CHAPTER: 3

GREENHOUSE GAS INVENTORY

Photo by State Trading Organisation

Maldives first greenhouse gas inventory was compiled for the year 1994 as part of the first national communication. The second inventory was compiled as part of the second national communication where the inventory for the year 2011 was presented.

According to the 2/CP.17, the BUR should cover an inventory for no more than 4 years prior to the submission year. Therefore, this BUR will cover the inventory for the year 2015. However, attempts are made to cover a time series of the inventory for the years 2011 to 2015 based on a sectoral approach while 2001 to 2015 emissions are also calculated based on a reference approach.

3.1 INSTITUTIONAL ARRANGEMENT FOR THE INVENTORY COMPILATION

The arrangement in place for the preparation of the BUR is described under the institutional arrangement in Chapter 2 of this report.

3.2 INFORMATION & DATA SOURCES

The sources of data information used is similar to the data sources used in the previous inventory as the key categories are similar and is provided in Table 7.

Table 7: Summary of data sources

Sectors	Data Sources
Electricity production	Energy balance reports 2010-2012 Power production data from STELCO and FENAKA Power production data from MACL Power production data from Regional airports Power production data from MWSC Power production from resorts (limited data) Tourist bed-nights from tourism statistics year books Population data from National Bureau of Statistics
Aviation data	Fuel sold statistic from MACL Fuel import and re-export data Customs
Transport (land and marine)	Vehicle and vessels registration from National Bureau of Statistics Resort transport from resorts (limited data) Tourist bed-nights from tourism statistics year books
Other energy usage	Energy balance reports 2010-2012 LPG usage from Maldive Gas and Villa Gas LPG import from Customs LPG resort usage from Carbon Audit 2009
Waste	North Province Regional Waste Management Project: Technical and Financial Feasibility Report (2011) Malé waste audit 2008 Population data from National Bureau of Statistics Assessment of solid waste management practices and its vulnerability to climate risks in Maldives Tourism Sector, 2013

3.3 EMISSION YEARS COVERED UNDER THIS BUR

Table 8: Years of emission estimates made in this BUR

Approach	2001 – 2010	2011	2012	2013	2014	2015
Reference approach	✓	✓	✓	✓	✓	✓
Sectoral approach		✓	✓	✓	✓	✓

As a part of this BUR, emissions in the following years are covered using the approach described in Table 8. However, as per the decision of 2/CP.17, the inventory for the year 2015 is discussed in detail for this BUR.

Emissions from the energy sector for the years 2001 to 2010 was calculated using the reference approach as sector data was not available for that duration. However, from 2011 onwards, emissions were estimated using both the sectoral and reference approach

3.4 ARCHIVING AND DOCUMENTATION

Since the Second National Communications, efforts have been made to collect and archive the data for inventory calculations in a systematic manner. With this BUR process, stakeholders have been informed on the importance of collecting the data, quality control of the data and archiving of data. Some of the stakeholder informed that some of their data are made available on the public domain and other detailed information could be provided on request. Stakeholders such as Customs, Airport and electricity providers have their internal databases in place where data are archived.

The datasets used for inventory preparation are archived on a central storage of the Ministry of Environment. The inventory is established using the IPCC inventory software. The database is backed up using this software. In addition to this, cloud storage facilities are also used to store the data for redundancy. Although a separate database is not developed to store the data obtained from the sectors, the raw and processed data are stored in excel sheets. The analysis sheets are documented with comments where possible, to indicate the assumptions and approximates used. In addition, the commenting feature in the IPCC software is also used to input remarks in respective fields for continuity and improvement of the inventory in the future.

3.5 OVERVIEW OF THE 1994 – 2011 NATIONAL GHG INVENTORIES

As part of the First National Communication, the first GHG inventory of Maldives was established for the year 1994. The emissions of 1994 was mainly from energy and waste sectors. Emissions from the energy sector was estimated to be 128.995 Gg of CO_2 and CH_4 emission from waste was estimated to be 1.142 Gg of CH_4. The total GHG emissions for 1994 was estimated to be 152.977 Gg of CO_2e (MHAHE, 2001).

The inventory of 2011 was established as part of the Second National Communication. shows the summary of the emissions for 2011 which was estimated as part of the 2nd National Communication. Due to availability of data, both the sectoral and reference approach was used to calculate the emissions. Emissions from energy sector was 1152.869 Gg CO_2e and that from waste sector was 72.729 Gg CO_2e using the sectoral approach. The total emissions for 2011 was 1225.598 Gg CO_2e using the sectoral approach. Total emissions from energy sector using the reference approach was 1146.512 Gg CO_2e.

As part of this BUR, efforts were made to estimate the emissions for the years 2001 to 2015 using a reference approach for the energy sector and from 2011-2015 using a sectoral approach. The emission levels are discussed under the chapter timeseries analysis.

Table 9: Emissions of 2011 (extracted from 2nd NatCom)

Greenhouse gas source and sink categories	Net CO_2 (Gg)	CH_4 (Gg)	N_2O (Gg)	Total (Gg CO_2eq)
Total National Emissions and Removals	1161.573	2.253	0.054	1225.6
1 - Energy	1146.512	0.083	0.015	1152.9
1A - Fuel Combustion Activities	1146.512	0.083	0.015	1152.9
1A1 - Energy Industries	775.820	0.031	0.006	778.3
1A3 - Transport	260.673	0.039	0.008	264.0
1A4 - Other Sectors	110.019	0.013	0.001	110.6
6 - Waste	15.060	2.170	0.039	72.7
6C - Waste Incineration	15.060	2.170	0.039	72.7
Memo Items				
International Bunkers	400.277	0.003	0.011	
1A3a1 - International Aviation	400.277	0.003	0.011	

3.5.1 Methodology

The inventory of 1994 was based on the reference approach for the energy sector and no sectoral approach was conducted due unavailability of data. CH_4 emissions were assessed from the solid waste disposal site. The inventory was based on IPCC 1996 guidelines using a tier 1 approach.

As the data availability within sectors have significantly improved compared to 1994, a better estimate was made for the 2011 inventory. The inventory of 2011 comprised of two approaches, sectoral and reference approach. The inventory for 2011 was based on the IPCC 2006 guidelines. Key category analysis using a level approach was carried to assess the key categories for the 2011 inventory. Verification of the data was done based on available literature from respective sectors, statistical data and internal stakeholder's interviews where ambiguities were identified within the data.

IPCC default emission factors were used for 1994 and the 2011 inventory.

For the years 2001 to 2010, emissions estimates were calculated using a reference approach for the energy sector. Fuel import data was made available by the Customs Authority and this was used as the primary energy source which was used in the reference approach.

3.5.2 Recalculation of inventories

If there is a change in the methodology, new data sources become available, change in assumptions used or changes in emission factors used, the previous inventories established needs to be recalculated for consistency and comparability. In this BUR, inventory of 2011 was recalculated using the new data made available, the new assumptions and the approximations used to establish the 2012 to 2015 inventory.

Electricity production data was reviewed using the methodology explained in Annex 8.3 for the inventory of 2011. Additionally, the methodology used for emissions from waste in 2011 was based on segregated open burning. However, based on sector expert opinion, this segregation was based on old data not representative of the time and was advised to recalculated based on bulk waste open burning. In addition, there was methodological changes brought in the transportation and electricity production for calculation of emissions of 2015 which is explained in the annex. Therefore, for consistency, inventory of 2011 was recalculated for both the sectoral and reference approach. Recalculation of the 2011 inventory shows a slight increase of 5% in total GHG emissions compared to the total emissions of 2011 reported in the SNC.

3.5.3 Improvements since FNC

Since there was a long-time lapse between the inventories of 1994 and 2011, significant efforts were made to improve the 2011 inventory. Importance was given to improve the data collection procedure and the data quality. In addition, the institutional capacity to data collection, management and analysis have been enhanced. Sectoral agencies have been establishing their data collection and quality management procedures and data collection and storage platforms. They have invested in increasing the human resource capacity. Therefore, inventories since 2011 was able to perform a sectoral approach to establish the inventory. It is suggested for improvement of the subsequent GHG inventories, extra waste audits and transport usage statics to be performed to improve the emissions estimations.

3.6 OVERVIEW OF THE 2012 – 2015 NATIONAL GHG INVENTORY

As per the decision of 2/CP.17, this BUR will cover the inventory for the year 2015 in detail. Following describes the process of establishing the inventory for the years 2011 to 2015. Emissions were calculated using both the sectoral and reference approach.

3.6.1 Methodology

Emissions were not directly measured for the sectors and estimations methods were used on the activity data from the sectors. The methodology followed during the inventory process was the IPCC 2006 guidelines using the Tier 1 method. In addition, the IPCC good practice guidance was also used to ensure that the inventory was transparent, accurate, consistent and comparable and complete (TACCC). Activity data was collected from the respective sectors to compile the sectoral approach. Sectors did not have enough information to do a higher tier. There are no country specific emission factors (EF) and therefore, default IPCC emission factors are used.

Reference approach was also calculated based on import data for comparison and validation of the sectoral approach. Data was analysed and quality controlled before used in the inventory. Reference approach was also calculated based on import data for comparison and validation of the sectoral approach. Data was analysed and quality controlled before used in the inventory. Table 10 shows the method and the emission factors used in the estimations. Statistical analysis methods were used for filtering, smoothing, interpolation and extrapolation of the data where necessary. The details of the data analysis procedures used are explained in the sections below. IPCC GHG inventory software is used to estimate the final emissions. The estimated emissions of the gases, CH_4 and N_2O, was converted to CO_2 equivalent using the 1995 IPCC Second Assessment Report (SAR) Global Warming Potential (GWP) values based on effect of greenhouse gas on a 100-year horizon. The GWP values used are provided in Table 11. shows the method and the emission factors used in the estimations. Statistical analysis methods were used for filtering, smoothing, interpolation and extrapolation of the data where necessary. The details of the data analysis procedures used are explained in the sections below. IPCC GHG inventory software is used to estimate the final emissions. The estimated emissions of the gases, CH_4 and N_2O, was converted to CO_2 equivalent using the 1995 IPCC Second Assessment Report (SAR) Global Warming Potential (GWP) values based on effect of greenhouse gas on a 100-year horizon. The GWP values used are provided in Table 11.

Table 10: Method and emission factors used

Greenhouse gases sources and sink categories	CO_2 (Gg)		CH_4 (Gg)		N_2O (Gg)	
	Method	EF ($kgCO_2/TJ$)	Method	EF ($kgCH_4$/ TJ)	Method	EF (kgN_2O/ TJ)
1 - Energy						
1.A - Fuel Combustion Activities						
1.A.1 - Energy Industries						
1.A.1.a.i – Electricity Generation	Tier 1	74100	Tier 1	3	Tier 1	0.6
1.A.3 - Transport						
1.A.3.1.a.i - International Aviation (International Bunker)	Tier 1	71500	Tier 1	0.5	Tier 1	2
1.A.3.1.a.ii – Domestic Aviation	Tier 1	71500	Tier 1	0.5	Tier 1	2
1.A.3.b.i.1 - Passenger cars with 3-way catalyst						
- Motor Gasoline	Tier 1	69300	Tier 1	33	Tier 1	3.2
1.A.3.b.ii1 - Light duty trucks with 3-way catalyst						
- Motor Gasoline	Tier 1	69300	Tier 1	33	Tier 1	3.2
- Gas/Diesel Oil	Tier 1	74100	Tier 1	3	Tier 1	0.6
1.A.3.b.iii.1 - Heavy duty trucks and buses						
- Motor Gasoline	Tier 1	69300	Tier 1	33	Tier 1	3.2
- Gas/Diesel Oil	Tier 1	74100	Tier 1	3	Tier 1	0.6
1.A.3.b.iv – Motorcycles						
- Motor Gasoline	Tier 1	69300	Tier 1	33	Tier 1	3.2
1.A.3.d.ii - Domestic water borne navigation						
- Motor Gasoline	Tier 1	69300	Tier 1	7	Tier 1	2
- Gas/Diesel Oil	Tier 1	74100	Tier 1	7	Tier 1	2
1.A.4 - Other Sectors						
1.A.4.a - Commercial/Institutional (LPG)	Tier 1	63100	Tier 1	5	Tier 1	0.1
1.A.4.b - Residential	Tier 1	63100	Tier 1	5	Tier 1	0.1
4 - Waste						
4.C - Incineration and Open Burning of Waste	0.58 – oxidation fact 0.08 – frac of CO_2		6500 ($kgCH_4$/Gg Wet waste)		150 (kg N_2O/Gg Dry waste)	

Table 11: GWP used in conversion

	Methane	Nitrous oxide
Formula	CH_4	N_2O
GWP	21	310

3.6.2 Data Collection

Data collection initially was followed based on the 2011 inventory key categories. In addition, a key category analysis was done for the years 2012 to 2015 to check on the requirements for data collection. Data was obtained from existing literature for the various sectors and further it was complimented by data provided from the sectors. The sources of data used were explained in Table 7: Summary of data sources.

3.6.3 Key Category Analysis

Two methods were used to analyse the key categories for 2014 to identify the categories for 2015. A level approach and a trend assessment were carried for 2014 to determine the key categories for the inventory. The Table 12 and Table 13 shows the key categories identified for the 2015 inventory using both the methods. It shows that both the methods showed the same categories and same gases which shows more importance to be given to these sectors. Therefore, consideration on those categories were given in data collection procedures for the improvement of the inventory. The details of the sectors identified for the other years are found in the Annex of this report.

Table 12: 2011 Key category using level assessment

IPCC Category Code	IPCC Category	Greenhouse Gas	Cumulative Total
1.A.1	Energy Industries - Liquid Fuels	CO_2	0.64
1.A.3.d	Water-borne Navigation - Liquid Fuels	CO_2	0.77
1.A.4	Other Sectors - Liquid Fuels	CO_2	0.85
1.A.3.a	Civil Aviation	CO_2	0.91
1.A.3.b	Road Transportation	CO_2	0.96

Table 13: 2014 Key category using trend assessment, 2011 as base year

IPCC Category Code	IPCC Category	Greenhouse Gas	% Contribution to Trend	Cumulative Total
1.A.1	Energy Industries - Liquid Fuels	CO_2	0.29	0.71
1.A.3.d	Water-borne Navigation - Liquid Fuels	CO_2	0.08	0.93
1.A.3.a	Civil Aviation	CO_2	0.14	0.85
1.A.3.b	Road Transportation	CO_2	0.04	0.97

3.6.4 Quality Assurance (QA) And Quality Control (QC)

A significant importance was given for the quality assurance and quality control while data collection and analysis. In some of the sectors, they have their own established procedures for data collection. Minimal data checks for consistency and quality checks are carried out by the sectors. Electricity production data is the most widely collected data as power logs are kept for operation and maintenance purposes. Some of the well-established industries such as aviation industry, systems are in place for archiving on the fuel information. Where QA/QC measures are undertaken, described below are the measures used for data sources. Data was also cross referenced with the respective sectors and if any issues were identified with the data, it was discussed with the respective sectors and were re-checked for the quality. Moreover, previous trends of the data in literature were also considered and expert opinion was also sought for reassurance of the quality. Additionally, an Independent review was also conducted for quality assurances via inventory experts supported by the Global Support Programme for National Communications and Biennial Update Reports (GSP). The following explains the process used for the QA/QC from the sectors.

3.6.4.1 Electricity Production

Electricity production data from the power producers were provided in different forms. The stakeholders themselves had their own internal procedures for data quality control. Some stakeholders provided monthly data while others provided annual totals.

For the stations where fuel volume and units produced (kWh) were provided, number of units per litre (kWh/L) estimate, was used as a quality measure of the data provided. Additionally, total usage growth trend was also considered to check for consistency and outliers to further check on the data. When inconsistencies are found, the issues were further discussed with the data providers to rectify the issue. Where significant data gaps were found, proxy methods and interpolation techniques were used to fill the gaps. Statistical analysis of the long-term data sets was done to analyze on the lower and upper bound of the estimate (kWh/L). A lower bound of 2 kWh/L and an upper bound of 4 kWh/L were used to filter the data. The details of the method applied is found in the annex of this report.

For the tourism sector, limited amount of actual power production data with the bed nights capacity was provided by the tourism sector. The above thresholds were used to filter and quality control the datasets. Additionally, the quality-controlled data was used to estimate the fuel usage per bed night. This estimate was then applied to the total number of annual bed nights to estimate the fuel usage for the entire tourism sector on the assumption that fuel consumption per night is same for the entire sector. This would however be a potential source of uncertainty which needs to be further addressed in future inventories.

3.6.4.2 Aviation

Aviation fuel consumption data was provided by MACL. MACL keeps the records of fuel data provided to domestic and international usage. This data was used as the activity data. Additionally, fuel import data was obtained by Maldives Customs and STO for verification and for reference approach data. Discussions with the MACL and Customs reveal that there are differences in the density conversion factors used between the two authorities which led to some differences in the volume of the fuel reported by two authorities. Customs provided the data in terms of weight while MACL and STO provided in volume. This issue was rectified using the MACL and STO datasets as the base for input to the emissions estimations.

3.6.4.3 Transport Sector

One of the main criteria used in the transport sector is the vehicle registration data provided by the NBS. Information on the number of retired or destroyed vehicles or vessels are limited and therefore, it is assumed that all the registered vehicles provided in the statistics are in use.

For the land and marine transportation, km/day and km/litre estimates used in the previous energy balances and GHG inventories were used as there was no information on this provided by the stakeholder. This information with the number of registered vehicles and vessels were used to estimate the GHG emission for the transport sector.

The number of fishing trips by fishing vessels are provided by the NBS. The estimated fuel usage per trip used in the previous energy balances were used with this number of trips, to estimate the emissions by the fishing vessels.

In 2015, a field survey was conducted in the tourism on limited number of resorts to estimate the fuel usage for transportation in the tourism. This data was used to estimate the fuel usage for transportation per bed night and the total number of bed nights was used to estimate the emissions for transportation for the tourism. However, for the safari vessels, the estimate used for fuel usage per bed night was the estimate used in the energy balance 2010-2012 as use of fuel by the safaris were not assessed during the field survey in 2015.

3.6.4.4 Other Sectors (Fuel Combustion)

Other sectors considered is the fuel combustion activities are as follows:

Other Sectors	Diesel	LPG	Kerosene
Domestic & Commercial use		✓	
Fishing vessels	✓	✓	✓

Import data of LPG was obtained by the Maldives Customs. This data was used in the reference approach. For the activity data, information provided by the two suppliers (STO Maldive Gas and Villa Gas) were used. They provided information segregated to domestic and commercial. Use of diesel, LPG and kerosene for the fishing vessels were based on the assumption used in the 2010-2012 energy balance. Additionally, stock change information was not used as according to the suppliers, no storage is kept. As a QA/QC procedure, the total import statistics was compared with the total sales by the two suppliers where they were matched with reasonable accuracy.

3.6.4.5 Waste Sector

For the emissions produced by the waste sector, it was assumed that all the waste produced are open

burnt. Maldives do not have large land-filled sites and large-scale incineration. According to the stakeholder, limited number of studies were conducted in the past to assess the volume of waste produced by the locals and the industries. Spatial variation in the volume and type of waste produced exists within the country due to variation of the tourism and industrial activity within the country.

Previous studies conducted has attempted to assess the per/capita waste production for the greater Malé population and the atoll population. Studies conducted by Ministry of Tourism (MoTAC, 2013) provided an estimate of 7.2 kg/cap/day for tourist and a 3.8 kg/cap/day for safaris.

The estimates used for the greater Malé and the other atolls are different since the nature of waste produced is different. The estimate used for the Malé is 1.8 kg/cap/day (World Bank, 2017b). For the other atolls, the estimate used is 1.3 kg/cap/day. This estimate was based on a waste audit conducted for the establishment of a regional waste management center in the north of Maldives (Regional Solid Waste Management Zone One Waste Audit 2018, unpublished report). These estimates were used with the respective populations for the atolls and the respective bed night occupancies for the tourism sector to determine the emissions by waste sector. For quality assurance and consistency, available audits were compared and expert judgment were sought for finalizing on the estimate.

3.6.5 Uncertainty Analysis

Assessment of the uncertainty requires detailed information of the data, collection procedure, quality control measures and assumptions used in data processing and analysis used by the sectors. According to the guidelines, a combined uncertainty has to be given for the entire sector which involves combination of the individual uncertainties. However, this detailed level of information was not available from the sectors partly due to unavailability of the data and partly due to confidentiality of the data. Therefore, since tier 1 sectoral approach was used, the default IPCC emission factors and the associated uncertainty values were used in the uncertainty analysis. Year 2011 is used as the base year to determine the trend uncertainty. Uncertainty assessment was done using the IPCC inventory software. Using these default values, the uncertainty in total inventory of 2015 is 4.58% and the trend uncertainty is 4.69%. Uncertainty calculations for the other years are attached in the annex of this report.

During the inventory process, there were assumptions made in the sectors which will contribute to the uncertainty. Although the magnitude of the uncertainty was not assessed, following are the assumptions used.

Sector	Assumptions
Energy Industries (emissions from electricity generation, desalination and LPG for cooking)	Emissions factors (EF) at the power houses of the individual island vary significantly due to energy generation and transmission losses. However, individual emissions factors are not available to all the islands. Therefore, EF Tier 1 of the IPCC used in the in emissions estimations. Information on the fugitive emissions are not assessed or recorded by the sectors and is considered insignificant. Thus, this is not considered in the estimations.
Transport (emissions from land, sea and domestic air transport)	Usage of road vehicles was based small sample population and extrapolated to a larger population. This assumption was used in the 2011 inventory. Marine transport in the tourism sector is based on a small population and extrapolated to the entire sector. Marine transport assumptions used are same assumptions used in previous 2011 inventory.
Waste sector	It was assumed all waste were opened burned. Per capita waste generation figures used are from old surveys as recent field assessed surveys were not available.

3.6.6 Emission Trends

The following sub chapters analyses the emissions by sectors and by gases.

3.6.6.1 Sectoral Trends

Figure 7 shows the trend in the total emissions by the sectors from 2011 to 2015. All the sectors have a growing emission except for the Other sectors. The declination of emissions in the Other sectors is due to the declined emissions in the fisheries mobile combustion.

3.6.6.2 Emissions By Gases Trend

Table 14: Trend in the emission of gases (CO2eq) shows the trend in the emissions of the individual gases. The most dominant gas is the CO2 since most of the emissions are from the energy combustion. Emission by all the gases has an increasing trend.

Table 14: Trend in the emission of gases (CO_2eq)

Year	CO_2	CH_4	N_2O
2011	1236.97	31.79	13.00
2012	1305.99	32.37	13.40
2013	1400.01	33.42	14.09
2014	1453.55	38.85	15.81
2015	1476.89	42.27	16.88

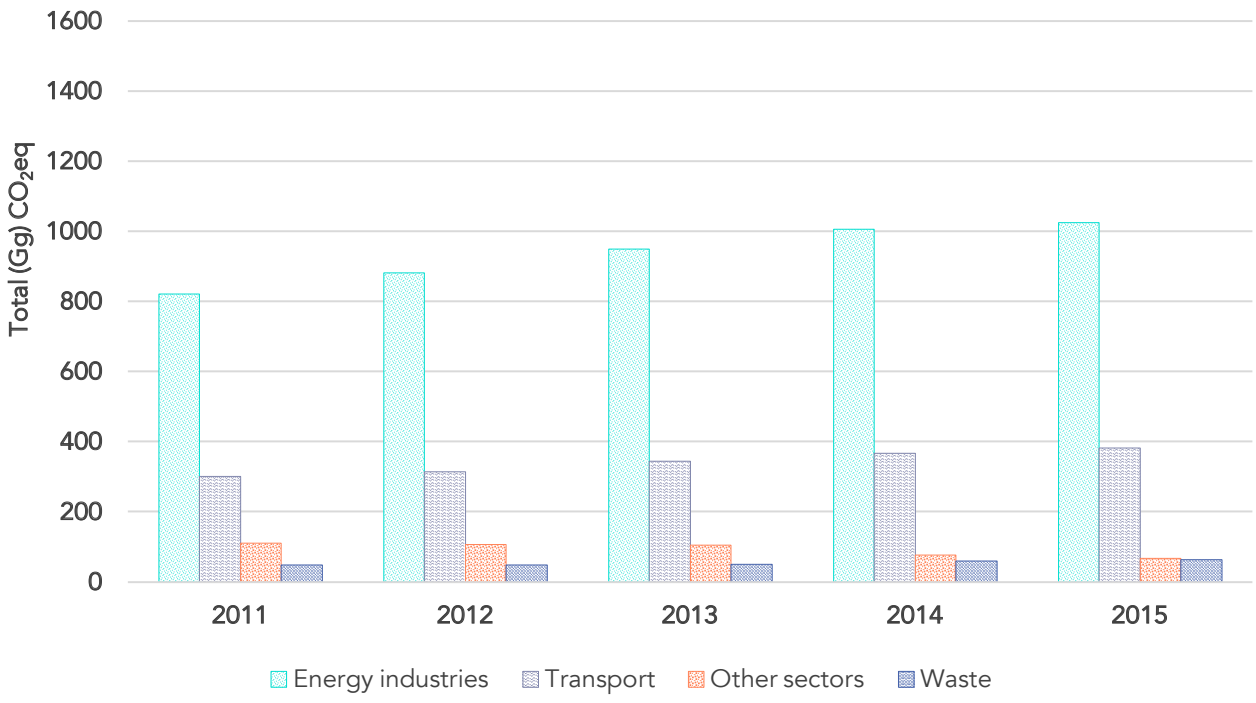

Figure 7: Emission trends by sectors

3.7 NATIONAL GREENHOUSE GAS INVENTORY OF 2015

As per the decision of 2/CP.17, this BUR will cover the inventory for the year 2015 in detail. Following describes the details of the inventory of the year 2015. The inventory of 2015 is calculated both on a reference and a sectoral approach.

3.7.1 Total Emissions

The total emissions of Maldives for the year 2015 is 1,536.04 Gg of CO_2 equivalent. A breakdown of the total emissions of 2015 is presented in Table 15. Similar to the previous GHG inventories the major sectors of emissions in Maldives is from energy and waste. Emissions from energy shares a 95.8% while waste shares 4.2% of the total emissions. Emissions from the international bunkering in presented but is not counted in the national totals. The complete tables for the years and 2011 to 2015 are attached in the annex.

Considering the contribution of greenhouse gases, CO_2 is the most emitted, sharing a 96% of the total emissions while CH_4 is 3% of the total emissions as shown in the Figure 8.

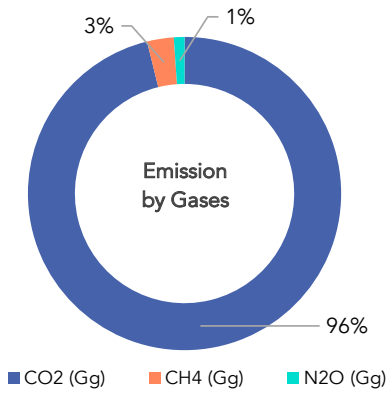

Figure 8: 2015 emissions by gases

Table 15: 2015 emissions by sources and sinks

Greenhouse gases sources and sink categories	CO_2 (Gg)	CH_4 (Gg)	N_2O (Gg)	Total (Gg) CO_2eq
Total National Emissions and Removals	1476.887	2.013	0.054	1,536.04
1 - Energy	1463.635	0.104	0.020	1472.05
1.A - Fuel Combustion Activities	1463.635	0.104	0.020	1472.05
1.A.1 - Energy Industries	1020.502	0.041	0.008	1023.93
1.A.3 - Transport	376.095	0.056	0.012	380.8
1.A.4 - Other Sectors	67.038	0.007	0.000	67.27
4 - Waste	13.252	1.909	0.034	63.99
4.C - Incineration and Open Burning of Waste	13.252	1.909	0.034	63.99
Memo Items				
International Bunkers	320.202	0.002	0.009	
1.A.3.a.i - International Aviation (International Bunkers)	320.202	0.002	0.009	323.03

3.7.2 Emission by sectors

Emissions by sources and sinks shows that emissions are from energy and waste. Figure 9: Emissions by sectors shows the breakdown of emissions by sectors. It shows that 67% of the emissions is from energy industries which is electricity generation. Next largest is transportation which is 25% of the total emissions. Emissions from waste is 4% and from Other sectors is also 4% of the total emissions. Following provides a description of a breakdown of the IPCC sectors.

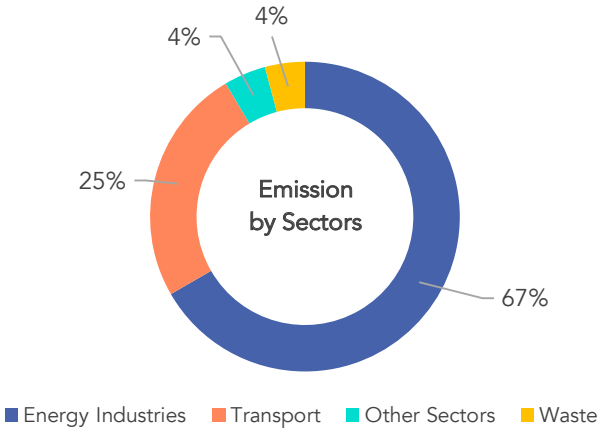

Figure 9: Emissions by sectors

3.7.2.1 Energy sector

Almost all of the power generation in Maldives is from diesel-based fossil fuel. Every island and every resort have their own power facility. With the growing population and growth in economic industries, the demand for power production is increasing. There are two state owned companies, STELCO and FENAKA who provides electricity services. Resorts and large industries have their own power generation facilities. The following sub-chapters provide a description of the sectors contributing to the energy sector.

3.7.2.1.1 Electricity Generation

Emissions by energy industries is the largest contributor to the national emissions and it is mainly fuel combustion for electricity generation. Figure 10: Emissions from electricity consumption by sectors. shows a breakdown of the electricity generation. It shows that 47% of the emissions is from the tourism sector while a 26% of the emissions is from residential use. The residential use includes electricity production for household uses for all islands. Commercial use (excluding tourism) shares a 15% of the emissions by electricity production. A total of 1023.93 Gg of CO_2 equivalent is emitted from electricity production.

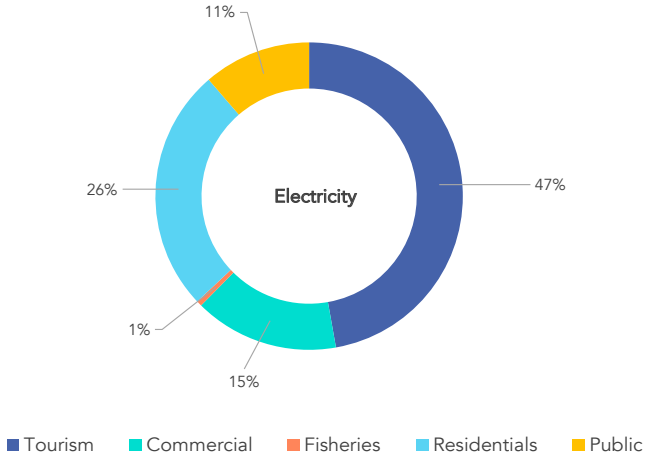

Figure 10: Emissions from electricity consumption by sectors.

3.7.2.1.2 Transport sector

Second largest energy consumption is from transportation. Due to the dispersed nature of the islands, main mode of transport is via either diesel or petrol based sea transport. Land transportation involves cars, buses, lorries and a significant amount of motor bikes. There are no railways in Maldives. In recent years number of domestic airports has increased and domestic air transfer is also getting as a popular mode of transport.

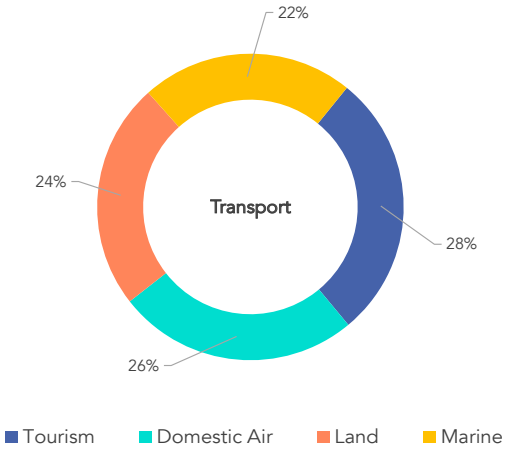

Figure 11: Emissions from the transport sector

A total emission of 380.84 Gg of CO_2 equivalent is emitted from transport sector. Figure 11 shows the breakdown of emissions from the transportation sector. It shows that 28% of the emissions is from the tourism (passenger, leisure, safari) and the second largest is from domestic air transportation while 24% and 22% is from land and other marine transportation respectively. With the increase in number of resorts and domestic airports, the largest share from these sectors is envisaged.

3.7.2.1.3 Other sectors

Energy combustion in Other sectors are from as those explained in 3.6.4.4. Largest emission (43%) is from fisheries mobile combustion. Second largest is the LPG usage by the residential use, which is 30% and tourism sector LPG usage contributes to 27% of the emissions as in . A total of 67.27 Gg of CO2 equivalent is emitted from Other Sector usage

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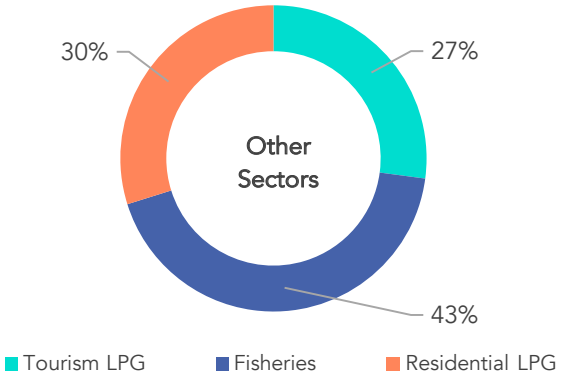

Figure 12: Breakdown of emissions from Other sectors

3.7.2.1.4 Manufacturing and construction

This sector involves emissions from energy intensive, manufacturing and construction industries due to direct fuel usage for the processes. Maldives does not have high energy intensive manufacturing and construction industries such as sugar production, textiles, Aluminum etc. therefore, emissions from this sector is not estimated.

3.7.2.1.5 Fugitive emissions

Fugitive emissions are emissions which occur as leaks or other unintentional or irregular emissions. Most common examples include emissions from storage, venting and flaring at oil and gas refineries. The most likely fugitive emissions in Maldives is due to fuel storage. However, according to the stakeholders responsible for fuel storage, they do not measure this as this will be a negligible amount due to small storage capacity and due to quick roll over of the volumes. Therefore, emissions for this category is not estimated.

3.7.2.1.6 International bunkers

International bunkering in this BUR is counted as the fuel used on international flights. Emissions from international bunkering is not counted in the national total emissions although it is reported separately.

3.7.2.1.7 Reference and sectoral approach

For comparison purposes, the emissions were also calculated using the reference approach. Table 16 shows the comparison between the reference and sectoral emissions for 2014 and 2015. On the individual fuel types, emissions by motor gasoline it shows a significant difference between the reference and sectoral approach. In 2014 its more by 13.92% and in 2015 it is less by 11.7% compared to sectoral approach. This could be attributed to the fact that some fuel imported and counted as emission in reference approach in a given year could be utilized in different sectors in the next subsequent year which would be counted as the activity data in the sectoral approach.

It was indicated by the customs that there could be time lags of recording the fuel import. Most of the motor gasoline is used in the marine and land transportation. The approximations and the estimate statistics needs to be revised or revisited to improve on the emissions on this sector. Considering the overall emissions, reference approach is +4% and -4% less than emissions from sectoral approach in 2014 and 2015 respectively.

3.7.3 Waste

With the growing population, management of solid waste has been a big environmental issue. Waste produced are disposed and open burnt. Waste segregation is not a common practice at household although a minimal sorting is done at waste management centres. Waste generated in Malé City, nearby island and most of the resorts are transferred to Thilafushi island where waste is open burnt. To manage the waste, waste management centres are being established on the islands and regional waste management centres are also being established. Emissions from waste sector considered in this BUR is due to open burning. Emissions from anaerobic decay in waste dumping sites are not estimated as the waste is pre-burned and due to mixing with salty high-water table.

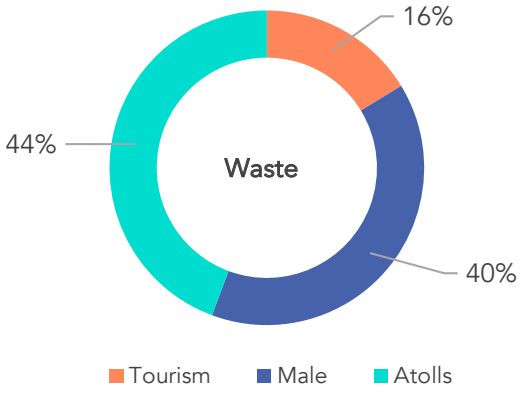

Figure 13: Emissions contribution by the waste sector

A total of 63.99 Gg of CO_2 equivalent is emitted from the waste sector. Figure 13 shows the breakdown of the emissions from the waste sector. Most of the emissions (44%) from the waste is generated by burning of waste in the atolls. Greater Malé composes of 40% while emissions from tourism sector is 16%.

Table 16: Reference vs sectoral approach 2014 and 2015

	Reference Approach		Sectoral Approach		Difference	
Fuel	Apparent Consumption (TJ)	CO_2 Emissions (Gg)	Energy Consumption (TJ)	CO_2 Emissions (Gg)	Energy Consumption (%)	CO_2 Emissions (%)
2014						
Motor Gasoline	1985.68	137.61	1743.03	120.79	13.92	13.92
Jet Kerosene	1260.09	90.10	1311.67	93.78	-3.93	-3.93
Gas/Diesel Oil	16633.55	1231.99	16027.09	1187.61	3.78	3.74
Liquefied Petroleum Gases	645.93	40.74	616.04	38.87	4.85	4.80
2015						
Motor Gasoline	1652.06	114.49	1871.01	129.66	-11.70	-11.70
Jet Kerosene	1258.07	89.95	1340.29	95.83	-6.13	-6.13
Gas/Diesel Oil	15690.38	1162.13	16181.50	1199.05	-3.04	-3.08
Liquefied Petroleum Gases	637.37	40.20	615.47	38.84	3.56	3.50

3.7.4 Industrial Processes and Product Use (IPPU) sector

Emissions from the IPPU consists of emissions released due industrial applications that involves physical or chemical process producing emissions or use of products that contains greenhouse gases which are released in to the atmosphere. For example, cement, lime, glass production are industries where emissions are produced during the process. Maldives do not have any of the industries which are categorized as IPPU sector. Therefore, emissions for this sector is estimated.

3.7.5 Agriculture, Forestry, and Other Land Use (AFOLU)

Emissions from AFOLU involves emissions from the use of agricultural land, husbandry, land use and land use changes. Maldives do not have large scale agriculture and husbandry farming. In addition, there are no large-scale forests to be cleared for land use. Therefore, emissions from this sector is not estimated.

3.8 TIME SERIES OF GREENHOUSE GAS EMISSIONS

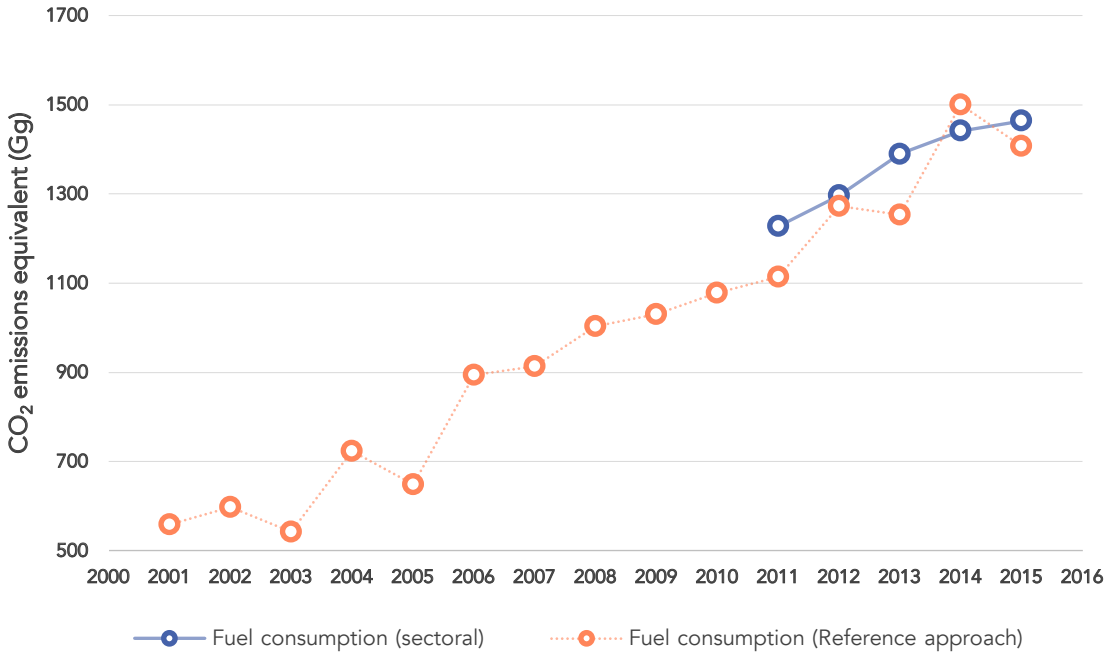

Figure 14: Timeseries of CO_2emissions (excluding waste) reference vs sectoral approach.

Under this BUR, an attempt was made to establish a timeseries of emissions from 2001 to 2015. Since reference approach level data was available for this duration, a complete time series data was established. In addition, for comparison and due to availability of sectoral data, time series was also established from 2011 to 2015. An inventory of 2011 was available which was completed in the Second National Communication. However, with some changes in the assumptions and methodology used in this BUR, it was recalculated for consistency and comparability. Reference approach excludes emissions by waste.

Figure 14 shows the timeseries of CO_2e emissions from fuel consumption with reference approach and sectoral approach. The proximity of the two profiles indicates that the emissions from both the methodologies are in agreement with reasonable accuracy. Except for two years (2011 and 2013, where the difference is within 10%) the difference is less than 5%.

Figure 15 shows the timeseries of the total GHG emissions from 2011 to 2015. The first inventory emissions reported in the FNC was for the year 1994 where the total emissions were 152.977 Gg of CO_2 equivalent. Considering this emission, the national total GHG emissions is on an increasing trend with an annual rate of 11.61%.

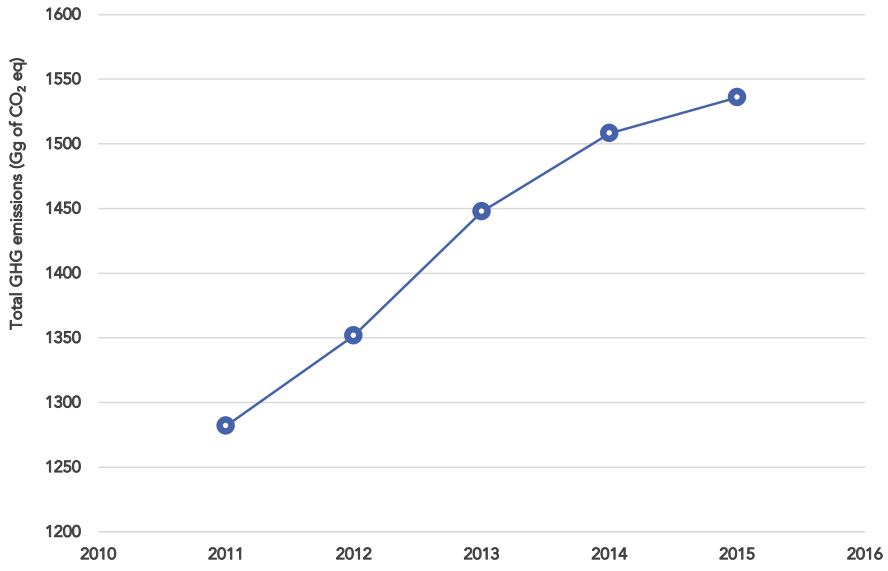

Figure 15: Time series of total GHG emissions in sectoral approach

3.9 SUGGESTIONS FOR IMPROVEMENT OF THE GREENHOUSE GAS INVENTORY

With the start of the BUR process, a great importance was given to improve the consequent GHG inventories. The first national inventory of 1994 was compiled in 2001. Since then, institutions have been improving gradually on their respective process of data collection and archiving for the respective sectoral use. However, some of the data collected are not in the most desirable form to be used to estimate emissions. Some key data needed were not available or collected. These issues were also discussed with the stakeholders during the stakeholder consultation of the BUR process. Challenges and possible means to address those issues were also discussed. Based on these discussions and the challenges identified during this BUR, the following suggestions are made for the improvement of the next GHG inventory.

Some of the sectors such as transport, the estimates used are based on assumptions used in the previous inventories. The assumptions need to be revisited. Possible means to revise this would be to conduct a field survey to improve the statistic or the approximation used especially for the fuel used per km. In addition, the data on number of vehicles and vessels use needs to be further assessed to refine the assumptions on the usage pattern in urban and rural areas. The number of retired vehicles and vessels needs to be identified and recorded. In this assessment it is assumed all registered vehicles are in use and a single value for mileage is used for all vehicles. The mileage covered would be different geographically given the small sizes life styles in different parts. Therefore, if these differentiations could be made through a field assessment, the statistics used could be improved. Moreover, the vehicle type based on the type of fuel used is also based on a previous estimate and that needs to be updated.

To improve on the emissions from waste, a nation-wide waste audit needs to be carried. This will help to refine the estimate for the volume, type of waste and the ratio of waste burnt. This needs to be carried for both the residential and tourism sector to improve on the assumption used.

Power production data has been well maintained for the Malé region and the quality of the data received reflected this. In the atolls, some of the power houses needs improvements and the data received shows that this is gradually improving. Power production data from the commercial industries such as harbours, ports and some of the regional airports were not provided by the time of compilation of this inventory and is considered to insignificant compared to national power production information. This has to be reconsidered in the next inventory. For the tourism sector the assumption explained in needs to be further improved by collecting power production data from all the resorts.

Emissions in the fisheries sector showed a decline. The methodology and the statistics used needs to be revised or revisited to reflect on the changes in the fishing patterns and operation of the vessels.

Moreover, formal arrangements need to be established between sectors for data sharing. This includes legal agreements (e.g. MOUs), access to established platforms for data collection and clear clarification of mandates for data collection, handling and analysis. For further information refer to section 7.3.