of completion.

The resulting development in energy service demand, final energy consumption and CO<sub>2</sub>e emission is shown in Figure 33.

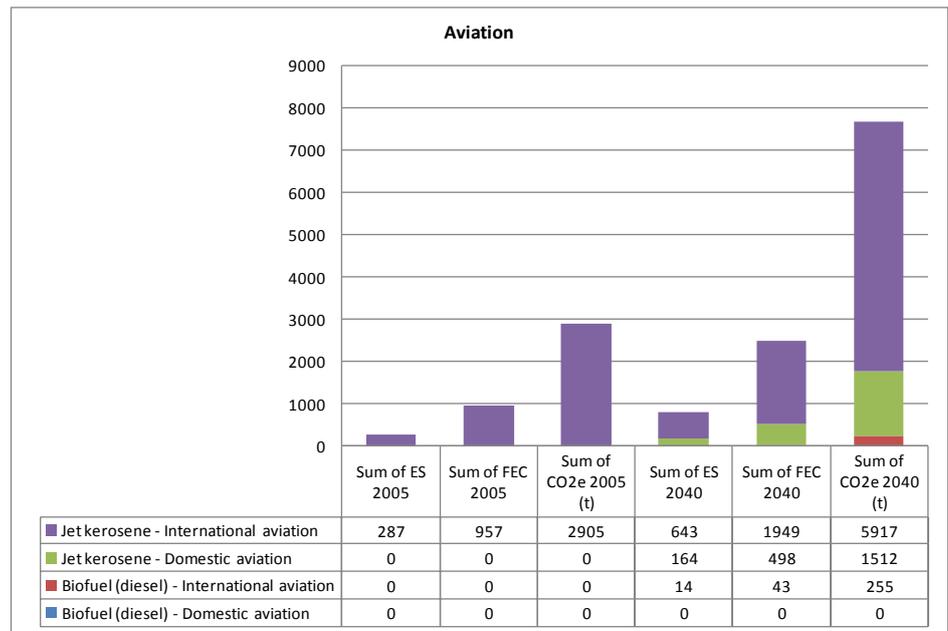


Figure 33: Energy service demand (toe), final energy consumption (toe), and CO<sub>2</sub>e emissions (t) 2005 and 2040 by fuel for **aviation**.

Figure 34 shows that the total emission relating to aviation rises from about 3 kt CO<sub>2</sub>e in 2005 to about 8 kt CO<sub>2</sub>e in 2040.

It is worth noting, that aviation related CO<sub>2</sub>e emissions are generally into the high atmosphere, and this is thought to have a larger greenhouse effect than CO<sub>2</sub>e released at sea level.

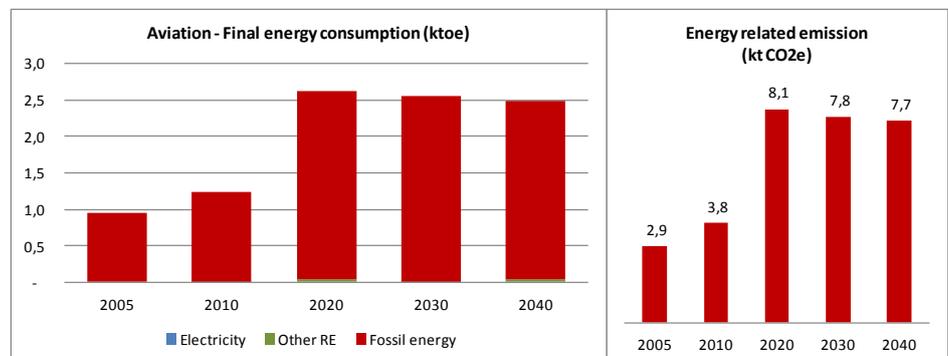


Figure 34: Development in final energy consumption (ktoe) and energy related CO<sub>2</sub>e emissions (kt) 2005-2040 for **aviation**.

### 3.4 Road transport

There has been a significant increase in the number of private vehicles in Bhutan and especially in Thimphu. Between 2001 and 2009 the number of light vehicles increased at an average rate of around 15% per year. This increase is a result of growth in both urban population and income levels (and taxation schemes).

According to RSTA there are approximately 37,000 light vehicles and taxis (81% of the stock of vehicles per end of April 2011) of which 74% use petrol.

	Petrol			Diesel		TOTAL	
	Light v	Taxi	Total	Heavy	Work	Total	Grand total
2005	14.365	2.050	<b>16.415</b>	11.055	1.002	<b>12.057</b>	<b>28.472</b>
2006	17.355	2.038	<b>19.393</b>	12.610	578	<b>13.188</b>	<b>32.581</b>
2007	19.798	2.218	<b>22.016</b>	13.055	633	<b>13.688</b>	<b>35.704</b>
2008	24.244	2.511	<b>26.755</b>	13.779	744	<b>14.523</b>	<b>41.278</b>
2009	27.145	2.859	<b>30.004</b>	14.886	929	<b>15.815</b>	<b>45.819</b>
2010	31.162	3.599	<b>34.761</b>	17.361	1.260	<b>18.621</b>	<b>53.382</b>

Figure 35: Historical development in number of vehicles by fuel type (RSTA).

With the exception of year 2008 there have been annual increases in fuel consumption of 10-14% in the period 2005-2009. There are only 3 companies importing fuel to Bhutan.

	Diesel	Petrol
2005	47.055	11.127
2006	47.508	12.508
2007	52.988	13.895
2008	54.479	14.326
2009	60.256	16.291

Figure 36: Fuel import (TOE) (GHG Inventory).

The Bhutan Transport 2040 Integrated Strategic Vision (ADB, December 2010) identifies the following critical challenges where improvements are required:

- Poor regulation of number of cars (cost of cars and cost of fuel);
- Poorly developed urban public transport;

- Poorly regulated taxis – these constitute an important element of the urban transport, especially in Thimphu and Phuentsholing<sup>1</sup>;
- Poorly regulated parking in Thimphu and Phuentsholing.

These critical areas will form the basis for mitigation measures.

### Energy related baseline

There has historically been a close correlation between increase in GDP per capita and increase in the number of vehicles (please see Figure 37).

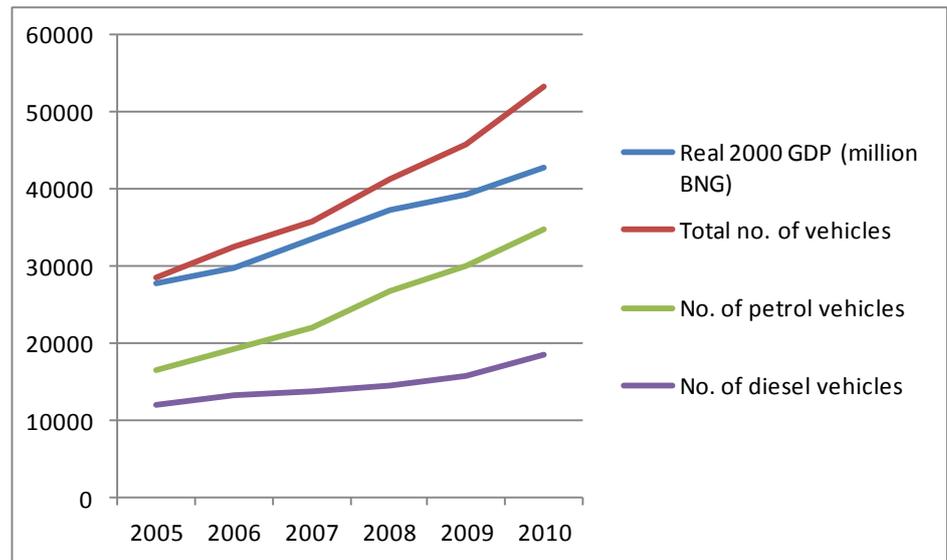


Figure 37: Comparison of real 200 GDP (million Nu.) and number of vehicles.

The increase in road transport is in the baseline assumed to continue to increase with GDP with an elasticity factor of 0.8 for light duty vehicles and two wheelers until 2020 when that market is assumed saturated and the need for transport services stabilised. The same is assumed for heavy duty vehicles.

In the baseline for road transport a small shift towards electricity is envisioned for light duty vehicles and two wheelers. Also a slight increase in transport with light duty vehicles based on gas/diesel oil is assumed at the expense of gasoline. Due to the global attention to reducing emissions from the transport sector a higher conversion efficiency gain is expected in road transport than in any of the other sectors of the economy, namely 15%.

<sup>1</sup> Bhutan Urban Transport Study, International Finance Corporation, September 2011.

		Final energy consumption (toe) 2005	Conversion efficiency 2005	Conversion efficiency gain 2005-2040	Fuel mix 2005	Fuel mix 2040
Heavy duty vehicles						
	Gas/Diesel oil	37,351	25%	15%	100%	100%
Light duty vehicles						
	Electricity	0	75%	15%	0%	10%
	Gas/Diesel oil	6,432	20%	15%	42,3%	50%
	Gasoline	8,787	15%	15%	57,7%	40%
Two wheelers						
	Electricity	0	75%	15%	0%	10%
	Gasoline	2,524	15%	15%	100%	90%
TOTAL		55,094				

Figure 38: Final energy consumption 2005 by fuel and applied conversion efficiencies, efficiency gains, and fuel mix.

Road transport more than doubles over the period 2005-2020 where after it remains more or less constant and the CO<sub>2</sub>e emissions follow suit.

In the course of the 35 year period 2005-2040, the emission increases from 178 kt CO<sub>2</sub>e to 347 kt CO<sub>2</sub>e (please see Figure 39 and Figure 40 below).

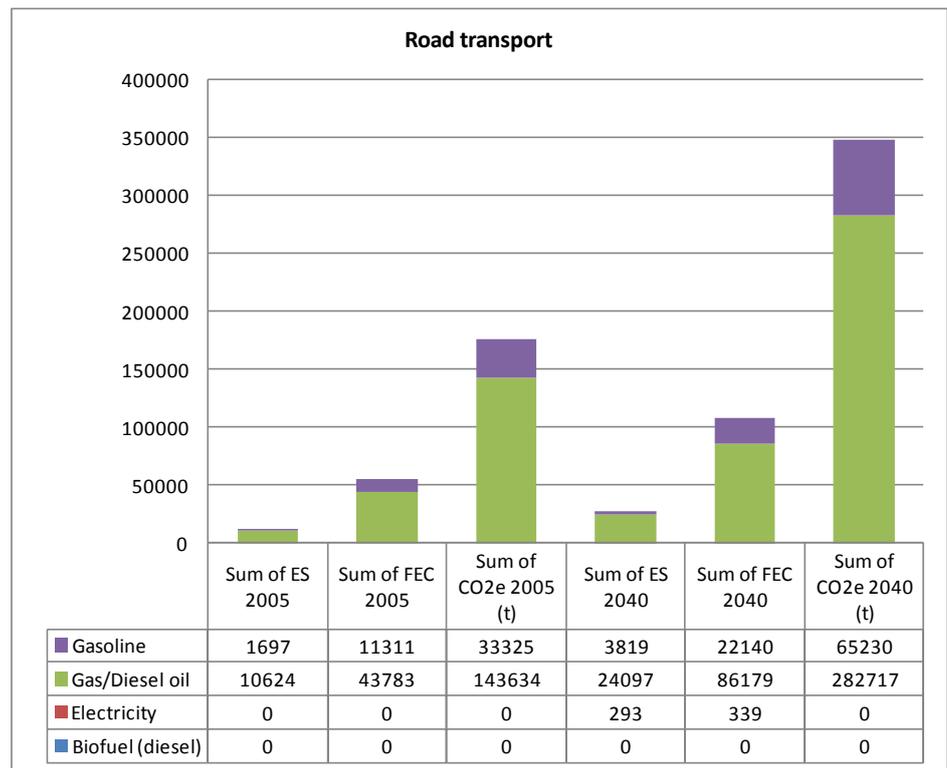


Figure 39: Energy service demand (toe), final energy consumption (toe), and CO<sub>2</sub>e emissions (t) 2005 and 2040 for road transport.

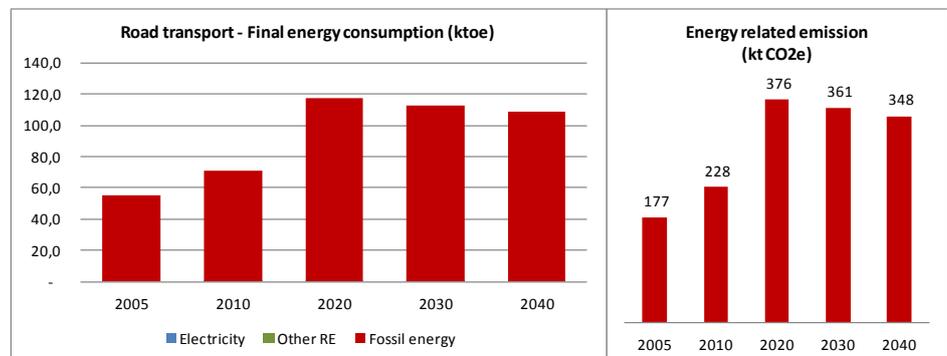


Figure 40: Development in final energy consumption (ktoe) and energy related CO<sub>2</sub>e emissions (kt) 2005-2040 for road transport.

### 3.5 Tertiary sector

The tertiary sector is also often referred to as the commercial/institutional sector. The tertiary sector includes both public and private enterprises. Examples are state and local government institutions, religious institutions, health sector, education sector, tourist sector including hotels and restaurants, and commerce. Within some there is already a noticeable awareness of environmental and climate issues and for example the tourist trade and the monasteries sectors are taking steps to increase sustainability of

their activities – something which is very much in line with the idea of "Brand Bhutan".

### Energy related baseline

The development in energy service demand of the tertiary sector excluding cremation is assumed to follow the GDP development with an elasticity of 0.8 and to mimic the development of the urban households in terms of fuel mix and conversion efficiency gains.

The demand for cremation is assumed to follow the population growth. Cremation will continue to rely on fuel wood but an efficiency gain of 10% over the period 2005-2040 is assumed.

An overview of the baseline assumptions for the tertiary sector (excluding cremation) is presented below in Figure 41). A significant shift away from fuel wood and kerosene is assumed. Gradual automatic efficiency gains reduce energy service demand by 10% in 2040 for all end-uses and fuels.

Tertiary	Cooking		Hot water heating		Lighting and appliances		Space cooling		Space heating	
	2005	2040	2005	2040	2005	2040	2005	2040	2005	2040
Biogas									0,4%	10%
Electricity	42%	70%	42%	99%	57%	98%	100%	100%		70%
Fuel wood (s)	36%		36%						99,6%	15%
Kerosene	16%		16%		43%	2%				5%
LPG	7%	30%	7%	1%						

Figure 41: Fuel mix 2005 and assumed fuel mix 2040 in the **tertiary sector** (excluding cremation). The fuel wood is assumed produced in a sustainable manner – hence the (s).

During the period 2005-2040 the demand for energy services in the tertiary sector increases with more than a factor 5. The final energy consumption increases less than a factor 4 mainly due to a shift towards electricity. The use briquettes for space heating and LPG for cooking increases significantly, but since briquettes are assumed to have zero CO<sub>2</sub>e emission, the total increase in CO<sub>2</sub>e emissions is only a factor 3.

In absolute terms the CO<sub>2</sub>e emission increases from 18 kt CO<sub>2</sub>e in 2005, as shown below in Figure 42, to 60 kt CO<sub>2</sub>e in 2040.

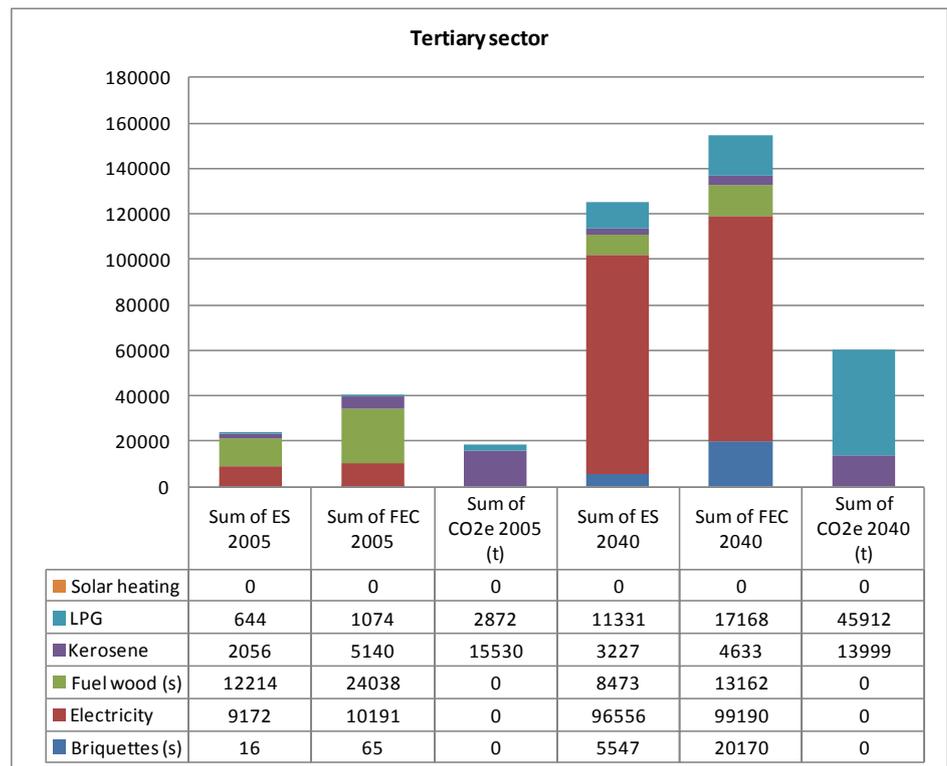


Figure 42: Energy service demand (toe), final energy consumption (toe), and CO<sub>2</sub>e emissions (t) 2005 and 2040 for the **tertiary sector**.

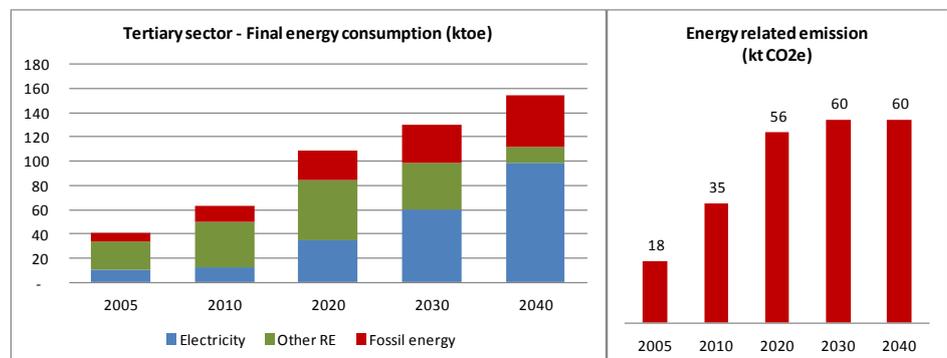


Figure 43: Development in final energy consumption (ktoe) and energy related CO<sub>2</sub>e emissions (kt) 2005-2040 for the **tertiary sector**.

### 3.6 Residential sector

#### Framework and characteristics of present situation

Residential carbon emissions have remained fairly constant in the past in part due to relatively low energy consumption and in part due to the fact that the main share of the energy demand is met by sustainable biomass and hydro power based electricity – none of which according to the IPCC rules contribute to the carbon emissions.

Household energy consumption is governed by the access to the various sources of energy and their affordability. Residential energy consumption pattern thus depends on the household income and whether the household is located in an urban or a rural area. For the low carbon strategy a distinction is therefore made between urban and rural households.

In 2005, more than 96% of urban households are electrified while only 40% of rural household were electrified. For the average urban household more than 60% of energy consumption in energy units is commercial energy like electricity, LPG and kerosene, while the consumption of commercial energy for an average rural electrified household is 13% and for a non-electrified household not more than 6%. This indicates that the non-electrified household are low income households living in remote areas where commercial energy is expensive if accessible at all.

As a result of the development strategy and the increasing welfare among households in Bhutan it can be expected that:

- Non-electrified rural households will be electrified and increase their consumption of commercial energy either because they move to urban centres or because they gain access to these energy types;
- Electrified rural households will increase their consumption of commercial energy towards a pattern known from the urban centres today.
- Urban households will increase their consumption of commercial fuels especially electricity due to increasing number of electricity consuming appliances.

	Urban households	Rural households	Total households
Grid electricity	98,2%	56,6%	69,1%
Other electricity	0,6%	3,6%	2,7%
No electricity	1,3%	39,8%	28,2%

Figure 44: Number of households by access to electricity in 2007 (Bhutan Living Standard Survey 2007, NSB, December 2007, p.86).

Bhutan living standard survey 2007, carried out by NSB with a sample of 125,500 households (NSB, December 2007, p. 80) shows the difference in energy consumption between urban and rural households (see Figure 45). Worth noting is the fact that in 2007 a little more than 40% of the total number of surveyed households did not have dedicated space heating. This illustrates the challenge of interpretation of energy statistics. Apart from the fact that many households truly do not heat their living space, the

technologies used for cooking and hot water heating in many of the households contributes to heating of the living space. Fodder cooking is prevalent in many rural households and equally contributes to space heating.

End-use		Urban households	Rural households	Total households
Lighting	Electricity	97,4%	56,1%	68,5%
	Kerosene/gas lamp	1,9%	37,4%	26,7%
	Candles	0,3%	0,7%	0,6%
	Other	0,5%	5,8%	4,2%
Cooking	Electricity	44,7%	13,0%	22,5%
	Gas	50,0%	27,4%	34,2%
	Wood	2,4%	57,2%	40,7%
	Kerosene	0,0%	0,1%	0,1%
	Other	1,6%	0,6%	0,9%
Heating	No heating	37,0%	44,1%	42,0%
	Wood/coal stove (bukhari)	21,2%	29,9%	27,3%
	Electric heater	36,0%	3,3%	13,1%
	Kerosene heater	2,6%	0,5%	1,1%
	Straw/brush/manure stove	0,8%	3,5%	2,7%
	Other	2,1%	18,7%	13,7%

Figure 45: Number of households by access to electricity in 2007 (Bhutan Living Standard Survey 2007, NSB, December 2007, p.80).

Similarly, in order to make projections on the future energy consumption in households, an understanding of the technologies available to each household is important. With an increase in household income and access to electricity an “electrification” of the consumption pattern naturally takes place.

		Urban households	Rural households	Total households
Appliances	Refrigerator	60,0%	11,3%	25,9%
	Microwave oven	9,2%	1,6%	3,9%
	Modern stove	50,9%	18,5%	28,3%
	Rice cooker	95,6%	47,5%	62,0%
	Curry cooker	83,5%	33,5%	48,5%
	Water boiler	86,4%	29,3%	46,5%
	Bukharis	23,4%	24,8%	24,4%
	Washing machine	12,7%	1,7%	5,0%
	TV	79,4%	19,8%	37,7%
	VCR/VCD	40,8%	12,6%	21,1%
	Radio	60,2%	62,8%	62,0%
	Computer	11,6%	1,8%	4,7%
	Heater	52,5%	10,0%	22,8%
	Fan	37,3%	9,8%	18,1%
Electric iron	44,3%	8,0%	18,9%	
Sewing machine	8,1%	4,6%	5,6%	
Other	Power-tiller	1,6%	3,9%	3,2%
	Grinding machine	3,8%	6,0%	5,3%
Transport	Bicycle	8,6%	3,1%	4,8%
	Motorbike, scooter	9,1%	2,7%	4,6%
	Family car	24,3%	4,2%	10,2%
	Other vehicle	5,4%	1,8%	2,9%
	Tractor	1,5%	0,9%	1,1%

Figure 46: Distribution of technologies in households in 2007 (Bhutan Living Standard Survey 2007, NSB, December 2007, p.94-95).

The Energy Data Directory 2005 lists the specific household electricity consumption as 324 kWh/year for urban households and 341 kWh/year for rural households with access to electricity – a very low number (see Figure 47 below).

Households	Electrified hh	Electricity consumption (kWh)	kWh/household
Urban	36923	11949649	324
Rural	35140	11998407	341
<b>Total</b>	<b>72063</b>	<b>23948056</b>	<b>332</b>

Figure 47: Electricity consumption level 2005 in electrified households (EDD2005, p.60+88).

Although fuel wood and other biomass consumed in households do not contribute towards the national carbon emissions (assuming sustainable exploitation) there are other reasons that justify limiting the use of these such as improved health and limiting the pressure on possibly limited biomass resources.

Furthermore, the social status associated with fossil fuels and electricity should not be underestimated as a driver for a development away from fuel wood and other biomass when opportunity arises.

### Energy related baseline

Figure 48 below lists the baseline assumptions made for calculation of the future energy service demand of the residential sector. The migration from rural to urban areas is expected to reduce the share of the rural population from 69% in 2005 to 23% in 2040. The demand for energy services is assumed to increase with GDP/capita with an elasticity of 0.8. Gradual automatic efficiency gains reduce energy service demand by 10% in 2040 for all end-uses and fuels.

Residential	Cooking		Hot water heating		Lighting and appliances		Space cooling		Space heating	
	2005	2040	2005	2040	2005	2040	2005	2040	2005	2040
Rural										
		2%								
	Briquettes			1%						5%
	Electricity	1%	44%	1%	66%	30%	100%	100%	100%	50%
	Fuel wood (s)	97%	38%	97%	30%	70%				100%
	Kerosene	1%	1%	1%	1%					5%
	LPG	1%	15%	1%	1%					
	Solar heating				1%					
Urban										
	Briquettes									15%
	Electricity	5%	70%	32%	99%	96%	100%	100%	100%	71%
	Fuel wood (s)	22%		15%						9%
	Kerosene	40%		28%		4%				5%
	LPG	33%	30%	24%						
	Solar heating				1%					

Figure 48: Fuel mix 2005 and estimated fuel mix 2040 in the residential sector.

The results of the baseline projection of the residential sector are presented in the following Figure 49 and Figure 50. The energy service demand in 2040 is more than 4 times larger than in 2005. Due to efficiency gains but mainly due to the fuel shift from fuel wood the final energy consumption in 2040 is only twice the size of the consumption in 2005. The CO<sub>2</sub>e emissions increase less than a factor 4 over the period in question and main contributors are briquettes and LPG.

The specific final energy consumption rises from 0.22 toe/capita in 2005 to 0.28 toe/capita in 2040 while the CO<sub>2</sub>e emissions grow from 0.04 t/capita to 0.20 t/capita. In absolute terms the emissions rise from 28 kt CO<sub>2</sub>e to 98 kt CO<sub>2</sub>e in the period 2005-2040.

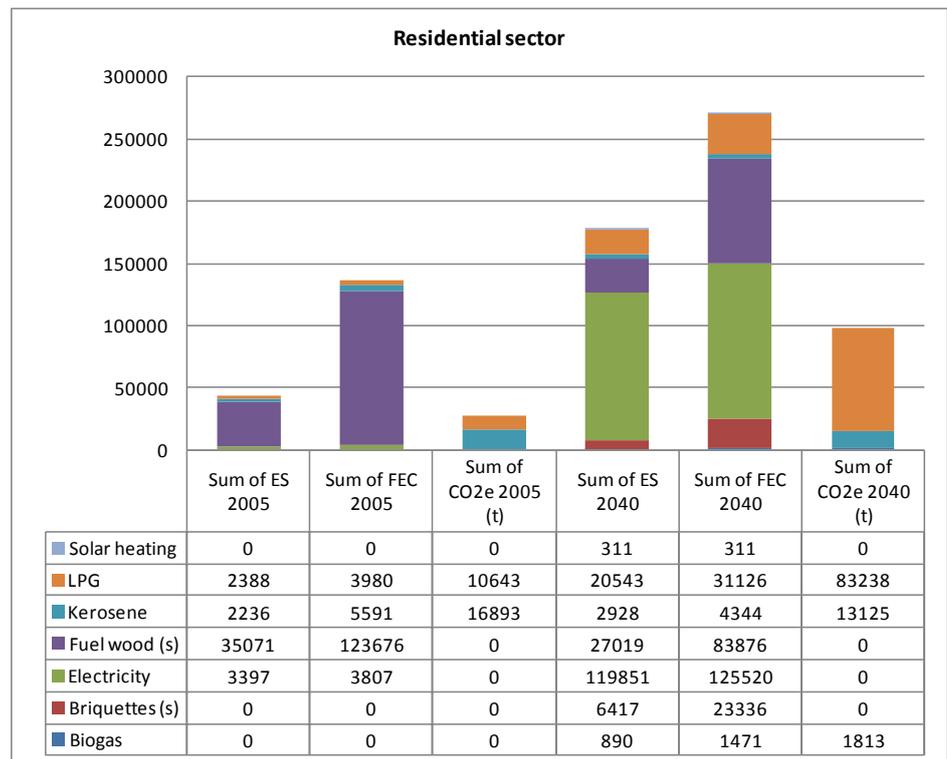


Figure 49: Energy service demand (toe), final energy consumption (toe), and CO<sub>2</sub>e emissions (t) 2005 and 2040 for the **residential sector**.

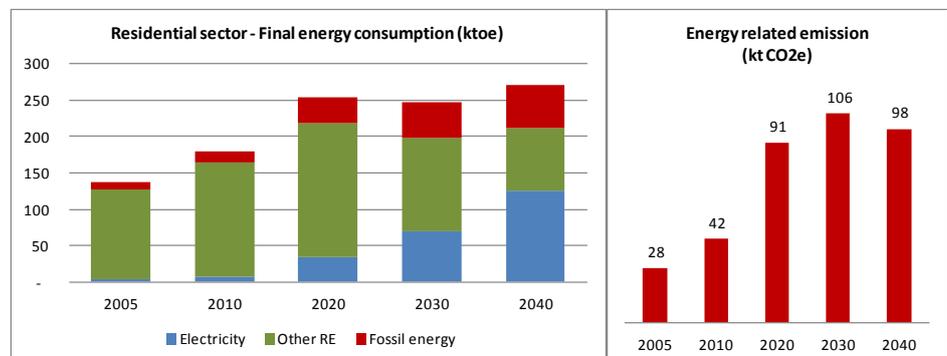


Figure 50: Development in final energy consumption (ktoe) and energy related CO<sub>2</sub>e emissions (kt) 2005-2040 for the **residential sector**.

### 3.7 Agriculture and forestry

Although the agriculture share of GDP is decreasing to just below 20% in 2008 there is around 70% of Bhutan's population that are dependent on agriculture for livelihood.

carbon emission from agricultural activity stems from husbandry, crop production, and energy consumption for tools and machinery. The non-energy related emissions within agriculture are significant, primarily due to CH<sub>4</sub>

emissions from enteric fermentation and manure. Agricultural soils and their cultivation are, however, also important contributors, namely below 450 kt CO<sub>2</sub>e in 2000 whereas enteric fermentation and manure contributed with about 570 kt CO<sub>2</sub>e. Decisions on choice of crop and cultivation methods have a significant impact on the level of emissions. The natural conditions and climate change place a limit on the expansion of crop areas but overall cultivation strategy (organic – not organic), refinement of cultivation methods (including use of fertilisers), and deliberate selection of crops can increase the yield while curbing emissions. The non-energy related emission from agriculture and its future development paths are not included in the present analysis.

Also, the non-energy related emissions from forestry or rather sequestration is not analysed in this project but instead taken as a given since it requires more detailed data and analyses.

The emissions deriving from use of tools and machinery (small tractors, threshers, pumps etc.) is addressed in the following section on energy related baseline emissions. If agriculture increases in intensity, energy use for tools and machinery is likely to increase as is emission if no preventive actions are taken. The machinery is considered “off-road” and thus not part of the “on-road” transport addressed in section 3.4.

Hardly any details on machinery and their energy consumption have been available for the present analysis. The analysis is therefore to be considered very preliminary. It is worth noting when comparing to the carbon inventory prepared by NEC that such emissions in the GHG Inventory are lumped under total transport emissions as consumption of diesel or petrol cannot be clearly segregated.

### **Energy related baseline**

With regard to the energy services needed within the agriculture and forestry sector, a distinction is made between fodder cooking and other production processes. Fodder cooking is assumed to be phased out while the energy service demand for other production processes is assumed to follow GDP development with an elasticity of 0.4.

Fodder cooking is entirely based on fuel wood with a conversion efficiency of only 10% in 2005.

Other production processes see a fuel shift from near 90% fuel wood to in particular biogas but also electricity and gas/diesel oil.

An overview of the assumptions is presented below.

	Energy service demand (toe) 2005	Conversion efficiency 2005	Conversion efficiency gain 2005-2040	Fuel mix 2005	Fuel mix 2040
Production processes	4,554				
Biogas	0	20%	10%	0%	40%
Electricity	68	75%	10%	1.5%	20%
Fuel wood	3,997	20%	10%	87.8%	20%
Gas/diesel oil	489	20%	10%	10.7%	20%
Fodder cooking	49,843				
Fuel wood	49,843	10%	10%	100%	100%
<b>Total</b>	<b>108,794</b>				

Figure 51: Final energy consumption 2005 by fuel and applied conversion efficiencies, efficiency gains, and fuel mix for agriculture and forestry.

The total energy service demand as well as the final energy consumption is reduced significantly in the baseline due to fodder cooking being phased out. Fodder cooking is assumed to be solely based on fuel wood and the efficiency is very low. The energy service demand for production processes alone increases with a factor 11 over the considered period.

On the other hand, fuel wood is assumed produced sustainably and thus having zero net impact on emission levels. Electricity is assumed to be produced by renewable energy and thus only biogas and gas/diesel oil consumption contribute to CO<sub>2</sub>e emissions in 2040. The emission level is less than 2 kt in 2005 (please see Figure 52) but increases a factor 7 over the period and reaches 11 kt in 2040.

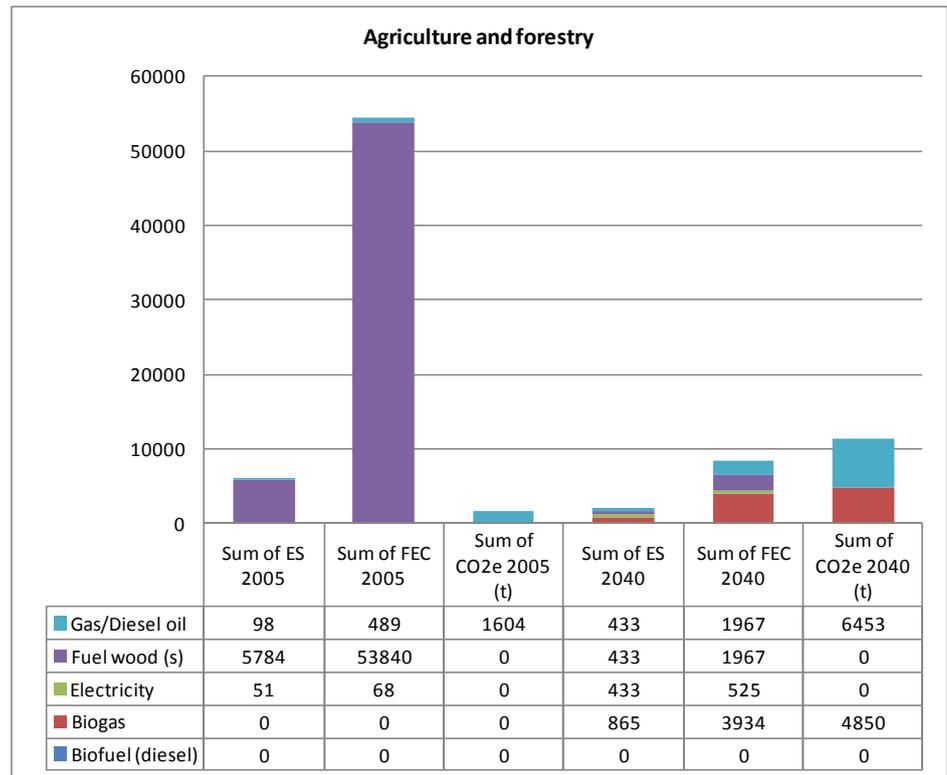


Figure 52: Energy service demand (toe), final energy consumption (toe), and CO<sub>2</sub>e emissions (t) 2005 and 2040 for **agriculture and forestry**.

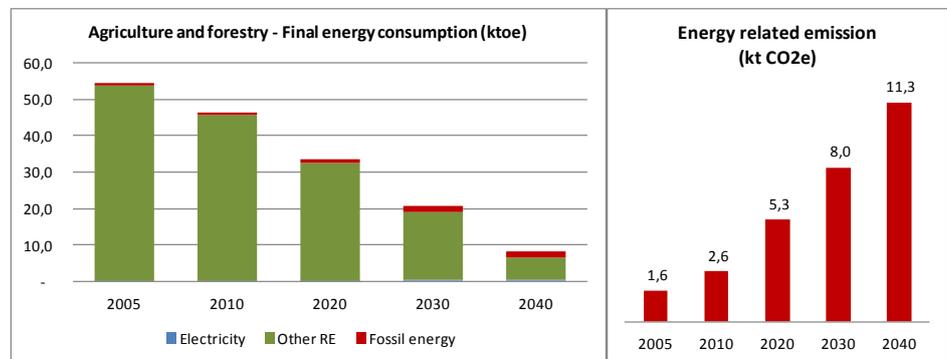


Figure 53: Development in final energy consumption (ktoe) and energy related CO<sub>2</sub>e emissions (kt) 2005-2040 for **agriculture and forestry**.

### 3.8 Municipal solid waste

Government body

The National Environment Commission is the regulatory authority while the lead institutions in charge of implementation are:

- The Ministry for Works and Human Settlements plus the City Corporations – Ensuring waste prevention and management in the Thromdes;
- The Dzongkhag Tshongdu and Gewog Tshongde supported by the Dzongkhag, Dungkhag and Gewog administration – Ensuring waste prevention and management at Dzongkhag, Dungkhag, Gewog and

Chiwog<sup>m</sup> level not covered by the above including rural human waste with guidance from the Ministry of Health.

Various collaborating agencies are also appointed of which the most pertinent in relation to future carbon emissions development and energy production is the Department of Industry under the Ministry of Economic Affairs responsible for industrial waste and the Tourism Council of Bhutan responsible for waste from hotels, restaurants, camp sites and trekking routes.

#### Government regulation

The 'Waste Prevention and Management Act of Bhutan 2009' is based on three guiding principles:

- Precautionary actions;
- Polluter pays;
- Principle of reduce, reuse and recycle.

The waste sector contributed with about 3% to the total carbon emissions of Bhutan in 2000. The dominant category in 2000 was by far solid waste disposal.

There are currently two major sources of carbon emissions from waste management activity in Bhutan:

- Solid waste from the ten urban areas, namely Thimphu, Phuentsholing, Samtse, Paro, Gelephu, Damphu, Samdrupjongkar, Bumthang, Trashigang, and Mongar. Landfill sites currently exist at Wangdue, Zhemgang, Trongsa, Trashy Yangtse, and Lhuntse and a land fill at Samdrupjongkhar is soon to be constructed since technical sanction has been given.
- Residential and commercial waste water treatment in Thimphu and Phuentscholing, with centralised sewage treatment facilities. Compact eco-line sewage treatment plants that cover the commercial waste exist in Trashigang, Gelposhing, and Damphu (Tsirang).

Thimphu generates about 50 tonnes of solid waste per day<sup>n</sup>. The total volume waste generated by the two major urban centres is assumed to be around 80 tonnes per day.

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<sup>m</sup> The administrative levels are: Thromde – urban area, Dzongkhag – district, Dungkhag, Gewog – block.

<sup>n</sup> Information from the Mayor of Thimphu, September 2011.

### Non-energy related baseline

No trend data exists for solid waste and waste water production in Bhutan. The NEC has in the 2<sup>nd</sup> GHG emissions inventory assumed waste increases at the same speed as the population growth (i.e. 1.9% per year till 2020). According to IEMMP 2010 Thimphu and Phuentsholing generated 37 and 25 tonnes of solid waste per day, respectively, and Bhutan 81,119 tonnes/year in 2005. This means, according to the IEMMP 2010 that there is a potential to sustain more than 3 MW power generation capacity (TERI 2010, p54) and suggests starting with a 1 tonne per day demonstration plant in Thimphu treating organic waste from hotels and the vegetable market.

It is assumed that there generation of solid waste is linked to the income in Bhutan, i.e. determined by the increase in GDP/capita. The base year for the baseline is 2005 with a generation of solid waste of around 0.5 kg/day per capita.

As presented in Figure 54 below the absolute emission municipal waste may increase from approximately 300 kt CO<sub>2</sub>e in 2005 to quite different levels in 2040 depending on the annual growth of the amount of waste.

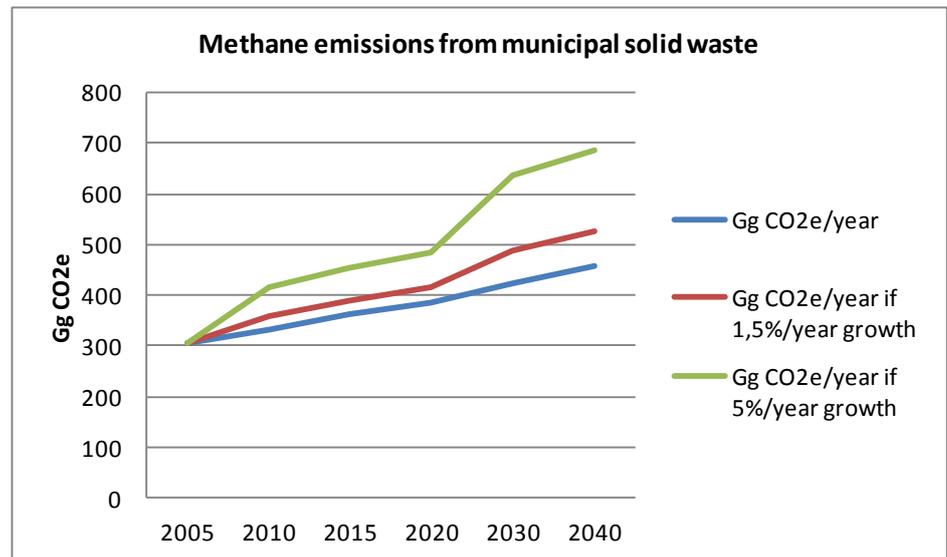


Figure 54: Projection of CO<sub>2</sub>e emissions (kt) from municipal solid waste for three different growth scenarios.

However, in the GHG inventories rural municipal waste is not counted. An estimate of the baseline development of the urban municipal waste related emission is presented in Figure 55 below. The underlying assumption is that waste generation is assumed to have an elasticity of 0.10 to GDP/capita.

The CO<sub>2</sub>e emission starts at less than 100 kt CO<sub>2</sub>e in 2005 and increases to 422 in 2040. Contributions from municipal waste from Thimphu alone are expected to increase from 38 to about 170 kt CO<sub>2</sub>e.

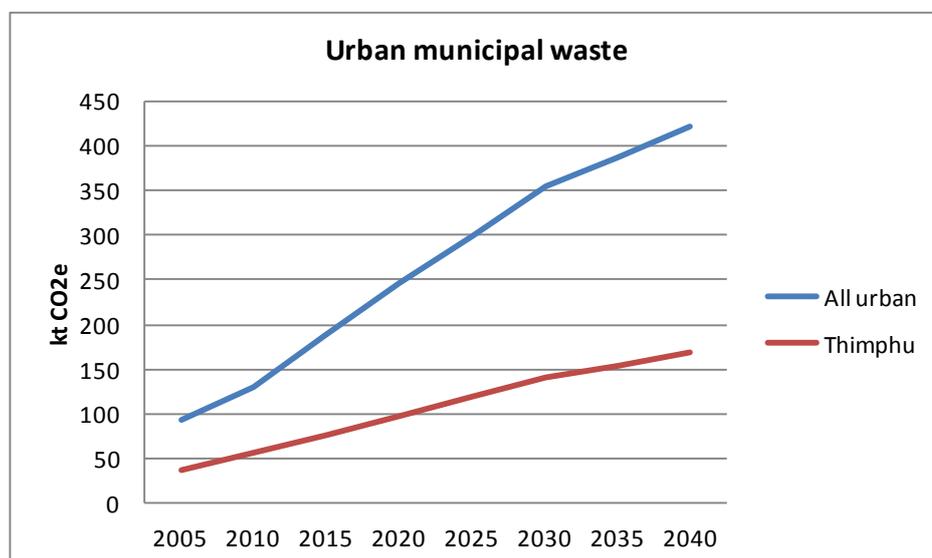


Figure 55: Projection of CO<sub>2</sub>e emissions (kt) from urban municipal waste.

### 3.9 Comparison of model results and GHG inventory

#### Energy related emissions

The approach applied for the baseline calculation of energy-related CO<sub>2</sub>e emissions does not strictly follow the approach applied in the GHG inventory. Instead the starting point is the energy service demand and the CO<sub>2</sub>e emission level is linked to the type of fuel consumed. A cross check is therefore carried out to verify that the modelled CO<sub>2</sub>e emissions 2005 (and 2010) do not differ significantly from the values derived from the GHG inventory approach applied by NEC.

A comparison between the carbon emissions calculated in the applied energy model and the figures from the NEC GHG inventory shows a reasonable consistency (see Figure 56). The main difference deviation occurs for industry in 2009/2010 where the model arrives at 160 kt while the inventory estimate is 228 kt.

The explanation is that excluding fuel wood and electricity the 2005 fuel consumption is 33,817 toe in the energy model and 42,380 toe in the GHG inventory and the emissions factors applied slightly higher in the energy model. In 2010 the final energy consumption calculated by the energy model

is 40,838 toe excluding fuel wood and electricity while the 2009 figure of the GHG inventory is 58,461 toe.

The main reason for the difference is that the model assumes a larger share of electricity in the final energy consumption.

No attempt has been made to rectify this difference in the model since the primary concern is to portray the possible situation in 2020, 2030 and 2040.

The energy related emissions increase from 360 kt in 2005 to 1,072 kt in 2040 which equals 0.57 t/capita and 1.1 t/capita, respectively. In comparison figures reported for 2008 for Bangladesh, India, and USA are 0.36 t/capita, 1.3 t/capita, and 19.7 t/capita (www.cdiac.ornl.gov).

All energy-related emissions (kt)	Energy model		GHG inventory	
	2005	2010	2005	2009
All primary sector	2	3	-	-
All industry	133	160	164	228
Tertiary and residential	46	78	42	42
Road transport	177	228	176	230
Aviation	3	4	3	3
<b>TOTAL</b>	<b>360</b>	<b>472</b>	<b>385</b>	<b>503</b>

Figure 56: Energy related CO<sub>2</sub>e emissions (kt) calculated in energy model and estimated from GHG inventory.

### Non-energy related emissions

A similar comparison is made concerning non-energy related emissions in Figure 57. While agricultural emissions increase slightly in the model there is a small reduction in the GHG inventory. The difference can be ascribed to the fact that the model simulates a long-term trend while the GHG inventory shows that actual development from year to year and therefore the GHG inventory shows greater variation from year to year.

The figures for emissions from industrial processes are quite consistent between the model and the NEC GHG inventory.

The growth in the waste related emissions is the same for the model and the GHG inventory, but the model starts at a lower level and continues to be lower than the GHG inventory figures.

Non energy-related emissions (kt)	Energy model		GHG inventory	
	2005	2010	2005	2009
Agriculture	1.117	1.169	1.081	974
Industrial processes	243	465	270	505
Waste	94	130	73	105
<b>TOTAL</b>	<b>1.454</b>	<b>1.764</b>	<b>1.424</b>	<b>1.584</b>

Figure 57: Non-energy related CO<sub>2</sub>e emissions (kt) calculated in model and estimated from GHG inventory.

### 3.10 Baseline scenario results summarised

#### Specific emissions

The total specific final energy consumption rises from 0.61 toe/capita in 2005 to 0.97 toe/capita in 2040 while the CO<sub>2</sub>e emissions grow from 0.57 t/capita to 1.1 t/capita. If also the non-energy related emissions are considered then the CO<sub>2</sub>e emissions increase from 2.9 t/capita in 2005 to 5.1 t/capita in 2040.

#### Energy mix

Fuel wood is the main source of energy in 2005 – it constitutes 60% of the total final energy consumption (see Figure 58). In 2040 the fuel wood share is reduced to 22% and electricity has taken the lead with 44%. A large share of the fuel wood consumption in 2005 is assumed gradually replaced by briquettes and briquettes grow to represent 5% of the total final energy consumption. Other fuel wood consumption is assumed completely phased out, namely fodder cooking.

All sectors	Final energy consumption			
	(toe)		(% )	
	2005	2040	2005	2040
Biofuel (diesel)	0	43	0%	0%
Biogas	0	5405	0%	1%
Briquettes (s)	65	43507	0%	5%
Coal	27498	64078	7%	7%
Electricity	50471	411663	13%	<b>44%</b>
Fuel wood (s)	231872	205136	<b>60%</b>	22%
Gas/Diesel oil	48711	113031	13%	12%
Gasoline	11311	22140	3%	2%
Jet Kerosene	957	2447	0%	0%
Kerosene	10973	9842	3%	1%
LPG	5054	48295	1%	5%
Other biomass	0	0	0%	0%
Residual fuel oil	1638	6488	0%	1%
Solar heating	0	311	0%	0%
<b>TOTAL</b>	<b>388550</b>	<b>932385</b>	<b>100%</b>	<b>100%</b>

Figure 58: Final energy consumption (toe) 2005 and 2040 by energy type (table).

In total fossil fuel based energy consumption constitutes 27% in 2005 and it only increases slightly in share by 2040 as depicted in the pie charts below in Figure 59. However, measured in absolute terms fossil fuel consumption increases from 106 ktoe to 266 ktoe.

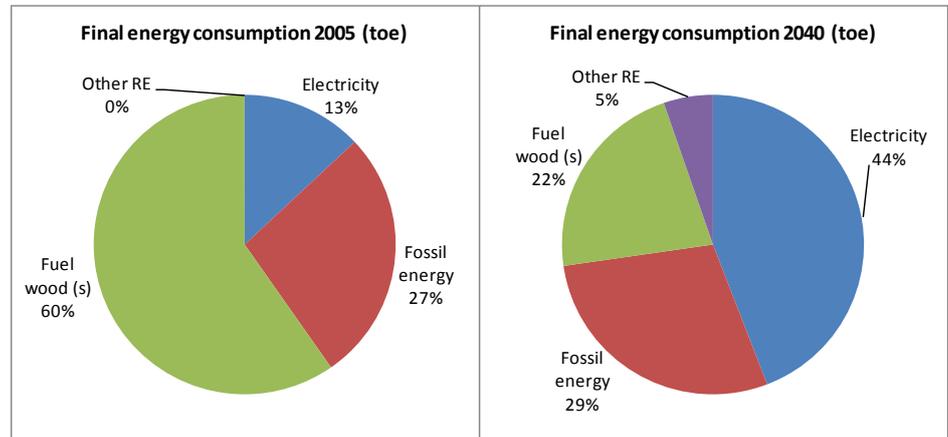


Figure 59: Final energy consumption (toe) 2005 and 2040 by energy type (two pie charts).

#### Energy service demand

Looking at the development in the energy service demand the different sectors behave quite different from one another (Figure 60). Industries and road transport reach a plateau after 2020. The migration from rural to urban areas results in a break in the rural curve. The aviation and primary sector show a gradual reduction which is due to the assumed efficiency gains being the main driver for the development. The energy efficiency gain is assumed 19% for all sectors except road transport where it is 15%.

Please note, that the graph below is “distorted” – the lapse of time is not same for each of the five measuring points and the development from 2005 to 2010 to 2020 therefore appears more abrupt than really is the case.

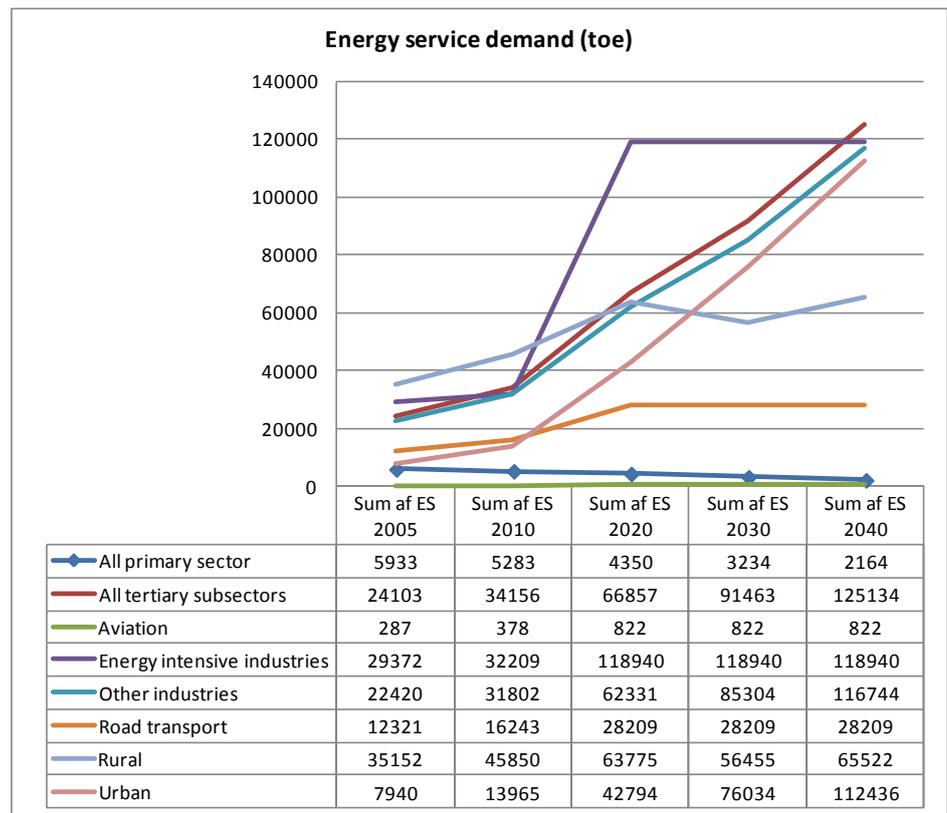


Figure 60: Summary of baseline scenario – projected energy service demand (toe).

## Final energy consumption

The most marked difference between the development of the energy demand and the final energy consumption occurs for the primary sector i.e. agriculture – energy demand decreases to 36% of 2005 demand while consumption decreases to only 15%. This is caused by a significant fuel shift from fuel wood to biogas, electricity and gas/diesel oil. Please see Figure 61.

All other sectors grow in terms of final energy consumption. Due to migration rural consumption only increase to double the 2005 level while urban consumption increase a factor 14. Tertiary sector and other industries increase a factor 5. Due to the restrictions placed on energy-intensive industries and road transport as of 2020 their increase is lower, namely a factor 4 and 2, respectively.

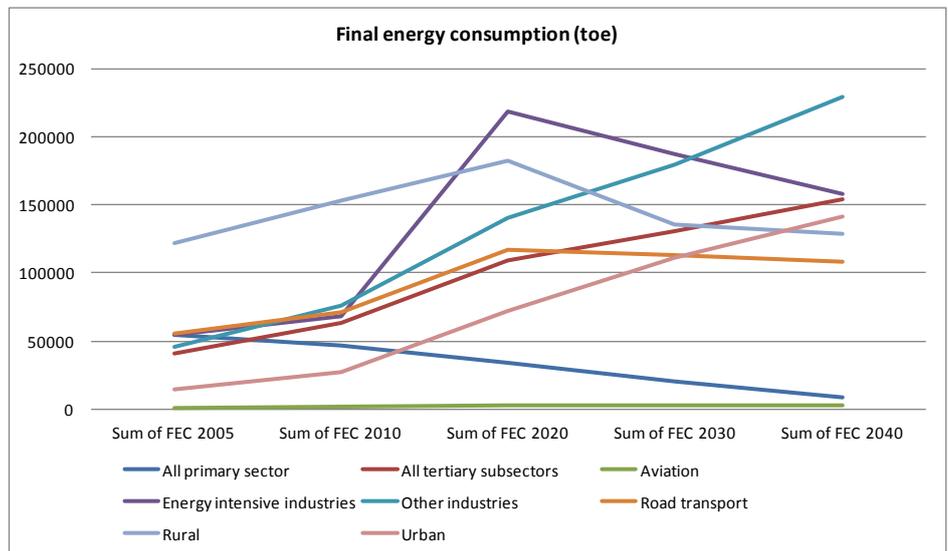
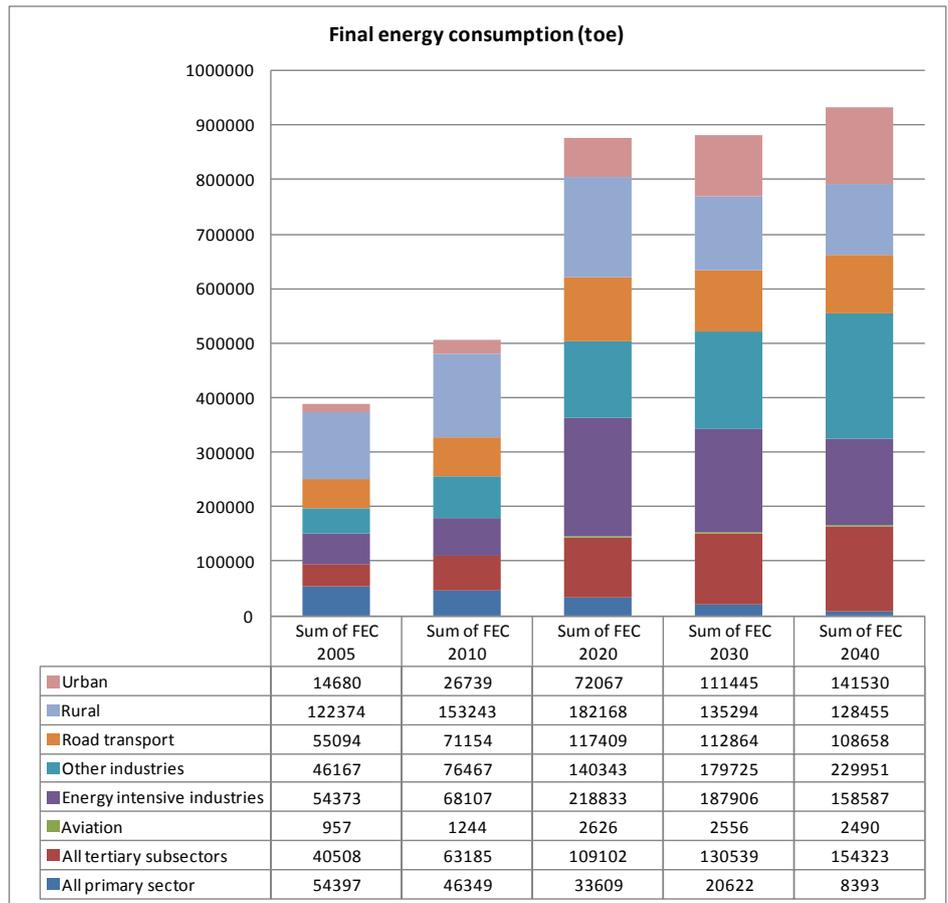


Figure 61: Summary of baseline scenario – projected final energy consumption (toe).

Energy related emission

The final energy consumption increases significantly from 2010 to 2020 (see Figure 62) but only very slightly from 2020 through 2030 to 2040. Meanwhile

the energy related CO<sub>2</sub>e emission increases significantly from 2010 to 2020 but starts falling from 2030 to 2040.

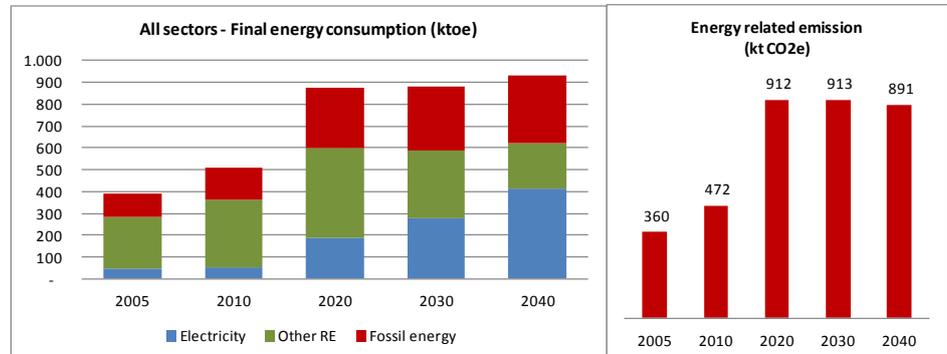


Figure 62: Development in final energy consumption (ktoe) and energy related CO<sub>2</sub>e emissions (kt) 2005-2040 for all energy related activity.

## Total carbon emissions

In conclusion the investigated baseline scenario shows that non-energy related emissions continue to make up 80% of the total emissions throughout the modelled period.

While livestock husbandry in 2005 constituted a relatively large share of the total emission, industrial production processes have taken the lead in 2040. Urban municipal waste and road transport emissions are likewise main contributors in 2040.

It should be noted that the analysis overview in Figure 63 does not include emissions resulting from international aviation. The activity is however included in the model and increases from 3 kt in 2005 to 7 kt in 2020 and down to 6 kt in 2040.

Without the emissions from international aviation the total emissions arrive at 4,723 kt CO<sub>2</sub>e in 2040. Given a sequestration level of approximately 6,300 kt CO<sub>2</sub>e there remains more than a 1,500 kt CO<sub>2</sub>e emissions margin in 2040.

Figure 64 illustrates that the energy related carbon emission continues to only constitute a modest share in 2040, namely 19% of the total carbon emissions in 2040.

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

Figure 63: Summary of baseline scenario (table) – projected carbon emissions from energy related and non-energy related emissions (kt CO<sub>2</sub>e). Note: International aviation is not included in the numbers.

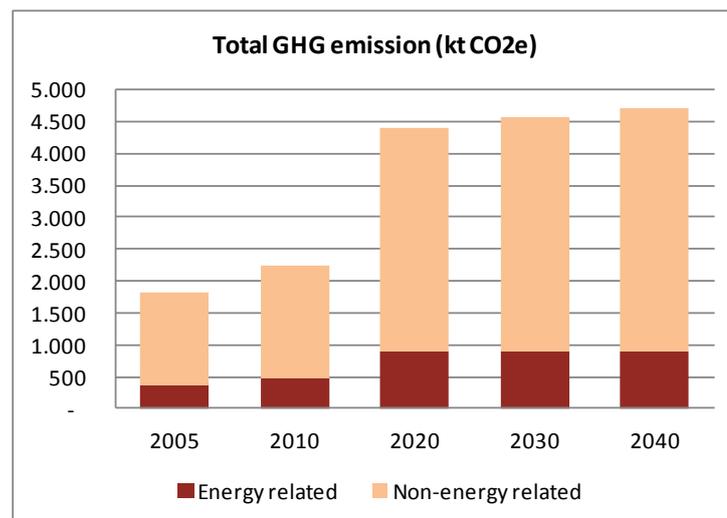


Figure 64: Summary of baseline scenario (graph) – development of projected carbon emissions from energy related and non-energy related emissions (kt CO<sub>2</sub>e). Note: International aviation is not included in the numbers.

## Electricity and CO<sub>2</sub>e

By developing the electricity industry in the form of hydro power for both domestic consumption and for export to India the regional CO<sub>2</sub>e emission will be substantially reduced compared to a scenario without such a development. The regional electricity system is not described in any detail in this report, but it should be noted that the CO<sub>2</sub>e emission factor of electricity produced in India from new coal plants will be app. 1 t CO<sub>2</sub>e/MWh electricity<sup>o</sup>.

<sup>o</sup> CO<sub>2</sub> Baseline Database for the Indian Power Sector, User Guide Version 5.0, Central Electricity Authority, Ministry of Power, Government of India, November 2009.

As new coal plants are a probable baseline for electricity production in India the hydro power based electricity export from Bhutan will cause substantial CO<sub>2</sub>e savings in the region as a whole.

## 4 Alternative energy scenarios

Alternatives to the baseline scenario were modelled in order to assess the potential carbon emission impact of changes in the underlying assumptions of the baseline scenario. These alternative scenarios are presented in the following.

Please note that these scenarios represent variations in the assumptions concerning the energy related emissions and not variations in the assumptions concerning non-energy related emissions.

### Unsustainable fuel wood and briquette production

Fuel wood is considered carbon neutral assuming that it is produced sustainably. If this would not be the case then the additional emissions would amount to 205,136 toe \* 4.0879 t/toe = 839 kt CO<sub>2</sub>e in 2040.<sup>p</sup>

Briquettes grow in the baseline scenario from 65 toe in 2005 to 43,507 toe in 2040. If unsustainable briquettes are assumed to emit 4.1525 t CO<sub>2</sub>e/toe, then the consequence of using such briquettes would be an extra 181 t CO<sub>2</sub>e in 2040 as shown in Figure 65.

	Fuel wood	Briquettes
Emission factor (t CO <sub>2</sub> e/toe)	4,0879	4,1525
Consumption 2040 (toe)	205.136	43.507
Emission (kt CO <sub>2</sub> e)	839	181

Figure 65: Potential impact of non-sustainable fuel wood and briquettes with regard to CO<sub>2</sub>e emissions (kt) in the baseline scenario.

### Increased energy efficiency

A focused effort aiming to achieve a high energy efficiency in the industrial, tertiary and residential sectors, is assumed to be able to increase the energy efficiency gain for the period 2005-2040 from 10% to 20% for industry and from 10% to 15% for the two other sectors. Within road transport it is assumed that extraordinary efforts could achieve 35% increase in energy efficiency rather than the 15% assumed in the baseline scenario. The impact on the final energy consumption and the CO<sub>2</sub>e emissions are shown in the table below in Figure 66.

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<sup>p</sup> Emission factor is from : Annex 9 Wood logs scope 3  
<http://archive.defra.gov.uk/environment/business/reporting/pdf/110707-guidelines-ghg-conversion-factors.pdf>

The combined impact is a reduction in final energy consumption of approximately 51 ktoe and a reduction in CO<sub>2</sub>e emissions of 89 kt in 2040 which constitutes 5% and 10%, respectively of the total national baseline.

The largest efficiency gains in absolute terms are **naturally** found in road transport, energy intensive industry, and other industries. Together they reduce emissions with 82 kt CO<sub>2</sub>e of which 52 kt CO<sub>2</sub>e is within road transport.

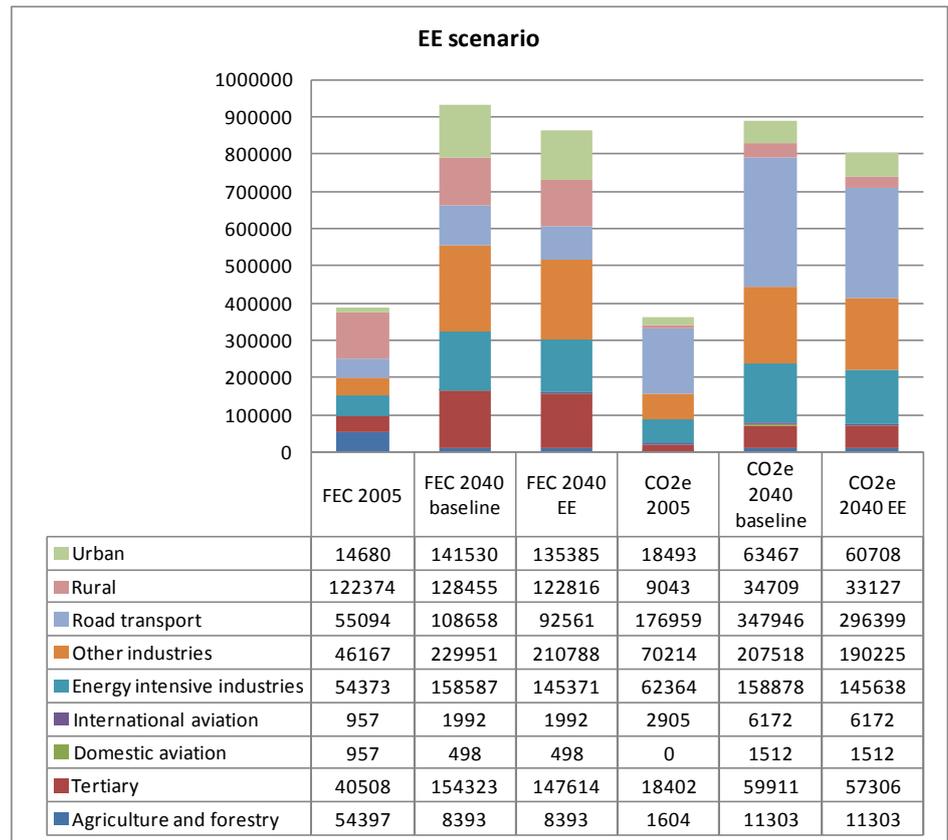


Figure 66: Final energy consumption (toe) and energy related CO<sub>2</sub>e emissions (t) by sector in an **energy efficiency** scenario compared to baseline. EE = energy efficiency.

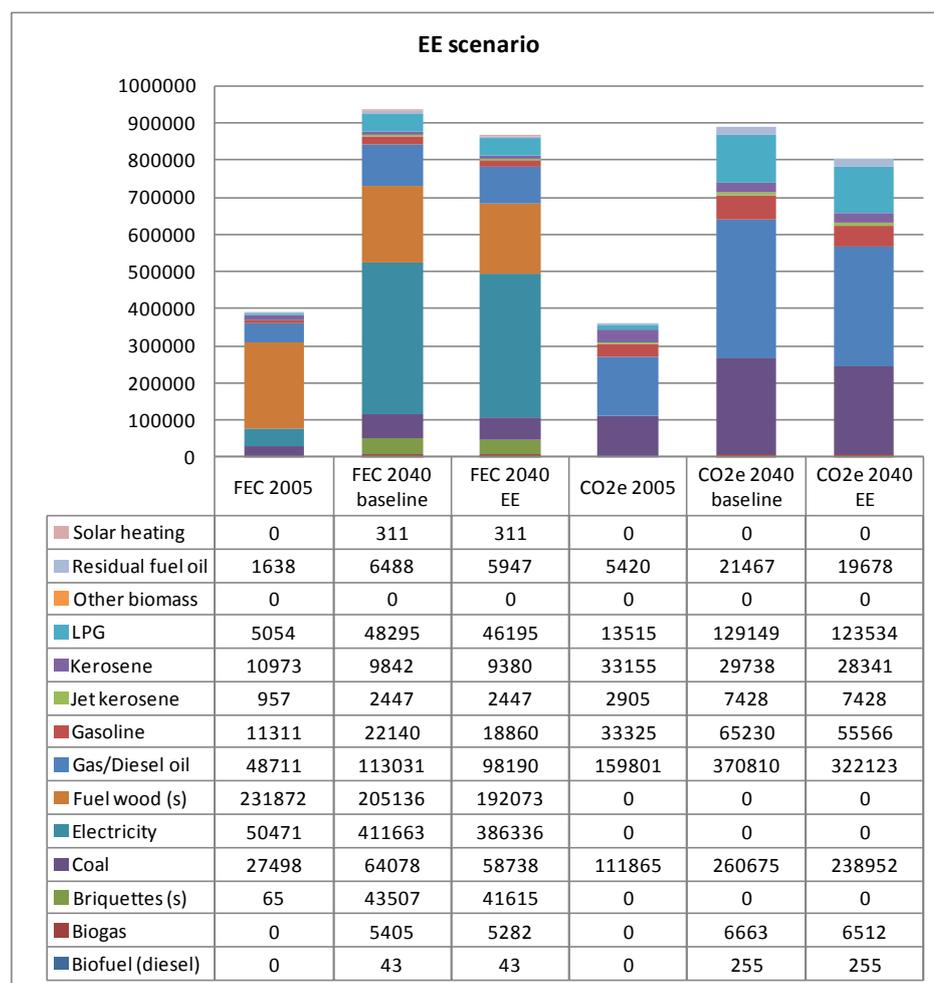


Figure 67: Final energy consumption (toe) and energy related CO<sub>2</sub>e emissions (t) by fuel in an **energy efficiency** scenario compared to baseline. EE = energy efficiency.

Global value of energy efficiency

One way to assess the international value of forced increases in energy efficiency is to consider any energy efficiency gains as way means to allow for larger export of hydropower based electricity to India (or other neighbouring countries) and thus a means to displace electricity produced by fossil fuels.

If the hydropower based electricity replaces electricity produced on modern coal fired plants in India with a carbon emission of 1 ton/MWh (11.64 t CO<sub>2</sub>e /toe), then 25.3 ktoe electricity saving equals a displacement of 300 kt CO<sub>2</sub>e emission. This is in the same order of magnitude as the 2040 energy related baseline emissions from the industrial segments.

### High share of renewable energy

A high degree of electrification exploiting large scale and small scale hydro power in combination with other renewable energy resources – in particular solar energy – can pave the way for replacement of fossil fuels and thus help

reduce reliance on imported fuels and help limit CO<sub>2</sub>e emissions while allowing for the envisioned economic development of the country.

In the renewable energy scenario the following assumptions have been made regarding the mix of fuels in 2040:

Road transport:

- Heavy duty – 5% electricity, 10% biodiesel, (85% diesel );
- Light duty – 50% electricity, 10% biodiesel, (30% diesel, 10% gasoline);
- Motorised two wheelers – 50% electricity, (50% gasoline).

Energy intensive industry – 90% electricity, 4% coal, 3% diesel, 3% residual fuel oil (assuming that a certain amount of coal and residual fuel oil cannot be replaced);

Other industry – 80% electricity, 10% coal, 10% fuel wood (assuming that a certain amount of coal cannot be replaced).

Rural households:

- Cooking – 73% electricity, 10% solar, 10% wood, 5% briquettes, 2% biogas;
- Hot water heating – 53% electricity, 30% solar, 10% wood, 5% briquettes, 2% biogas;
- Space heating – 73% electricity, 12% solar, 10% wood, 5% briquettes.

Urban households and tertiary sector:

- Cooking – 100% electricity;
- Hot water heating – 50% electricity, 50% solar;
- Space heating – 80% electricity, 20% solar.

Aviation and primary sectors are assumed unchanged.

No distinction is made as to which sustainable electricity production technology is applied for the grid based electricity supply. The main share will be hydro power whether large or micro now and in the future but also other renewable energy sources will contribute and thus help diversify the energy base and further energy security.

The resulting impact is 16% reduction in final energy consumption due to the better conversion efficiencies of the technologies involved and 42% reduction

in CO<sub>2</sub>e emissions. In absolute terms the final energy consumption is reduced by about 153 ktoe and CO<sub>2</sub>e emission by 372 kt in 2040 relative to the baseline. The energy service demand covered by solar energy is 42,402 toe (see Figure 69) – a demand that would otherwise have to be covered by electricity or other energy types. The intensified electrification of other industries alone brings about a 121 kt reduction of CO<sub>2</sub>e. Urban households and tertiary sector become carbon neutral.

As was the case for the energy efficiency scenario, diversification of the renewable energy types exploited may be assumed to make room for larger export of hydropower. Solar energy could thus be interpreted as displacing 42,402 toe \* 11.63 MWh/toe \* 1.0 t CO<sub>2</sub>e/MWh = 493 kt CO<sub>2</sub>e of Indian emissions.

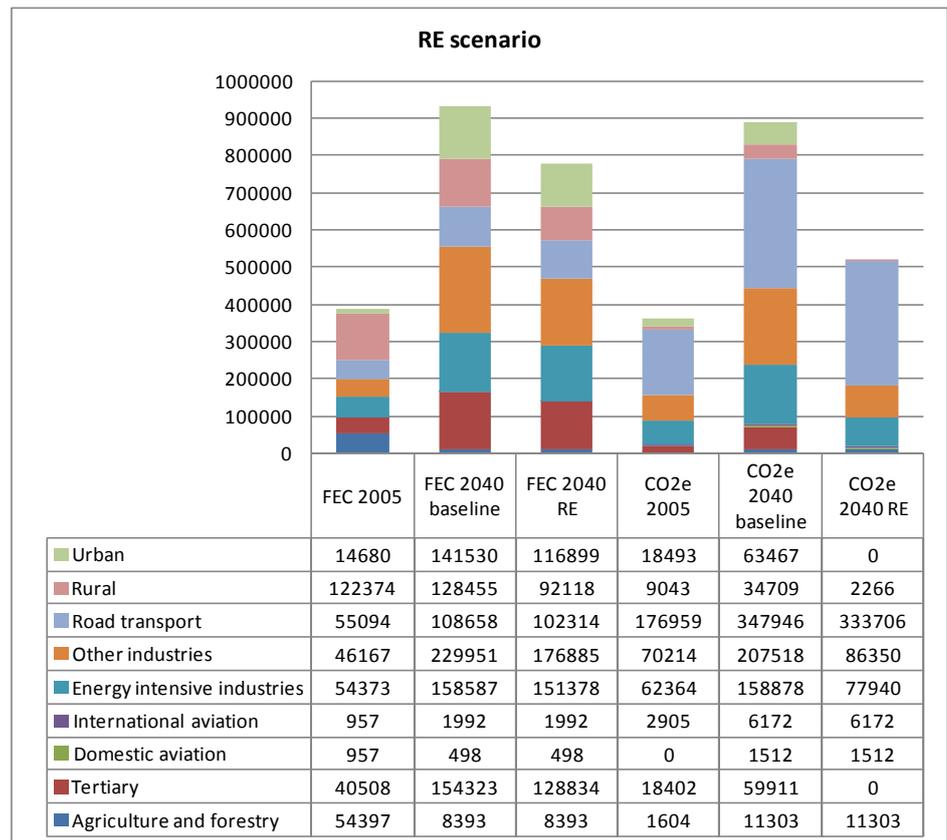


Figure 68: Final energy consumption (toe) and energy related CO<sub>2</sub>e emissions (kt) by sector in a **renewable energy** scenario compared to baseline. RE = renewable energy.

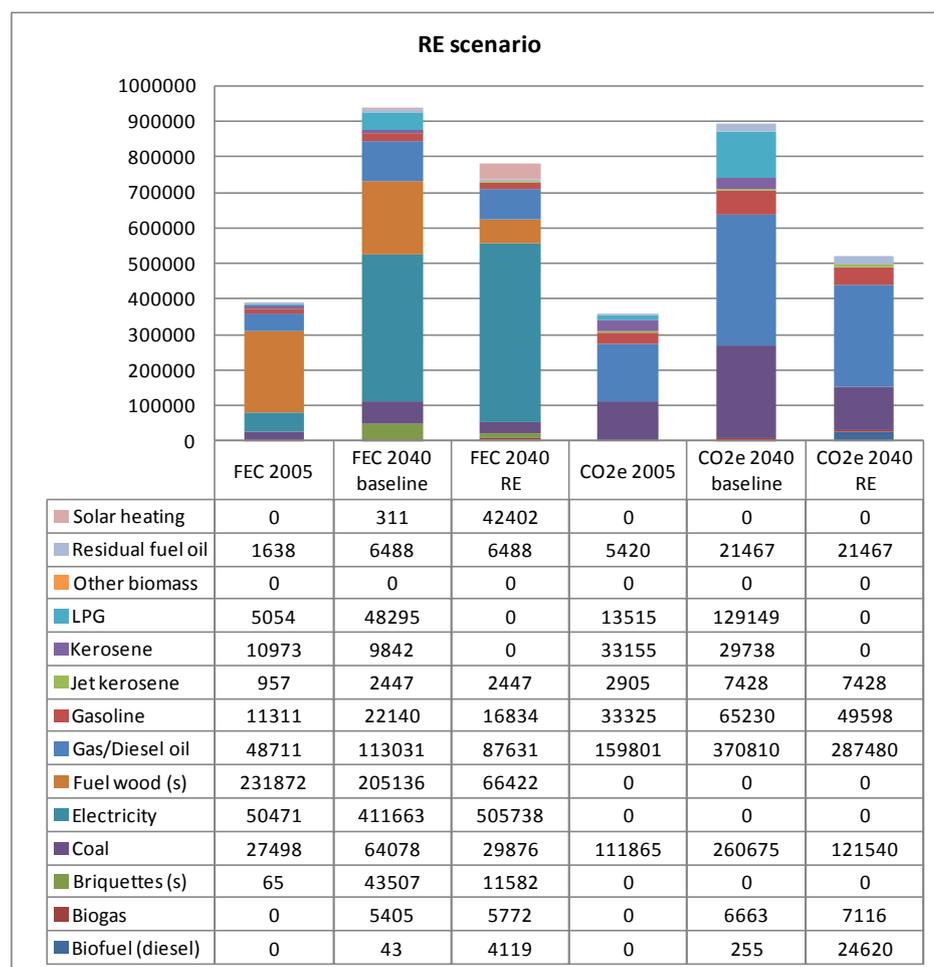


Figure 69: Final energy consumption (toe) and energy related CO<sub>2</sub>e emissions (kt) by fuel in a **renewable energy** scenario compared to baseline. RE = renewable energy.

### Energy efficiency and renewable energy

Combining the assumption of the energy efficiency scenario and the renewable energy scenario the result is as follows (see Figure 70): The final energy consumption is reduced by 22% reaching about 724 ktoe in 2040 and the CO<sub>2</sub>e emissions is reduced 49% reaching 456 kt in 2040. The absolute difference between baseline and the combined energy efficiency and renewable energy scenario is 208 ktoe and 435 kt CO<sub>2</sub>e emissions. The largest emitter is the category “Other industries” with 128 kt CO<sub>2</sub>e.

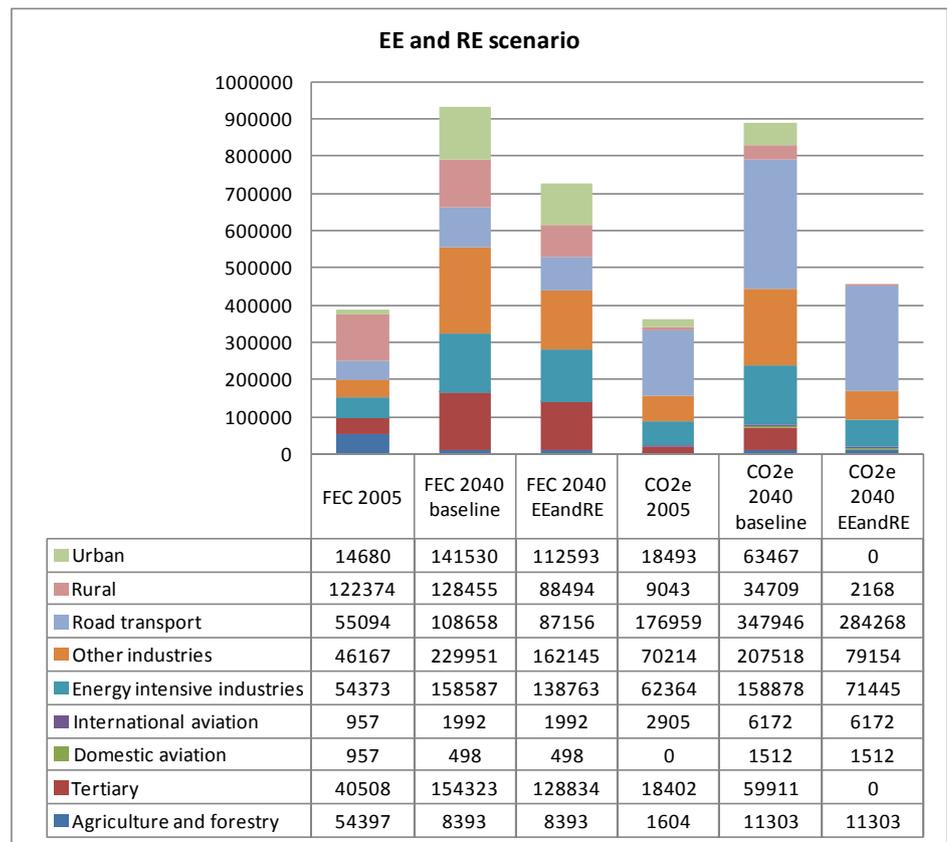


Figure 70: Final energy consumption (toe) and energy related CO<sub>2</sub>e emissions (kt) by sector in a combined **energy efficiency and renewable energy** scenario compared to baseline. EE = energy efficiency; RE = renewable energy.

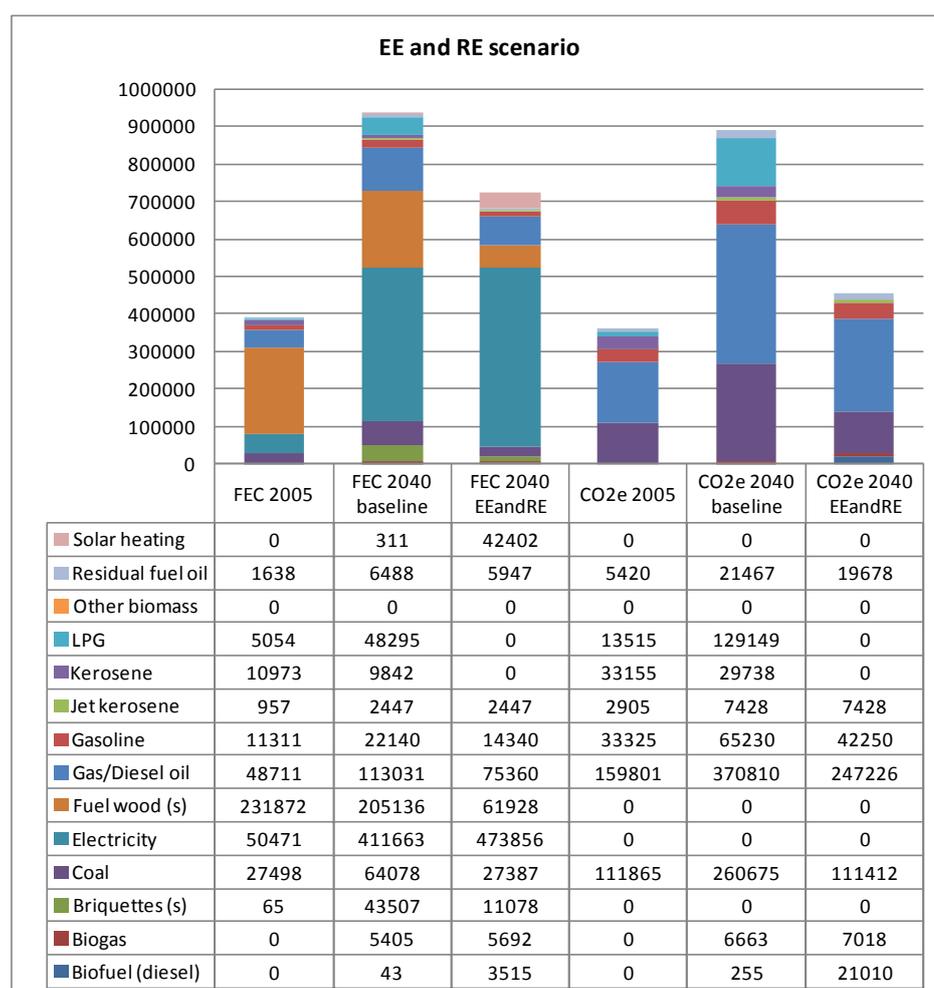


Figure 71: Final energy consumption (toe) and energy related CO<sub>2</sub>e emissions (kt) by fuel in a combined **energy efficiency and renewable energy** scenario compared to baseline. EE = energy efficiency; RE = renewable energy.

### Overview of modelled alternative scenarios

A comparison of the modelled energy scenarios shows that the impact of energy efficiency efforts is a 25% reduction of the CO<sub>2</sub>e emissions (Figure 72). A deliberate shift from fossil fuels to renewable energy sources can reduce final energy consumption by 16% and more than halve the CO<sub>2</sub>e emissions. Combining energy efficiency efforts with renewable energy efforts has limited additional impact relatively speaking compared to the baseline energy scenario – a 22% decrease is achieved in final energy consumption and 57% reduction in emission. The absolute difference between the 2040 emission in the energy efficiency scenario and the renewable energy scenario is 63 kt CO<sub>2</sub>e. It should be noted that with the shift from fossil fuels to renewable energy there is an in-built energy efficiency gain as a result of the higher conversion efficiencies of the end-user technologies in question.

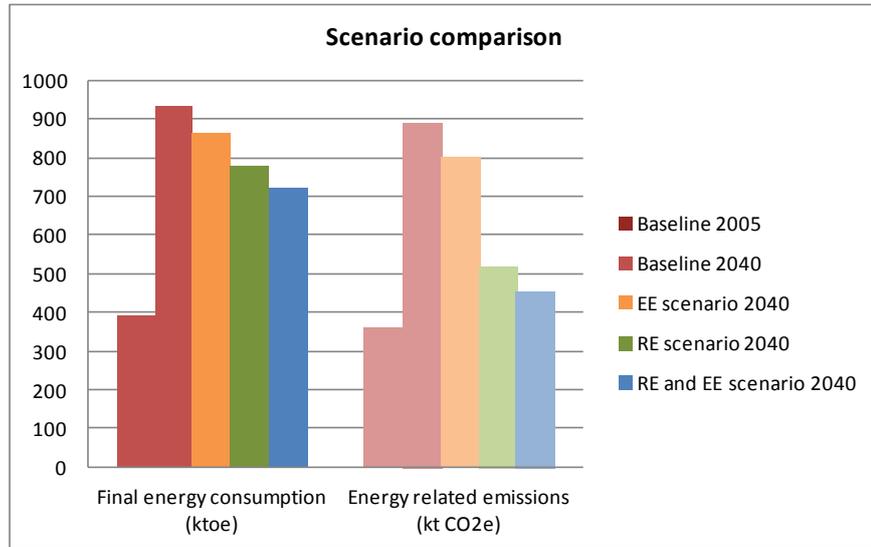


Figure 72: Final energy consumption (ktoe) and energy related CO<sub>2</sub>e emissions (kt) in 2040 of the four modelled energy scenarios compared to the starting point in 2005.

Figure 73 shows that in the ‘RE scenario’ and the ‘RE and EE scenario’ the emission development is gradually more and more “de-coupled” from the final energy consumption.

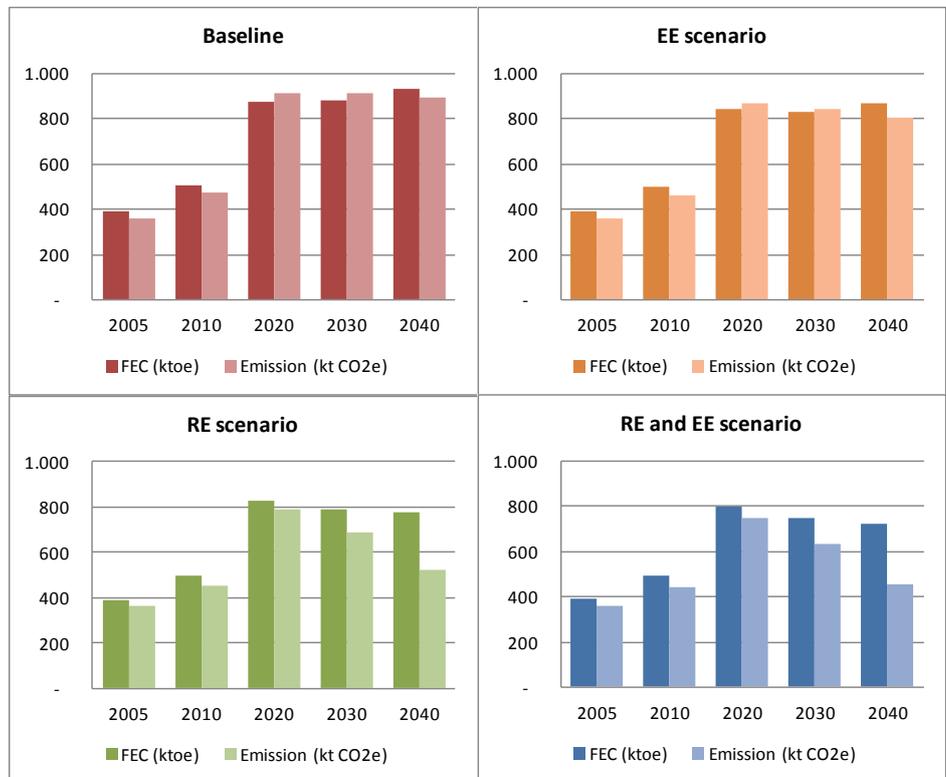


Figure 73: Development in final energy consumption (ktoe) and energy related CO<sub>2</sub>e emissions (kt) of the four modelled energy scenarios 2005-2040.

From 2005 to 2040 fodder cooking is phased out and thus the final energy consumption of the primary sector falls drastically in the baseline (see Figure 75). Some of the largest savings are achieved in the residential sector, tertiary sector and other industries – the key driver being a shift towards electricity. A strategy to provide access to sustainable electricity supply is thus consistent with a low carbon strategy.

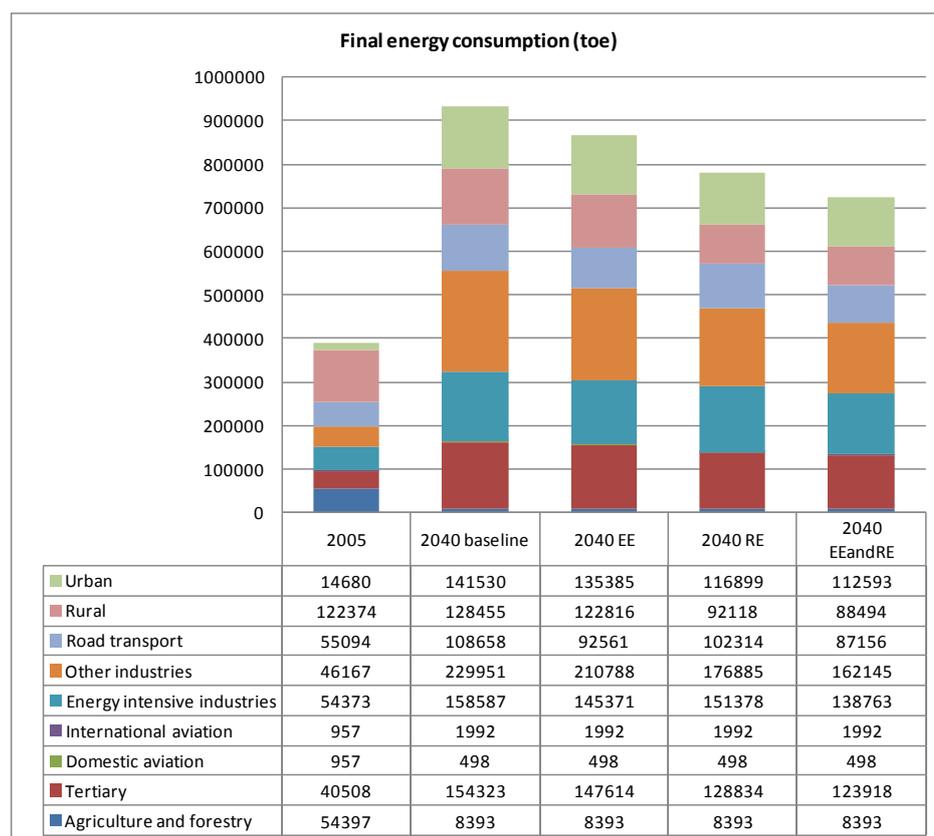


Figure 74: Final energy consumption (toe) of the four modelled energy scenarios – by sector.

	Final energy consumption (toe)				
	2005	2040 baseline	2040 EE	2040 RE	2040 EEandRE
Agriculture and forestry	648%	100%	100%	100%	100%
Tertiary	26%	100%	96%	83%	80%
Domestic aviation	192%	100%	100%	100%	100%
International aviation	48%	100%	100%	100%	100%
Energy intensive industries	34%	100%	92%	95%	88%
Other industries	20%	100%	92%	77%	71%
Road transport	51%	100%	85%	94%	80%
Rural	95%	100%	96%	72%	69%
Urban	10%	100%	96%	83%	80%
<b>TOTAL</b>	<b>42%</b>	<b>100%</b>	<b>93%</b>	<b>84%</b>	<b>78%</b>

Figure 75: Final energy consumption (toe) of the four modelled energy scenarios – by sector – 2040 baseline = index 100%. The light red colour indicates that no change was made in the assumptions for these sectors.

Looking at the mix of fuels consumed LPG and kerosene are completely phased out in the renewable energy scenario<sup>9</sup>. Electricity, fuel wood and gas/diesel oil remain dominant in all scenarios.

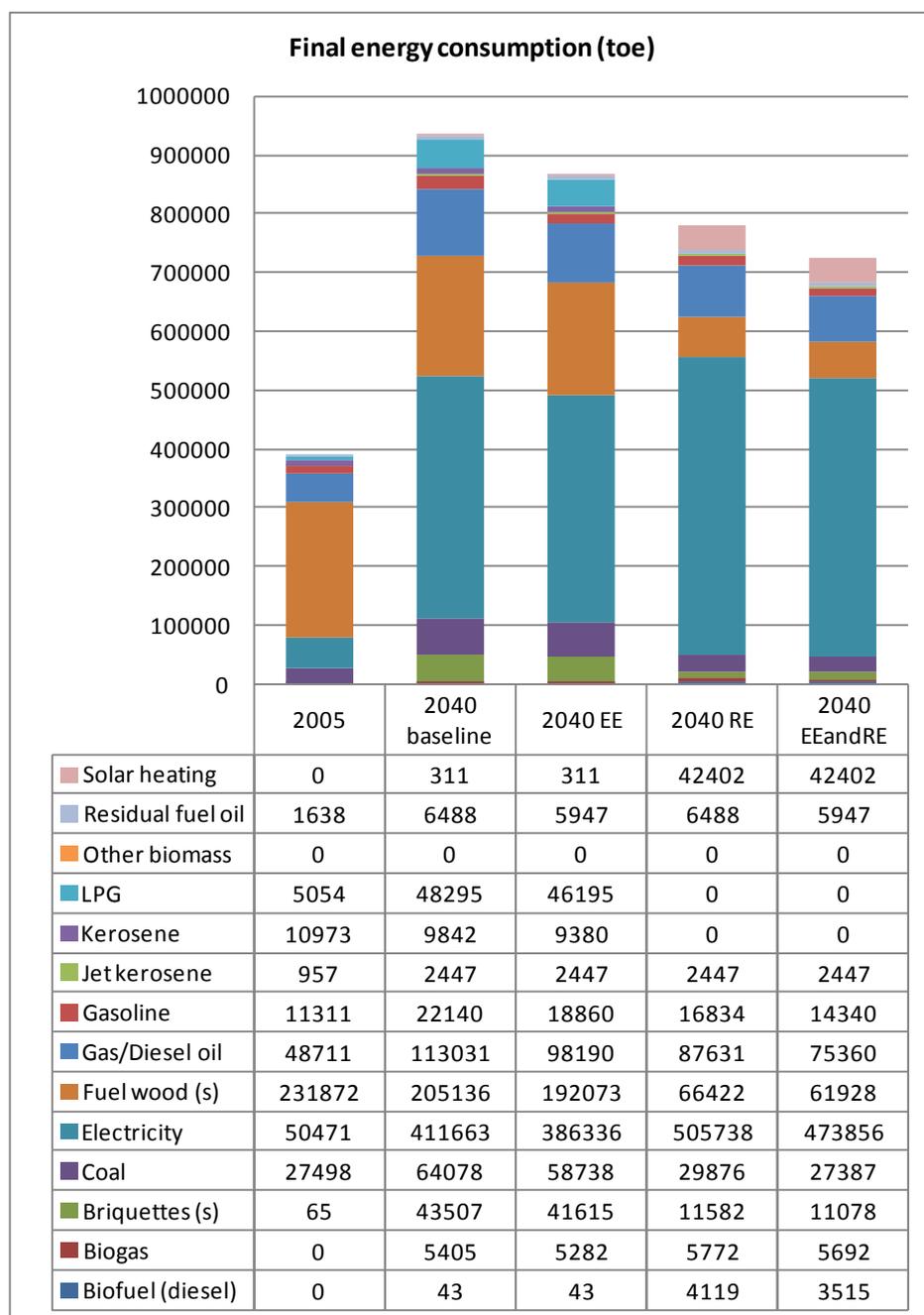


Figure 76: Final energy consumption (toe) of the four modelled energy scenarios – by fuel.

<sup>9</sup> Currently LPG and kerosene are heavily subsidised by India. If a phase out were to be the target then the subsidies would have to be removed.

As can be seen in Figure 76 above there are several substantial differences between the baseline development and a development with focus on energy efficiency and renewable energy. In all scenarios the electrification of the country is considered to be almost 100%. In the EE and RE scenarios the fuel switching towards electricity is radical. In addition to this, the focus on local small-scale energy production in the form of solar heating, biogas, firewood etc. is intensified in those scenarios.

Electrification based on large renewable electricity production will increase the overall energy efficiency and reduce CO<sub>2</sub>e emission. As has been mentioned earlier the CO<sub>2</sub>e impact from saving electricity in a national perspective is quite small due to the fact that almost 100% of the electricity production is based on renewable energy (hydro power). However, in a regional context every saved kWh will have an impact in India since India imports hydropower based electricity from Bhutan. Increasing the efficiency of electricity consumption will in other words “make room” for more export to India which in turn supplants coal based electricity production in India. The marginal emission of Indian electricity production is 1.0 t CO<sub>2</sub>e/MWh<sup>f</sup>. So limiting the growth in electricity consumption in Bhutan can be claimed to increase export to India and thus to reduce the CO<sub>2</sub>e emission in India. The difference between the electricity consumption in the hypothetical RE scenario and the hypothetical combined EE and RE scenario is 32 ktoe (equivalent to 372 GWh). Such electricity savings would in the Indian system equal 372 kt CO<sub>2</sub>e emission savings. And the 25 ktoe electricity savings in the hypothetical EE scenario relative to the baseline scenario would spare the regional environment of 290 kt CO<sub>2</sub>e emissions.

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<sup>f</sup> CO<sub>2</sub> Baseline Database for the Indian Power Sector, User Guide Version 5.0, Central Electricity Authority, Ministry of Power, Government of India, November 2009. The value (1.0 t CO<sub>2</sub>e/MWh) used in the calculation shown in the text above is the emission value of the operating margin. The operating margin describes the average CO<sub>2</sub> intensity of the existing stations in the grid which are most likely to reduce their output if another project supplies electricity to the grid (or reduces consumption of grid electricity).

	Final energy consumption (toe)				
	2005	2040 baseline	2040 EE	2040 RE	2040 EEandRE
Biofuel (diesel)	0%	100%	100%	9649%	8234%
Biogas	0%	100%	98%	107%	105%
Coal	0%	100%	96%	27%	25%
Electricity	43%	100%	92%	47%	43%
Fuel wood (s)	12%	100%	94%	123%	115%
Gas/Diesel oil	113%	100%	94%	32%	30%
Gasoline	43%	100%	87%	78%	67%
Jet Kerosene	51%	100%	85%	76%	65%
Kerosene	39%	100%	100%	100%	100%
LPG	111%	100%	95%	0%	0%
Other biomass	10%	100%	96%	0%	0%
Residual fuel oil	-	-	-	-	-
Solar heating	25%	100%	92%	100%	92%
Briquettes (s)	0%	100%	100%	13625%	13625%
<b>TOTAL</b>	<b>42%</b>	<b>100%</b>	<b>93%</b>	<b>84%</b>	<b>78%</b>

Figure 77: Final energy consumption (toe) of the four modelled energy scenarios – by fuel – 2040 baseline = index 100%.

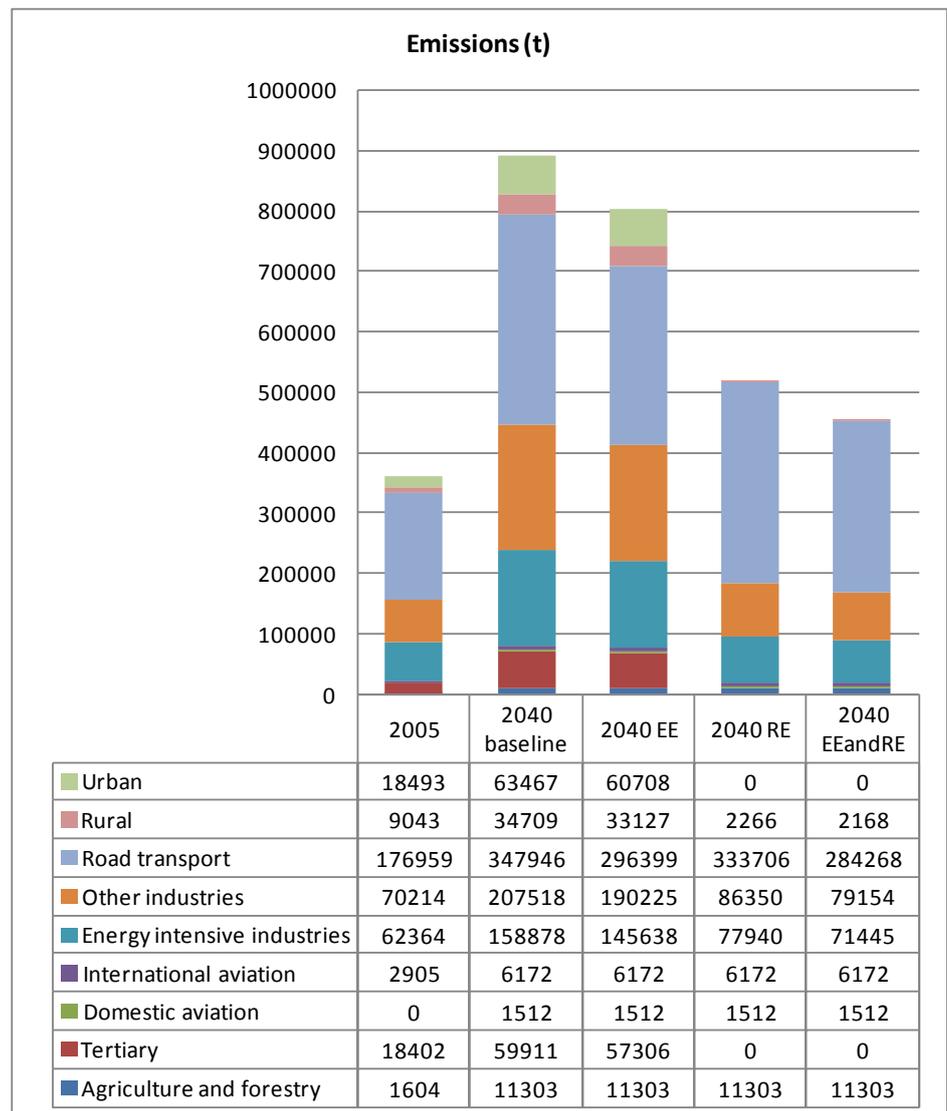


Figure 78: CO<sub>2</sub>e emissions (kt) of the four modelled energy scenarios – by sector.

With regard to carbon emissions the baseline development leads to an increase in emissions by a factor 2.5 over the investigated period. Energy efficiency may limit the increase with 10% of 2040 baseline emissions. Renewable energy offers a 42% reduction and renewable energy combined with energy efficiency can achieve almost a 50% reduction. In the energy efficiency and renewable energy scenarios the 2040 emission is only 27% higher than the 2005 emission level.

In the energy efficiency and renewable energy scenarios road transport makes up 62% of total emissions simply due to the fact that the possibility for a shift to renewable energy is difficult.

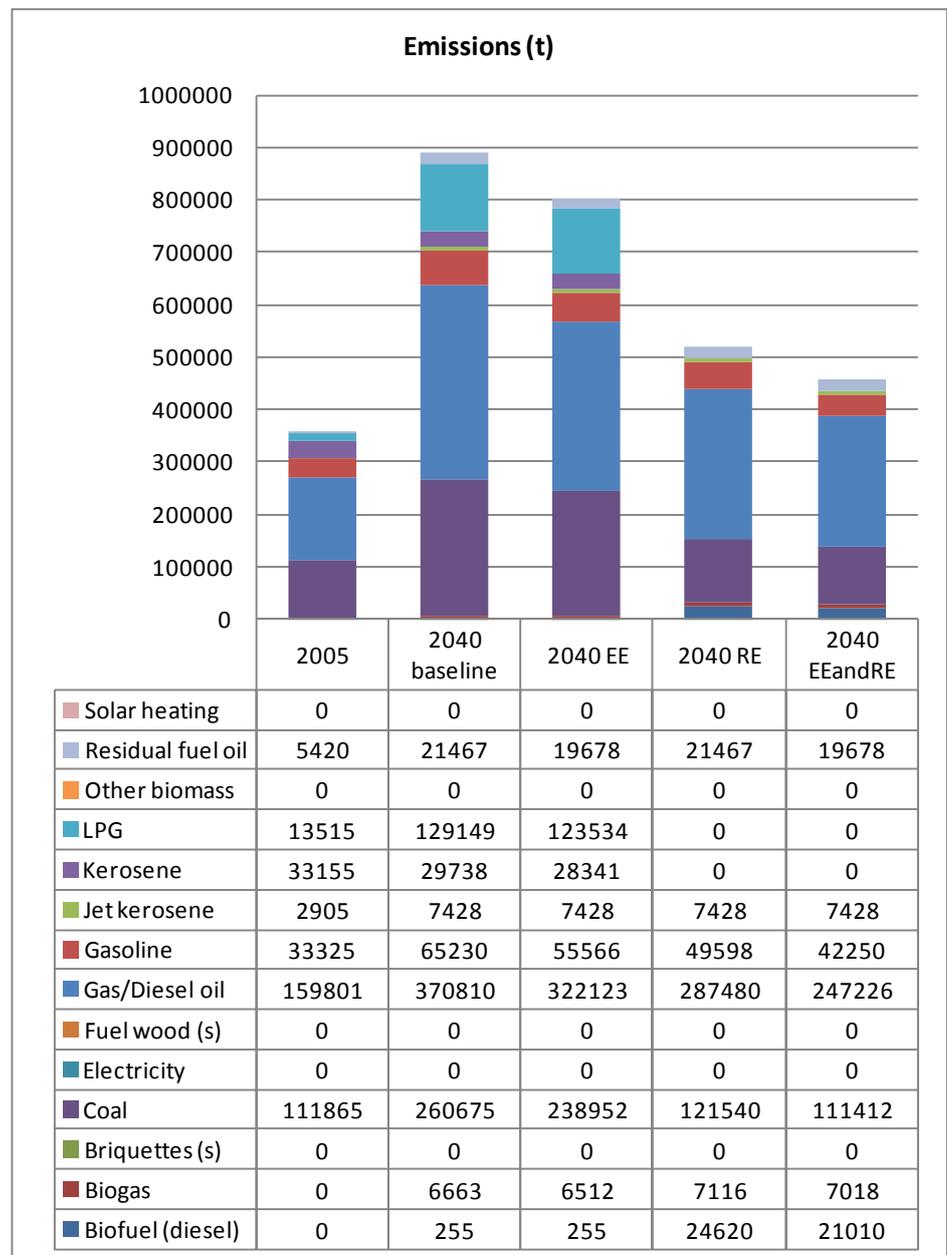


Figure 79: CO<sub>2</sub>e emissions (kt) of the four modelled energy scenarios – by fuel.

## 5 Available financing mechanisms

Climate change is of global concern and international measures to mitigate and adapt to the climate change includes among other supporting financing mechanisms.

A Green Climate Fund was agreed in principle at COP15 in Copenhagen in 2009 and an agreement on the broader design was reached at COP17 in Durban in December 2011. The Green Climate Fund will start operating from 2013 with a fund of 100 billion USD that rich countries have promised to make available to poor countries by 2020 to help mitigate emissions and adapt to climate change. However, the final document from COP17 does not clarify where the money will come from or how much cash, if any, is already there.

At present there exists a number of financing options under the international climate regime such as the project based Clean Development Mechanism (CDM), the sector approach like CDM's Programme of Activities (PoAs) and broader approach like Nationally Appropriate Mitigation Actions (NAMAs). In addition there is the special programme for Reducing Emissions from Deforestation and Forest Degradation (REDD+). While CDM and PoA are part of the Kyoto Protocol the NAMA and REDD+ are mechanisms under the Climate Convention.

### Clean Development Mechanism

The Clean Development Mechanism (CDM) is one of the flexible mechanisms under the Kyoto Protocol<sup>5</sup>. The CDM allows emission reduction projects in developing countries to earn Certified Emission Reductions (CERs) which can be sold and used by industrialised countries to meet part of their emission reduction target under the Kyoto Protocol.

Although there have been several initiatives to register CDM projects in Bhutan so far only two projects are registered. It seems to be a serious problem that the baseline for the energy sector in Bhutan is electricity generated from hydro power which has no CO<sub>2</sub> emissions. Most of the electricity generated at the hydro power plants in Bhutan is exported to India

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<sup>5</sup> Under the Kyoto Protocol, 37 industrialised countries – the so-called Annex I Parties – must meet their GHG emissions targets primarily through national measures. However, the Protocol offers them an additional means of meeting their targets by way of three market-based mechanisms: International Emissions Trading (IET), Joint Implementation (JI), and Clean Development Mechanism (CDM). CDM is defined in Protocol's Article 12.

and here replacing fossil fuels, but it has been very difficult to have an Indian baseline approved for a project in Bhutan.

With few opportunities to have larger hydro power projects approved under the CDM scheme there should be opportunities for minor industrial or household based renewable energy and energy efficiency project. However, experience has shown that approval of methodologies requires a rather large effort and high transaction costs which cannot be made up for by the value of CERs. That is one of the reasons why the CDM has a geographic and sector bias towards the larger developing countries and towards sectors with emissions of either very aggressive GHGs like landfill projects or large power plants in a coal baseline environment.

### **CDM Programme of Activities**

The Programme of Activities (PoA) started in 2005. Worldwide there are almost 100 PoAs being developed with about half of all involving emission reductions at the household and community level. PoA requires less administrative effort to be registered which results in lower transaction costs and shorter time for implementation. The PoA can be seen as a stepping stone towards the sector approach.

### **Post-2012 carbon market**

So far the carbon markets have been politically driven mainly under the frame of the Kyoto Protocol. The current commitment period of the Kyoto Protocol will end in 2012 and the post-2012 demand for CERs will depend on the outcome of negotiations to extend the commitment period and/or the development of existing carbon markets.

There are many uncertainties related to the future demand for CERs. The biggest demander for carbon emission allowances and carbon credits on the global carbon market is the European Emission Trading Scheme (EU ETS). The price of carbon credits, i.e. CERs, on the carbon market is closely linked to the prices of European carbon emission allowances (EUA) as long as CERs are a compliance unit for EU ETS participants. The EU ETS has already been extended with a third phase from 2013 to 2020 but it is highly unclear which types of CERs will be accepted into the EU ETS. It is certain that CERs from least developed countries will be accepted into the post 2012 EU ETS. While investors so far have been focusing on projects in China and India there has been an increasing interest in projects in South East Asia. This shift could reflect that CERs from the region are more likely to be accepted in the post 2012 phase of EU ETS.

At the regional level there are emerging carbon markets in the United States and other countries like Japan, Australia and New Zealand are developing carbon markets.

### **National Appropriate Mitigation Actions (NAMA)**

The rationale behind the Kyoto Protocol is that developed countries are mainly responsible for past emission. However, developing countries increase their contribution to carbon emissions and the developing countries are today the main emitters. Therefore developing countries will be integrated in a post-2012 climate agreement although their level of involvement will be at a lower level compared to developed countries as they are in developing process where mitigation actions have to be integrated with general development targets such as poverty eradication, health care and education. There are major differences between developing countries with respect to for example natural resources, population density, emitting sectors and demographic development. The Nationally Appropriate Mitigation Actions is an instrument that is foreseen to take these differences into consideration.

NAMA is a new mechanism and though modalities and procedures for NAMAs are still evolving many developing countries have pledged NAMAs. However, these NAMAs are often held at the level of aggregate targets and do not include much detail.

NAMAs are part of the Bali Action Plan (BAP) but the BAP does not provide a specific definition of NAMAs. The provisions in the BAP can be broken down into the following elements<sup>t</sup>:

- Developing countries are to undertake nationally tailored mitigation actions;
- These actions shall be embedded in the broader national sustainable development strategy;
- They are to be measurable, reportable and verifiable (MRV);
- They are to be supported by developed countries.

NAMAs can consist of specific project based actions like CDMs and/or refer to broader policies or targets. Specific actions can consist of only one measure, a set of measures or implementation of a holistic action plan.

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<sup>t</sup> JIKO Policy Paper 01/2011, Wuppertal Institute, August 2011

On 5<sup>th</sup> February 2010, the Royal Government of Bhutan registered in the NAMA pipeline<sup>u</sup> a NAMA with a nationwide approach and carbon emission target to remain carbon neutral as emission reduction goal.

### **REDD+**

Although estimates showed that carbon emissions from deforestation and forest degradation accounted for 15-20% of global carbon emissions an agreement to take actions against further deforestation and degradation was not reached until Bali Action Plan in 2007. At COP15 in 2009 a consensus was reached about collective commitment by developed countries for new and additional resources. It is predicted that financial flows for greenhouse gas emission reductions from REDD+ could reach up to 30 billion USD/year. This significant North-South flow of funds could reward a meaningful reduction of carbon emissions and could also support new, pro-poor development, help conserve biodiversity, and secure vital ecosystem services.

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<sup>u</sup> UNEP Risoe NAMA pipeline

## 6 Low carbon strategy and action plan

### Long-term strategy

The task of the long-term national strategy for low carbon development is to strike the difficult balance of economic growth and sufficient energy at reasonable cost while preserving the local environment and contributing to climate protection. More specifically the strategy shall enable Bhutan to fulfil its commitment to remain carbon neutral. In addition, the strategy will align with the Green Economy theme in the UN Conference on Sustainable Development (RIO+20) taking place in June 2012. The concept of Green Economy focuses on the intersection between environment and economy.

### Policy instruments

In its portfolio of policy instruments the government has three policy instruments, namely informative, normative and economic instruments, as illustrated in Figure 80.

The informative instruments aim to inform the target group or influence the target group. The target group has a large degree of freedom regarding whether or not to act in accordance with the information. The economic instruments i.e. market based instruments give the target group an economic incentive to act as the regulator wishes and can be in form of a reward (“carrot”) or a punishment (“stick”). The normative instruments oblige the target group to do the wanted and often include sanctions in case of lack of adherence.

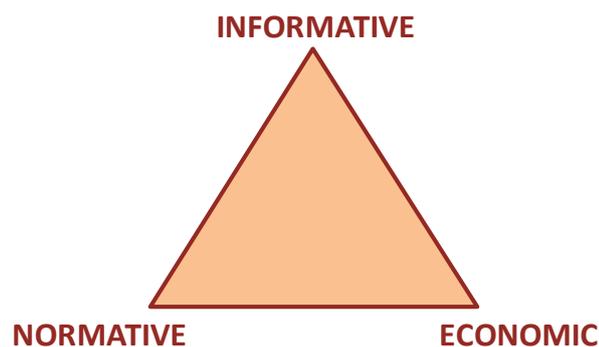


Figure 80: Types of policy instruments.

Typically, a mix of instruments is the best choice – either used at the same time or consecutively. The most effective mix of instruments will depend on the case in question. Is it important that the entire target group acts as wanted or is a section sufficient? How much freedom of choice is politically necessary? To what extent do personal/business interests coincide with

societal interests? Is it possible to verify compliance? How soon are results required?

In addition to these three instrument types the government and local authorities may also chose to use their position to facilitate dialogue and public-private partnerships to further the intended socio-economic development.

## **6.1 Assumptions**

There are several studies on potential mitigation measures for various sectors in Bhutan. All relevant information for the low carbon scenario analysis is based on information from studies available per November 2011 and consultations with stakeholders.

The Consultant has not undertaken own empirical studies to verify or add information.

Assessments of costs and benefits from the selected interventions are mainly qualitative as quantification will require specific and detailed studies. However, in order to be able to proceed with project proposals for the NAMA detailed studies will be required to substantiate related costs and benefits.

## **6.2 Interventions identified in existing documents**

The review of existing documents concerning intervention possibilities for reducing carbon emissions in Bhutan revealed the interventions listed below.

### Available documents

The encountered studies on carbon reduction potential and intervention opportunities relevant to Bhutan are:

- Integrated Energy Management Master Plan for Bhutan. TERI/DoE 2010 (IEMMP);
- ADB Capacity building of NEC. May 2011 (ADB/NEC);
- Energy Intensive Sectors of the Indian Economy. Path to low carbon development. ESMAP 2010 (ESMAP-I);
- CO<sub>2</sub> Reductions in Transport Sector in Thailand: Some Insights, 2008 (THAI);
- Capacity development for scaling up decentralised energy access programmes. Lessons from Nepal. UNDP 2010 (NEPAL);
- Analysis of Energy-Efficient Opportunities for Cement Industry in Shandong Province, China. Lawrence Berkley National Laboratory. October 2009 (Cement-China);

- Bhutan: Economic Analysis of Cleaner Technologies and Options in the Non-Energy Sector. ADB. December 2010 (Non-energy);
- Pathway to a Low-Carbon Economy. Version 2. McKinsey & Company. 2009 (McKinsey);
- Second National Communication from Bhutan to UNFCCC, 2011.

The study 'Bhutan: Economic Analysis of Cleaner Technologies and Options in the Non-Energy Sector' comprises calculations of carbon reduction potentials and marginal abatement costs for a number of interventions in the non-energy sectors of Bhutan. Other reports present rough estimates of reduction potentials and rough estimates of costs.

Figure 81 shows a schematic overview of identified interventions and related reduction potential and costs.

Sector	Opportunity	Emission reduction potential 2010-2020/30	Cost	Source
Energy consumption in industry	General	21-25% coal reduction (in cement industry)	30 mill Nu.	IEMMP
Energy consumption in transport	General	14% petrol and 10% diesel	No information	IEMMP
	Tax/elimination of tax exemption or parking fees	16.4% with CO2 tax of 100USD/t CO2e	No information	THAI
	Fuel shift (bio fuels)	1% reduction 0.8%	No information	ESMAP-I THAI
	Technical standards	16% reduction	No information	ESMAP-I
	Modal shift	3% reduction 2.2%	No information	ESMAP-I THAI
Energy consumption in residential	Improved cook stoves	1.75 tCO2e per ICS per year Target: 40,000 ICS	290 mill Nu.	Nepal IEMMP
	Efficient fodder cooking	Target: 1,000	150 mill Nu.	IEMMP
	LPG stoves	Target: ?	30 mill Nu.	IEMMP
	Solar PV	0.8 tCO2e per household per year Target: ?	400 mill Nu.	IEMMP
	Energy efficient buildings	Target: 5,000 by 2020	1,000 mill Nu.	IEMMP
Industrial processes	Limitation of production of ferro- alloys	No information	Value of increased electricity sales minus value of lost ferro- alloys sales	
Cement industry	Clinkers substitution by fly ash	8%		McKinsey
	CCS cement	260 kt CO2e / year	137 USD/tCO2e	Non-Energy
Mineral		No information	No information	
Metal	There are alternative reducing agents but no estimates	No information	No information	
Agriculture	Livestock	1.6 kt CO2e / year	13.5 USD/tCO2e	Non-Energy
	Rice	3.9 kt CO2e / year	4.2 USD/tCO2e	Non-Energy
Waste	Recycling	11.1 kt CO2e / year	1.2 USD/tCO2e	Non-Energy
	Composting	16.2 kt CO2e / year	0.4 USD/tCO2e	Non-Energy

Figure 81: Available information about reduction potential and abatement costs in Bhutan.

### 6.3 Selection criteria

The criteria applied for selecting the interventions included in the low carbon strategy and the first action plan presented in this report are as follows:

- The sector represents a large carbon reduction potential and/or rapidly increasing carbon emissions in the baseline that holds potential for mitigation;
- Potential interventions with relative low economic barriers, i.e. abatement costs, exist;
- There are few non-economic barriers i.e. conflicts with other policies;
- There are significant sustainability benefits such as employment, reduced traffic congestion, or health improvements;
- There is a 'window of opportunity' such as an energy efficiency element in the building code regulating the boom in construction of new buildings.

The baseline projection shows that the key emitting sectors in 2040 are likely to be the following five in order of carbon emissions:

- Industrial processes and the related energy consumption;
- Crop production and the related energy consumption;
- Livestock raising and the related energy consumption;
- Urban municipal waste; and
- Road transport related energy consumption.

While livestock related emissions in the baseline remain relatively constant in the period 2005-2040, the emissions of the other four sectors grow significantly.

In addition to the abovementioned sectors the energy consumption of the residential sector represents a 'window of opportunity' and high sustainability benefits for households replacing fuel wood with hydro power based electricity.

The recommended low carbon strategy is focused on these six areas and the realisation of the opportunities for carbon reduction that also provides additional benefits such as increased economic self-reliance, employment, improved health, etc.

Finally, a critical component for all decision-making is sufficient and reliable data and analysis of these data. At present the information necessary to make an informed decision on an appropriate carbon strategy is hampered by insufficient detail and lack of up-to-date information. Amending this is an important step towards steering the development of the nation as well as monitoring progress and efficiency of implemented policies.

In other words the selected intervention areas included in the low carbon strategy and action plan are as follows:

- Energy intensive industries' non-energy related emissions
- Crop production
- Livestock raising
- Municipal solid waste
- Road transport
- Residential sector
- Data improvement
  - Sequestration capacity
  - Carbon footprint.

Each individual area is described in more detail in the following section.

#### **6.4 Interventions in the low carbon strategy and action plan**

The descriptions of the interventions of the low carbon strategy and short-term action plan address where relevant the following topics:

- Mitigation measures
- Reduction potential
- Abatement costs
- Non-economic barriers
- Sustainability benefits
- Actions
- Suggested responsible entities
- Time schedule.

##### **Energy intensive industries**

Industries are a major source of carbon emissions. Various fossil fuels are used for heating and mechanical functions in the industries but the emissions from the reducing agents (coke and coal) are emitting even more.

The major mitigation option relating to the use of fossil fuels will be a requirement to new industries to apply the best available technology also with respect to energy efficiency.

##### Mitigation measures

In relation to the use of reducing agents there seems to be two major options to limit emissions from industrial processes in the three major emitting industries:

- Limit the number of licences to exploit and process natural resources.

- As limitations in the number of licenses may not be in accordance with Bhutan’s industry policy to attract new industries. Clear and transparent requirements to use best available technology could be an efficient way to reduce the use of coal and coke as reducing agents in the production process.

**Reduction potential** The industrial sector is one the most emitting sectors in Bhutan with a major increase expected from 2010 to 2020. It is difficult to find valid figures about the potential for efficiency improvements but reductions in the size of 10-15% should not be unrealistic for the cement industry based on figures from China<sup>v</sup>.

**Abatement cost** The abatement costs of limiting the number of licenses will be the lost opportunities for export and employment. Industries are providing employments to large numbers of both national and non-national workers and villagers may benefit economically from industries through employment<sup>w</sup>. These costs will be considerable but has to balance against alternative use of electricity and raw materials.

The abatement costs of placing strict carbon reduction requirements on the applied technology will be considerable as new technology requires major investments. Investments are often a barrier to introducing new efficient technology although lifetime calculations can justify the investment. Increased requirements to technical standards could be seen by investors as a barrier for establishing production in Bhutan compared to other countries that also have low electricity prices and low requirements to production facilities.

**Non-economic barriers** The development will depend on a political decision on what is an acceptable level of exploitation of the national resources. There are examples that local population and local authorities oppose against new mining activities.

**Sustainability benefits** Today Bhutan exports natural resources such as electricity and raw material for chemical and ferro-alloy industries. The export generates income to the country. However, the main value increase takes place later in the value chain outside Bhutan. A moderate exploitation of the resources would create an opportunity for Bhutan to build up the capacity that makes it possible to exploit a larger share of the value chain. A slower exploitation might also be gentler towards the environmental and social impacts.

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<sup>v</sup> Analysis of Energy-Efficient Opportunities for Cement Industry in Shandong Province, China. Lawrence Berkely National Laboratory. October 2009.

<sup>w</sup> Audit of Industries on environmental compliance. Royal Audit Authority, October 2009

## Main action

Controlled development of energy intensive industries so as to gain optimal societal benefits from this economic activity.

Outcomes in addition to carbon reduction:

- The carbon emission of the energy-intensive industries naturally depends on the number of future licenses issued. Restricting the number of licenses may not be consistent with the strategies to diversify the economic base and to increase exports. A controlled development should therefore aim to ensure employment opportunities, to develop local capacity to exploit a larger share of value chain, to consider the available mineral resource base of the industrial production in a long term perspective, to limit local environmental impacts from mining and processing, and to off-set the carbon emission through sequestration efforts.

Suggested responsible entity in cooperation with NEC:

- Ministry of Economic Affairs

Time schedule:

- Immediate term (1-2 years): Further investigations on how international standards can be applied to Bhutan to reduce emissions and increase sustainability benefits.
- Medium term (2-5 years): Combine licensing with various obligations that limits carbon emissions and increases benefits for example obligation to provide data for assessing the carbon footprint more accurately, to implement energy management, to employ local work force, to train local work force etc. Investigate the possibility for the government to demand that the licensed factories are of a certain technological standard with highly qualified operation (e.g. through reward schemes and education programs for attracting and maintaining skilled labour).

## Crop production

The assessment made by UN<sup>x</sup> identifies three main sources of carbon emissions from crop production. The largest emitter is rice cultivation followed by field burning of residues and use of synthetic fertilizers.

## Mitigation options

The key mitigation option is regulation of flood through multiple aeration of areas previously under a single aeration regime.

## Reduction potential

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<sup>x</sup> Bhutan: Economic Analysis of Cleaner Technologies and Options in the Non-Energy Sector, Asian Development Bank, December 2010.

Regulating flood in rice production is expected to have a total abatement potential of around 90 kt CO<sub>2</sub>e from 2006 to 2030.

**Abatement costs** There are no detailed cost estimates for rice production in Bhutan but the UN report estimates the marginal abatement costs to be around 4 USD/t CO<sub>2</sub>e.

**Non-economic barriers** The major non-economic barrier is a strong tradition combined with lack of information about these options.

**Sustainability benefits** New rice farming system may enable farmers to combine an increasing yield with a reduction of emissions.

**Actions** The Royal University of Bhutan has already undertaken studies of new rice farming systems. The experience from this research is being tested and should be expanded during the next years in combination with awareness campaigns.

### **Livestock raising**

**Mitigation options** Important energy-related mitigation measures such as a phase-out of fodder cooking and a fuel switch to biogas are included in the baseline projection. According Bhutan's Second National Communication to UNFCCC the main non-energy related emissions from livestock raising are methane (CH<sub>4</sub>) emissions mainly from enteric fermentation and nitrous oxide (NO<sub>x</sub>) emissions from manure.

The stock of dairy and non-dairy cattle has been almost constant in the period 1994-2009 and it is in the baseline projection assumed that the stock will remain constant during the period 2010-2040. Emissions of CH<sub>4</sub> and NO<sub>x</sub> are calculated per head of livestock per year as an average for the years 1994-2009 and then converted to emissions of CO<sub>2</sub>e/head/year. The annual emissions are determined by the number of livestock and the emission factors for enteric fermentation and manure management. The result is a constant emission of 567 kt CO<sub>2</sub>e per year for the period 2010-2040.

**Mitigation options** Bhutan's Second National Communication to UNFCCC presents a number of options for mitigating carbon emissions from enteric fermentation and manure management. Two key mitigation options are:

- Enteric fermentation: Reduce livestock population by improving yak and cattle breed
- Manure management: Keeping livestock in pens or stalls.

ADB<sup>y</sup> assesses that providing urea-molasses multi-nutrient block supplementation and urea-treatment of straw prior to feeding it to local dairy cattle in Bhutan has a potential of major reductions in emissions from livestock.

Abatement cost	ADB estimates that cost of using urea-molasses multi-nutrient block supplementation and urea-treatment of straw prior to feeding to local dairy will 6-7 USD/t CO <sub>2</sub> e which is a rather low cost. There are no estimates of the potential reduction impact available for the two other mitigation options.
Non-economic barriers	The major non-economic barrier is a strong tradition combined with lack of information about the options.
Sustainability benefits	Through manure management farmers can utilise manure from the livestock for biogas production through anaerobic digestion. The biogas could be used for cooking and lighting. The Ministry of Agriculture is currently managing a programme for promoting manure management and use of biogas.
Actions	Both identified mitigation options, improved breeding and manure management, are option already under preparation and implementation by Ministry of Agriculture. The efforts should be further pursued during the next years to obtain the benefits from improved household income and reduced emissions.

### **Municipal solid waste**

To reduce carbon emissions from landfills in Bhutan the methane must be utilised and/or the volumes reduced either by recycling or composting. There are no studies of the potential of utilising methane in Bhutan but ADB<sup>z</sup> has studied two options of reducing volumes of solid waste: Recycling and composting.

ADB calculates the reduction potential from recycling at around 18% per year and around 25% from composting. The government has taken some initiatives by building composting plants.

The ADB study calculates abatement costs for recycling at 1.18 USD/t CO<sub>2</sub>e and 0.42 USD/t CO<sub>2</sub>e for composting. These are rather low abatement costs.

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<sup>y</sup> Bhutan: Economic Analysis of Cleaner Technologies and Options in the Non-Energy Sector, Asian Development Bank, December 2010.

<sup>z</sup> Bhutan: Economic Analysis of Cleaner Technologies and Options in the Non-Energy Sector, Asian Development Bank, December 2010

No non-economic barriers have been identified.

There will always be a potential risk of pollution from a landfill so reduction of volumes at the landfill will provide environmental and health benefits.

#### Actions

Limiting the production of municipal solid waste and exploiting the waste efficiently for example through composting. Awareness and information campaigns should aim to limit waste production but also to further collection of waste for exploitation.

Outcomes in addition to carbon reduction:

- Reduced need for land fill space for depositing waste
- Compost for agricultural production
- Reduced waste in the surroundings.

Suggested responsible entities in cooperation with NEC:

- Ministry of Works and Human Settlement
- Local authorities of the urban areas.

Time schedule:

- Immediate term (1-2 years): Establish system of composting of market waste (as in Thimphu) and municipal waste collection in all urban areas.
- Subsequent term (3-5 years): Feasibility study of biogas possibilities in the largest cities.

#### **Road transport**

The emissions from the road transport are also expected to increase from 2010 to 2040 with the increasing demand for transport services following the economic development.

#### Mitigation measures

The following mitigation measures have been suggested in the 2040 Transport Strategy by ADB:

- Decreasing the number of vehicles as a result of increasing prices of cars (elimination of tax exemption for public servants) and increasing fuel prices (CO<sub>2</sub> tax).
- Time limitation and fee for parking in urban areas.
- Regulation of taxis (highly efficient and electric cars).
- Improved efficiency in the stock of vehicles.

- Upgrading pedestrian and cycling facilities.
- Increasing the share of electrical cars in the stock of vehicles.
- Improve the public transport (safe, affordable and responsive to demand).
- Improved traffic engineering and management techniques

Some of the measures could be implemented and enforced within a short time perspective while implementation of others will require longer time. The 2040 Transport Strategy also recommends strengthening the organisational structure and role distribution among the institutions of the transport sector.

Reduction potential	According to the 2040 Transport Strategy it can be expected that a further reduction in carbon emissions of around 15% should be feasible up to 2040.
Abatement costs	Interventions such as taxes/fees and technical standards have relatively low abatement costs while fuel shift and modal shift have higher abatement costs.
Non-economic barriers	Non-economic barriers are relatively high including potential conflicts with the "access to quality transport service by all" policy and a general reluctance against taxes.
Sustainability benefits	<p>The sustainability benefits are relatively high including reduced congestion and need for parking space in urban areas, reduced number of injuries and improved air quality.</p> <p>Curbing the increase in driving short distances to the benefit of walking and bicycling is an important component of a transport solution that will also bring about health and social benefits.</p>
Actions	A well functioning transport sector is vital to social cohesion and economic development of any nation. Bhutan is expanding its transport system and with increased income levels the number of vehicles increases. A wide portfolio of interventions is required in order to steer development in a sustainable direction: Minimum efficiency standards on imported vehicles, regular vehicle inspection, taxation on purchase of vehicles and fuel consistent with sustainability strategies, facilities for charging of electric vehicles, intelligent transport logistics, parking restrictions, safe and easy opportunities for walking and bicycling, and well-functioning, convenient and comfortable public transport. A pilot trial of electric vehicles for example in urban areas may pave the way for a wider dissemination. Modal shift interventions may be

combined with promotion campaigns to encourage a change in habit and prestige. Sustainability aims should be aligned with the overall aim of providing "access to quality transport services for all".

The demand for transport services can also be restrained through careful holistic urban planning that places transport of people and goods in focus instead of vehicle access and incentivises people to drive less and at the same time provides attractive alternatives.

Furthermore, it should be kept in mind that a significant amount of transport in rural areas today is non-motorised. Good access for people and goods to public transport or other affordable transport solutions in rural areas should also be given high priority in order to ensure rural development.

Outcomes in addition to carbon reduction:

- Improved air quality and health
- Limitation of congestion
- Improved live-ability.

Suggested responsible entity in cooperation with NEC:

- Ministry of Information and Communication
- Municipalities of major urban areas
- Ministry of works and Human Settlement (for environmentally friendly road construction)

Time schedule:

- Immediate term (1-2 years): Parking fees, tax revision with elimination of tax exemption on import of cars, and/or parking fees could increase government revenue which could be earmarked for a modal shift. Improvement of public transport offer. Promotion of walking and bicycling for short journeys. Fully integrating transport issues in urban planning work.
- Subsequent term (3-5 years): Pilot test of electric vehicles – both cars and busses.

### **Residential sector**

Mitigation measures

Existing reports list the following mitigation measures:

- Promotion of efficient/improved cook stoves
- Promotion of efficient LPG stoves
- Promotion of solar PV
- Promotion of solar water heating systems

- Targeting building energy efficiency.

Regarding energy demand for the residential sector IEMMP focuses on reducing fuel wood share in the residential sector by introducing high efficient cook stoves and switching to modern fuels like LPG, electricity, solar and biogas. These are highly efficient measures to reduce the fuel wood share of residential energy consumption but the impact on net CO<sub>2</sub>e emissions will depend on the changes in forest and other woody biomass stocks as recorded in the national communications. There are, however, other reasons that justify limiting the use of these such as improved health and limiting the pressure on possibly limited biomass resources.

In 2005, the total consumption of fuel wood in the residential sector was 490 kt. In the Business as Usual case the study assessed that fuel switch will result in a reduction of 200 kt in 2020 or a reduction almost 40%. This reduction in fuel switch is mainly caused by the rural electrification programme and a switch towards LPG. Improved cooking stoves would result in additional reduction of 100 kt fuel wood by 2020 or a further reduction of 20% in an energy efficiency scenario.

#### Improved cooking stoves

Centre for Rural Technology, Nepal (CRT/N) is implementing an improved cooking stove programme in Nepal funded by DANIDA and Government of Nepal. The programme started more than 10 years ago and has resulted in more than 100,000 improved cooking stoves introduced in Nepal<sup>28</sup>. Recently CRT/N has participated in a registered carbon offsets programme. Under this programme CRT/N has worked with local partners to install 1,500 improved cooking stoves. The total project grant was about 18,100 USD and estimated carbon reductions are 1.75 t CO<sub>2</sub>e per year per improved cooking stove.

#### Promotion of LPG stoves

Use of LPG as cooking fuel is common in urban areas. The main barriers to dissemination into rural areas are poor infrastructure and high cost of transportation. A rural household with an LPG cooking stove uses around 50 kg LPG per year which corresponds to 0.16 t CO<sub>2</sub>e.

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<sup>28</sup> Capacity development for scaling up decentralised energy access programmes. Lessons from Nepal on its role, costs, and financing. UNDP 2010.

### Promotion of solar PV

Solar PV will mainly replace kerosene as a source of lighting. Today about 3,000 households have solar PV systems. A rural household uses around 300 litres of kerosene per year for lighting which corresponds to 0.8 t CO<sub>2</sub>e per year. Is this consumption replaced by electricity from hydropower the carbon reductions are 0.8 t CO<sub>2</sub>e per household connection per year.

### Promotion of solar water heaters

Solar water heating systems save electricity and fuel wood used for heating water and space heating. While solar water heating for hot water is quite widely used in many countries, solar water heated space heating is relatively unique for Bhutan. Data on existing systems can together with pilot tests of various models form the basis for greater application. The possibilities for further expansion of use and organising local production of the technologies may provide new business and employment opportunities.

### Energy efficient buildings

Bhutan has a design code of buildings to secure and maintain a cultural building tradition but codes are lacking in terms of energy efficiency.

## Non-energy benefits

All of the listed mitigation opportunities (see Figure 82) have an added benefit in the form of improved living conditions and health. Higher energy efficiencies and electrification saves time for fuel collection and transportation. Solar PVs can provide access to electric end-uses for households otherwise without reach of the electric grid and further an informed and politically active population.

Building regulations already exist that address e.g. the cultural heritage aspects of building construction. It would be a logic step to include energy efficiency as well as safety aspects in the building regulations. However, to create the necessary legislation is the easiest element – upgrading the skills of the building entrepreneurs and the building workers as well as equipping the inspectors with the necessary know-how to verify whether or not building regulations are met is quite a different and significant task. Increased costs of energy efficient measures also act as barriers to adopting the necessary measures. The challenge is augmented by the fact that urban areas at present experience a building boom which gives a certain urgency if the ‘window of opportunity’ is to be exploited at lowest possible cost to society. A building will remain in function for many decades.

Opportunity	Added benefit	Non-economic barriers
Improved stoves	Health Less time consuming	
PV	Health Less time consuming Access to electric end-uses	Outlets and transport Maintenance
Solar water heaters	Health Less time consuming No fuel expenses	Outlets and transport
Building regulation addressing energy efficiency	Health Less time consuming	Lack of skills Lack of materials Enforcement (especially during building boom)

Figure 82: Overview of opportunities and their added benefits and non-economic barriers.

## Actions

Promote a fuel shift from fossil fuels to hydro-power based electricity and other renewable energy sources; limit the future need for energy; and facilitate energy efficient choices within the tertiary and residential sector.

A fuel shift is greatly helped by access to electricity whether from the national grid or smaller systems. Solar heating will in combination with sustainable fuel wood, sustainable briquettes and biogas be main contributors to a diversified supply. Minimum standards, labelling, information campaigns and access to best-available-technologies contribute to minimising future energy need. Here an important area is building regulations and enforcement of these. National or local authorities may for example require that certain building types be equipped with solar heating for hot water and/or space heating and that the structure be designed so as to minimise the need for space cooling. Studies on the energy characteristics of buildings adhering to traditional elements in building design whilst accommodating a modern life style are needed to ensure a high quality building stock. Such studies could be linked to research on how to secure the buildings against earth quakes. Another important aspect is training and upgrading of the qualifications of the construction sector as well as those enforcing the building regulations. The efforts of the tourist industry could be used as a front runner.

Outcomes in addition to carbon reduction:

- Reduced vulnerability to changes in fossil fuel prices.
- Limit dependence on import of energy (through higher share of local energy resources).
- Contribute to lessening the migration from rural to urban areas.
- Improved living standards and business opportunities through affordable access to clean energy.
- Improved health (reduced smoke).
- Skilled construction workers.
- A modern Bhutanese building tradition.
- Visibility of Brand Bhutan to both guests and local inhabitants.

Suggested responsible entities in cooperation with NEC:

- Ministry of Works and Human Settlement
- Municipalities of major urban cities
- Division of Renewable Energy and Division of Energy Efficiency and Conservation under the Department of Energy, Ministry of Economic Affairs.

Time schedule:

- Immediate term (1-2 years): Intervention in particular in the building sector is urgent in order to use the window of opportunity that the building boom provides. Testing of solar hot water heating and solar space heating technologies in order to adapt these to the Bhutanese needs and prepare local production, installation and maintenance capacity of these technologies.
- Subsequent term (3-5 years): Enforce minimum energy efficiency standards on electric appliances and cooking stoves. Information campaign to sensitise the population and businesses to energy efficient purchase and use.

### **Data on sequestration capacity**

Detailed mapping of sequestration capacity and development including both agriculture and forestry aspects is an important tool in managing the resources sustainably while contributing to economic development within these sectors. Such mapping is closely linked to the development possibilities of the agricultural and forestry productions.

Outcomes in addition to carbon reduction:

- Improved validity of the “upper limit” for carbon emission if carbon neutrality is to be maintained.
- Identification of possibilities for sustainable fuel wood exploitation.

- Identification of the need and possibilities for developing carbon efficient crop production.
- Systemised monitoring at regular intervals and coordinated with NSB responsibilities.

Suggested responsible entity in cooperation with NEC:

- Ministry of Agriculture and Forests

Time schedule:

- Immediate term (1-2 years): Complete the already planned and partially initiated National forest Inventory to enable the assessment of current and future sequestration capacity and measures to realise this. Establish monitoring system and organisation.
- Subsequent term (3-5 years): Information campaign and targeted education program targeting the rural population and those employed in the agricultural and forestry sectors.

### **Data on carbon footprint**

Carbon emission must remain below the sequestration capacity as promised by the RGoB at COP15 and in order to assess whether this is the case it is necessary to expand and improve the data on the carbon footprint of the various economic sectors, in particular the industrial sector and the tertiary sector. Inspiration can be found within the tourist industry. Of special interest to Bhutan is the carbon footprint from import-export activities which could be given increased focus. This is due to the fact that the regional carbon impact from the planned increase in electricity exports by far outbalances the carbon footprint from the planned increase in industrial output.

The carbon mapping can be devised in steps starting with a certain segment of the economy and then gradually expanded to include more. This will allow development of a method that can provide the necessary information with a minimum of bureaucracy. Important for the general acceptance of the need to provide data to the authorities is to use the collated data to analyse aspects of relevance to the contributors.

Information on the carbon footprint of various activities can also be incorporated in the communication from the RGoB to the nation that aims to sensitise the population to sustainable development and market the as environmentally conscious.

Outcomes in addition to carbon reduction:

- Sound foundation for informed decision-making and policy design.

- Possibility for branding of sectors as “green”.

Suggested responsible entity in cooperation with NEC:

- National Statistics Bureau

Time schedule:

- Immediate term (1-2 years): Devise mapping system and conduct pilot test of the system. Further analysis of the interventions of the short term action plan among other with the aim to determine costs and specific impact targets.
- Subsequent term (3-5 years): Establish sample data collection routines and for selected sectors data reporting obligation.

## **6.5 Recommended next steps**

An overview of the recommended interventions of the short-term action plan can be found in Figure 83.

Each of the descriptions of these interventions should be further developed by NEC in cooperation with the relevant ministries and departments and suitable NAMAs designed. Important for the approval of NAMAs is that baseline assumptions, rationales, data and calculations are explicitly stated, justified and reasonable. Furthermore, the proponent should cite independent sources.

Immediate term (1-2 years)	Medium term (2-5 years)
<b>Energy intensive industry</b>	
Further investigations on how international standards can be applied to Bhutan to reduce emissions and increase sustainability benefits.	Combine licensing with obligations that limit carbon emissions and increases benefits (energy efficiency standard, data for carbon footprint, energy management, employment of local work force, training, etc.).
<b>Crop production</b>	
The Royal University of Bhutan already has undertaken studies of new rice farming systems. The experience from this research is being tested and should be expanded during the next years in combination with awareness campaigns and training.	
<b>Livestock raising</b>	
Both identified mitigation options – improved breeding and manure management – are already under preparation and implementation by the Ministry of Agriculture. The efforts should be further pursued during the next years in combination with awareness campaigns and training.	
<b>Municipal solid waste</b>	
Establish system of composting of market waste (as in Thimphu) and municipal waste collection in all urban areas.	Feasibility study of biogas possibilities in the largest cities and if relevant pilot test.
<b>Road transport</b>	
<p>Parking fees and tax revision with elimination of tax exemption on import of cars could increase government revenue which could be earmarked for a modal shift.</p> <p>Improvement of public transport offer.</p> <p>Promotion of walking and bicycling for short journeys. Fully integrating transport issues in urban planning work.</p>	Pilot testing of electric vehicles.
<b>Residential sector</b>	
<p>Energy efficiency requirements in the building regulation and enforcement of the regulation. Provision of training of construction workers and enforcers.</p> <p>Test and adaptation of solar water heating and solar space heating technologies to the Bhutanese needs and build local production, installation, and maintenance capacity of these technologies.</p>	<p>Enforce minimum energy efficiency standards on electric appliances and cooking stoves.</p> <p>Information campaign to sensitise the population and businesses to energy efficient purchase and use.</p>
<b>Data on sequestration</b>	
Complete the already planned and partially initiated National Forest Inventory to enable the assessment of current and future sequestration capacity and measures to realise this. Establish monitoring system and organisation.	Information campaign and education program targeting the rural population and those employed in the agricultural and forestry sectors.
<b>Data on carbon footprint</b>	
<p>Devise mapping system and conduct pilot test of carbon footprint data system.</p> <p>Further analysis of the interventions of the short-term action plan among other with the aim to determine costs and specific impact targets.</p>	Establish sample data collection routines and test for selected sectors a data reporting obligation.

Figure 83: Recommended short- and medium-term actions.

Much of the required initiatives to drive the development of the country down a low carbon path are already in place or being discussed and negotiated. Substantial work in terms of creating the necessary legislative and organisational framework has been carried out.

The greatest challenge that remains is probably a speedy implementation of agreed legislation and projects while upholding strict enforcement of legislation and coordination of initiatives.

Access to reliable, detailed and up-to-date information is critical for monitoring progress and cost-efficiency of policies and for underpinning NAMAs. A coordinated development of the data collection systems required is important to avoid unnecessary bureaucracy and ensure a uniform quality. Such a task is best handled by a national institution such as NSB.

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- Intergovernmental Panel on Climate Change, [http://www.ipcc.ch/publications\\_and\\_data/ar4/wg1/en/ch2s2-10-2.html](http://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch2s2-10-2.html)
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Five Year Plan	Period covered
1 <sup>st</sup>	1961-66
2 <sup>nd</sup>	1967-72
3 <sup>rd</sup>	1972-77
4 <sup>th</sup>	1977-82
5 <sup>th</sup>	1982-87
6 <sup>th</sup>	1987-92
7 <sup>th</sup>	1992-97
8 <sup>th</sup>	1997-2002
9 <sup>th</sup>	2002-07
10 <sup>th</sup>	2008-13

## Abbreviations

BNG – Bhutanese currency Ngultrum  
Carbon – Green house gases counted in CO<sub>2</sub> equivalents  
CER – Certified emission reductions  
COP15 – UNFCCC 15<sup>th</sup> session of Conference of Parties  
CO<sub>2</sub>e – CO<sub>2</sub> equivalents  
DHMS – Department of Hydro-Met Services, Ministry of Economic Affairs  
DoR – Department of Roads, Ministry of Works and Human Settlement ([www.dor.gov.bt](http://www.dor.gov.bt))  
DUDES – Department of Urban Development & Engineering Services, Ministry of Works and Human Settlement  
FYP – Five Year Plan  
GDP – Gross domestic product  
Gg – Giga gram = 1,000 tonnes  
GHG – Green house gases  
GNHC – Gross National Happiness Commission ([www.gnhc.gov.bt](http://www.gnhc.gov.bt))  
kt – 1,000 tonnes  
ktoe – 1,000 tonnes oil equivalents  
LULUCF – Land use, land use change, and forestry sector  
MoAF – Ministry of Agriculture and Forests ([www.moaf.gov.bt](http://www.moaf.gov.bt))  
MoEA – Ministry of Economic Affairs ([www.moea.gov.bt](http://www.moea.gov.bt))  
MoF – Ministry of Finance ([www.mof.gov.bt](http://www.mof.gov.bt))  
MoIC – Ministry of Information & Communication ([www.moic.gov.bt](http://www.moic.gov.bt))  
MoLH – Ministry of Labour and Human Resources  
MoWHS – Ministry of Works and Human Settlement ([www.mowhs.gov.bt](http://www.mowhs.gov.bt))  
MSTCCC – Multisectoral-Technical Committee for Climate Change  
NEC – National Environment Commission ([www.nec.gov.bt](http://www.nec.gov.bt))  
NSB – National Statistics Bureau of Bhutan ([www.nsb.gov.bt](http://www.nsb.gov.bt))  
Nu. – Bhutanese currency Ngultrum, also abbreviated to BNG  
REDD+ – Reduction Emissions from Deforestation and Forest Degradation  
RGoB – Royal Government of Bhutan ([www.bhutan.gov.bt](http://www.bhutan.gov.bt))  
RSTA – Road Safety and Transport Authority, Ministry of Information & Communication ([www.rsta.gov.bt](http://www.rsta.gov.bt))  
toe – tonne(s) oil equivalents  
ToR – Terms of reference  
UNFCCC – United Nations Framework Convention on Climate Change

## **Annex 1 – Stakeholder Consultation**

Early consultation – and active involvement where relevant – in strategy development is critical to stakeholder acceptance of the vision outlined in the national strategy and for the realisation of the ensuing projects. In accordance with the ToR two rounds of stakeholder consultations was carried out during the project with the aim to

- identify possible data sources,
- identify key concerns and interests of the stakeholders,
- solicit ideas for short-term actions,
- confirm relevance of the chosen scenarios,
- discuss modelling results, and
- discuss recommendations.

### **First stakeholder consultation**

#### **Monday 5<sup>th</sup> September 2011**

Mr. Ugyen Tshewang, Secretary, National Environment Commission (NEC)

Ms. Peldon Tshering, Chief, PPS, NEC

Wangchuk Namgay, Senior Planning Officer, Gross National Happiness Commission (GNHC)

Tashi Dorji, Chief Livestock Officer, Department of Livestock

Kinley Tshering, Chief Forestry Officer, Forest Resources Development Division (FRDD), Department of Forest & Park Services, MoAF

Mr. Chencho Norbu, Director, Department of Agriculture, MoAF

Mr. Henrik A. Nielsen, Head of Representation Office, Thimphu, Representation Office of Denmark

#### **Tuesday 6<sup>th</sup> September 2011**

Khandu Wangchuk, Minister, Ministry of Economic Affairs (MoEA)

Sonam Tshering, Secretary, Ministry of Economic Affairs (MoEA)

Mewang Gyeltshen, Offtg. Director, Department of Energy, MoEA

Tandin Tshering, Director, Department of Industry, MoEA

Loknath Chhetri, Industry Specialist, MoEA

Wangchuk Loday, Planning Officer, MoEA

Kinley Dorji, Secretary, Ministry of Information & Communication (MoIC)

Bhimlal Subedi, Chief Planning Officer, Ministry of Information & Communication (MoIC)

Karma Pemba, Chief Transport Officer, Road Safety & Transport Authority (RSTA)

Namgay Wangchuk, Chief Engineer, Road Safety & Transport Authority (RSTA)

Phub Tshering, Secretary General, Bhutan Chamber of Commerce & Industry

**Wednesday 7<sup>th</sup> September 2011**

Dasho Sonam Tenzin, Secretary, Ministry of Works & Human Settlement

Ichharam Dulal, Department of Urban Development & Engineering Services

Mr. Tandin, Department of Urban Development & Engineering Services

Kinlay Dorjee, Thrompon (Mayor), Thimphu Municipality

Visit to DSB shop (solar appliances)

Mr. Lekzang, Chief Planning Officer, Policy & Planning Division, Ministry of Finance

Multisectoral Technical Committee on Climate Change:

- Sonam Dendup, Sr. Planning Officer, MOIC
- Jamyang Phuntshok, Head, Climate & Water Section, Watershed Management Division, Dept. of Forest and Park Services
- Karma P Dorji, Executive Engineer, Dept. of Energy
- Peldon Tshering, Head, Policy & Planning Services, NEC
- Thinley Namgyel, Head, Environment Monitoring Division, NEC
- Phuntsho Pelgay, Geologist, Department of Geology & Mines (DGM) (On behalf of Ms. Pem Deki, Geologist, DGM)
- Phuntsho Namgyal, Hydro-met Services Division (HMSD), Dept. of Energy (On behalf of Mr. Karma Dupchu, Head, HMSD)
- Mr. Tandin, Ministry of Works & Human Settlement (MOWHS) (On behalf of Ms. Daw Zam, Dy. Chief Environment Officer, PPD, MOWHS)

Visit to appliance store Dolma Enterprise

Karma L. Raptan, Head of Unit, Energy, Environment and Disaster Cluster, UNDP

Anne Erica Larsen, Programme Analyst, Energy, Environment and Disaster Cluster, UNDP

Yeshey Penjor, Climate Change Policy Specialist, UNDP

**Thursday 8<sup>th</sup> September 2011**

Kuenga Tshering, Director, National Statistics Bureau (NSB)

Dago Tshering, Environment Education Officer, Royal Society for Protection of Nature (RSPN)

Rinchan Wangmo, Program Manager, Royal Society for Protection of Nature (RSPN)

Unknown name, Officiating Managing Director (Head of Civil Division),  
Construction Development Corporation Ltd  
H.P. Phuyel, Sr. Manager, Construction Development Corporation Ltd  
Cheku Drukpa, General Secretary, Construction Association of Bhutan  
Karma Lotey, Managing director, Yangphel Adventure Travel, on behalf of the  
Hotel Association of Bhutan  
Sonam Dorji, General Secretary, Association of Bhutanese Tour Operators  
(ABTO)

### **Monday 12<sup>th</sup> September 2011**

Pema Gyamtsho, Minister-In-Charge, NECS & Minister, Ministry of Agriculture  
& Forest  
Sonam Tashi, Senior Planning Officer, Policy & Planning Division, Ministry of  
Economic Affairs

## **Second stakeholder consultation**

### **Thursday 3rd November 2011**

Mr. Dasho Ugyen Tshewang, Secretary, NEC  
Mr. Tandin Tshering, Director, Dept of Industry (DoI)  
Mr. Chencho Norbu, Director, Dept of Agriculture (DoA)  
Mr. Yonten Phuntsho, Forestry Officer, Dept of Forest & Park Services (DoFPS)  
Mr. Phuntsho Namgyal, Deputy Executive Engineer, HMSD, Dept of Energy  
(DoE)  
Mr. Dago Tshering, RO, RSPN  
Mr. HP Phuyel, Sr. Manager, Construction Development Corporation Limited  
(CDCL)  
Mr. Phuntsho Pelgay, Geologist, Dept of Geology & Mines (DGM)  
Ms. Dechen Yangden, Executive Engineer, Dept of Urban Development &  
Engineering Services (DUDES)  
Mr. G.K Chhopel, Chief, Water Resources Coordination Division, NEC  
Ms. Peldon Tshering, Chief, PPS, NEC  
Mr. Sonam Dorji, General Secretary, Association of Bhutanese Tour Operator  
Mr. Sonam Tenzin, National Statistical Bureau  
Mr. Karma L Rapten, ARR (P), UNDP, Bhutan  
Mr. Chhimi Rinzin, Chief Agriculture Officer, DoA  
Mr. Wangchuk Namgay, Sr. Planning Officer, GNHC  
Mr. Karma Tshering, Planning Officer, NEC  
Mr. Tshering Tashi, Communication Officer, NEC  
Ms. Tshewang Zangmo, Planning Officer, NEC  
Ms. Jigme Zangmo, Technician, NEC  
Ms. Sonam Lhaden Khandu, Climate Change Unit, NEC

Mr. Sonam Dagay, Climate Change Unit, NEC

## Annex 2 – Scenario model training

It has been important that the experiences gained through the strategic planning process of the task outlined in the ToR is retained within NEC and that selected stakeholders so that relevant staff possess the capacity to operate and modify the economic and emissions model applied for the strategic planning.

The aim of the scenario model training carried out in relation to the scenario modelling for the long-term national strategy and short-term action plan has thus been to enable Bhutanese experts to use, maintain, and expand the model.

The topics covered during the training as part of the capacity building were:

- Input data and assumptions;
- Operation and maintenance of the model;
- Scenario analysis construction and interpretation of output.

The training took place Wednesday 2<sup>nd</sup> November 2011 and the persons that received training in the model were:

- Mr. Naitan Wang Chek, Deputy Chief, Livestock Officer, Ministry of Agriculture
- Mr. Birkha B. Chheti, General Secretary, Association of Bhutan Industries
- Ms. Sonam Pem, Project Director, Tarayana Foundation
- Ms. Roseleen Gurung, Project Officer, Tarayana Foundation
- Mr. Dawa Chhoedron, Deputy Executive Engineer, Renewable Energy Division, Department of Energy, Ministry of Economic Affairs
- Mr. Chhimi Dorji, Deputy Executive Engineer, Hydro Meteorological Service Division, Department of Energy, Ministry of Economic Affairs
- Ms. Jigme Zangmo, NEC
- Mr. Tshering Tashi, NEC
- Mr. Karma Tshering, NEC
- Ms. Sonam Lhaden Khandu, Climate Change Unit, NEC
- Mr. Sonam Dagay, Climate Change Unit, NEC.