NATIONAL ACTION PLAN
ON AIR POLLUTANTS

DETERMINING NATIONALLY AVOIDED EMISSIONS
2019
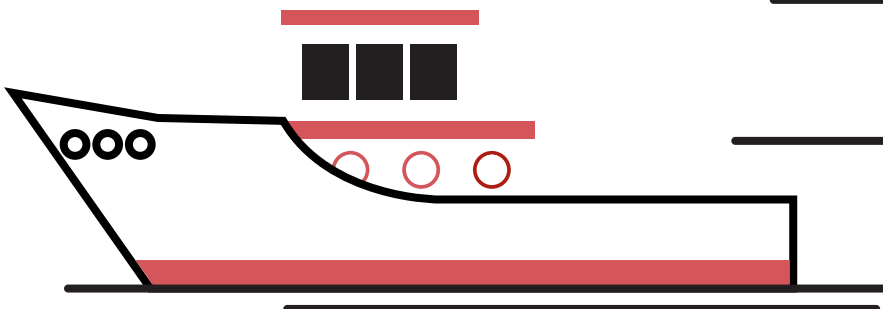
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FOREWORD

Few environmental issues so directly affect human health, and the health of the planet, as air pollution.

Until recently, scientific and political conversations around climate change and air pollution had taken place separately. Nowadays, however, it is increasingly recognized that both issues are closely linked.

Several air pollutants and greenhouse gases have common sources. Therefore designing mitigation strategies with both in mind certainly has the potential to deliver multiple benefits - by helping to achieve rapid near-term climate goals, as well as to achieve real world benefits for the ecosystem and human health.

In order to develop an integrated analysis on air pollution and climate change for this Action Plan, an air pollutant emissions inventory was compiled, which generated mitigation scenarios and estimated benefits of action. It is a significant step towards identifying science based policy decisions with regards to managing air quality.

Although clean air is a basic human right, it has also become a luxury; with nine out of ten people worldwide breathing air declared unsafe by World Health Organization standards. Maldives, a relatively small contributor to global emissions, is not immune to the effects of air pollution. In 2013, almost 90% of air pollution during the dry period in Male' was recorded from transboundary sources.

Certainly, air pollution can no longer be considered a local problem. It is very much a global phenomenon which requires international political leverage. The government of Maldives is committed to take concrete and strategic action to address the issues of air pollution to protect the environment, and safeguard human health.

ACRONYMS

BAU Business as Usual
CCAC Climate and Clean Air Coalition
CO_2 Carbon dioxide
CO_2e Carbon dioxide equivalent
GDP Gross Domestic Product
GEF Global Environment Facility
GHG Greenhouse Gas
GWP Global Warming Potential
Ha Hectare
HFC Hydroflouro carbons
IPCC Intergovernmental Panel on Climate Change
Kg Kilogram
Km Kilometer
Km^2 Square kilometer
kWh Kilo Watt Hour
WTE Waste to Energy
M Meter
M^3 Cubic meter
µg m^{-3} microgram per cubic meter air
MT metric ton (tonne)
MTPD metric ton per day
NDC Nationally Determined Contrbution
NO_x Nitrogen oxides
NO_2 Nitrogen dioxide
PM Particulate Matter
SDG Sustainable Development Goals
SEI Stockholm Environment Institute
SLCP Short Lived Climate Pollutants
SO_2 Sulphur dioxide
ToE Tons of Oil Equivalent
UNFCCC United Nations Framework Convention on Climate Change
WHO World Health Organization
WTE Waste to Energy
VOC Volatile Organic Compounds

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EXECUTIVE SUMMARY

The formulation of the National Action Plan on Air Pollutants is the first time that the reductions in air pollution have been quantified for measures originally developed with the aim of reducing greenhouse gases.

It also describes the pollutants in detail, including the emission levels of different pollutants in the Maldives, and their likely progression in the future.

The analysis shows that in general, the largest sources of air pollutants and short-lived climate pollutants in the Maldives are transport and waste sectors, with electricity generation as a source for specific pollutants. However, electricity generation is the major source of the greenhouse gas carbon dioxide, and is simultaneously a major source of sulphur dioxide and nitrogen oxides. Waste sector is the major source of methane, and is also a major source of many other air pollutants. Therefore, there is a potential for developing integrated strategies to simultaneously improve air quality and reduce the Maldives' contribution to global warming even further.

While many of the air pollutants also have a warming effect on climate, some pollutants such as organic carbon and sulphur dioxide have a cooling effect. Therefore, in order to understand the overall effect of a mitigation measure on climate-relevant emissions, it is essential to align the air pollution inventory and scenario analysis, with analyses performed for greenhouse gases.

The mitigation measures included in this Action Plan are in line with existing national plans to reduce greenhouse emissions from the key source sectors. To this end, the measures selected for this Action Plan were compiled firstly from the mitigation measures that have been included in the Maldives' long term climate goals, also known as the Nationally Determined Contributions (NDC), and then from the planned measures from different sectors which were not part of the NDC. These sectoral measures are collectively termed 'air quality measures' in comparing their effects with the NDC measures.

The NDC communicated that it intends to unconditionally reduce 10% of its greenhouse gases for the year 2030 compared to a business as usual scenario; and that this 10% could be increased up to 24% reduction in a conditional manner, contingent on the availability of financial resources.

This Action Plan demonstrates that, the full implementation of both NDC measures and air quality measures result in a reduction of carbon dioxide emissions by 28.78% in 2030. The implementation of the air quality strategy measures resulting in a small additional reduction in carbon dioxide emissions, indicates that taking additional actions to improve air quality can be done *without* increasing greenhouse gas emissions.

It also demonstrates that the full implementation of both NDC and air quality measures result in 59.3% reduction in PM2.5, 39.9% reduction in black carbon, and 26.97% reduction in Nitrogen oxides by 2030, compared to a business as usual scenario.

Importantly, for both air pollutants and greenhouse gases such as nitrogen oxides and carbon dioxides, it is the unconditional NDC measures which produce the largest reductions in emissions - signifying that it is these actions to which Maldives has pledged to achieve with existing resources, which ultimately leads to the largest reductions in air pollution and greenhouse gases.

01
INTRODUCTION

1.1 AIR POLLUTION AND THE MULTIPLE BENEFITS OF MITIGATION

Emissions to the atmosphere result in a variety of negative impacts on both climate and air quality. Alarmingly, air pollution does not consist of a single chemical substance, but a mix of several pollutants released from a wide range of anthropogenic activities and natural sources. Table 1 maps the effects of some major pollutants on human health, environment and on the climate. Hence while emissions to the atmosphere can result in a wide range of negative human health, climate and environmental impacts, it also means that developing strategies, which can reduce emissions of multiple pollutants from a particular source, have the opportunity to simultaneously mitigate multiple impacts. In addition, in many cases the implementation of these mitigation measures can also contribution to sustainable development benefits.

TABLE 1: POLLUTANTS AND THEIR IMPACTS ON HUMAN HEALTH, CLIMATE AND THE ENVIRONMENT (EC4MACS INTERIM ASSESSMENT, 2010)

	Black carbon	Particulate Matter	Sulphur dioxide	Nitrogen oxides	Volatile Organic Compounds	Ammonia	Carbon dioxide	Methane	Nitrous oxide	Hydro Flouro Carbons
Health impacts										
Particulate Matter exposure (associated with premature mortality, loss in life expectancy and a range of other non-fatal health impacts)	+	+	+	+	+	+				
Ozone (Premature mortality and non-fatal respiratory diseases)				+	+			+		
Vegetation damage										
Ozone				+	+			+		
Acidification			+	+		+				
Eutrophication				+		+				
Climate Impacts										
Long-term warming							+		+	
Short-term warming	+							+		+

Key: '+' indicating that emissions have an impact.

1.2 LINKING CLIMATE CHANGE AND AIR POLLUTION

Short-lived climate pollutants or SLCPs[1] are among those pollutants most linked with both health effects from air pollution and near-term warming of the atmosphere. The main SLCPs are black carbon, methane, tropospheric ozone and many hydrofluorocarbons (HFCs). SLCPs all warm the atmosphere but SLCPs (apart from HFCs) are also air pollutants, with various detrimental impacts on human health, agriculture and ecosystems. They persevere in the atmosphere for as little as a few days or up to a few decades, in contrast to long-lived greenhouse gases like carbon dioxide (CO_2) which can remain in the atmosphere for hundreds of years after emitted. This means that reducing SLCPs can have an almost immediate and noticeable effect on climate, and on air quality and health for those living in places where the emission reductions occur. SLCPs are responsible for up to 45% of current global warming (IGSD 2013).

The fifth assessment report of the Intergovernmental Panel on Climate Change (2013) warns that if global emissions of SLCPs continue to rise at the current rate (alongside long lived climate pollutants), there will be disastrous effects such as rapid melting of glaciers, increased frequency of extreme weather events, and increased stress on wildlife and plants, among others. The IPCC (2018) special report on 1.5 degrees of global warming similarly states that fast, ambitious actions to reduce SLCPs are needed and are complementary to fast, ambitious reductions in CO_2 and other long-lived greenhouse gases to achieve this goal. According to report 'Well Under 2 Degrees Celsius: Fast Action Policies to Protect People and The Planet from Extreme Climate Change' by Ramanathan et al, (2017); one of the three indispensable policy actions to limit global temperature rise is the fast action on SLCPs, including the implementation of the Kigali Amendment to eliminate HFCs. Eliminating warming from HFCs through the Kigali Amendment can potentially achieve up to 0.5 degrees Celsius alone in avoided warming by 2100 (Xu, Y., et al, 2013).

The development of strategies that focus on reducing SLCPs can be useful to identify those mitigation measures that can simultaneously improve air quality and mitigate climate change. These strategies achieve this by reducing SLCPs themselves, which have air quality and climate impacts, but also because in many cases the mitigation measures to reduce SLCPs also reduce emissions of pollutants and greenhouse gases that are co-emitted from the same source. Identifying the most effective measures to simultaneously improve air quality and reduce climate change can help to ensure that mitigation measures implemented to improve air quality do not increase global temperatures, and that climate mitigation measures simultaneously deliver local benefits through improved air quality.

[1] Also referred to as near-term climate forcers or NTCF in the IPCC fifth assessment report.

1.3 LINKING HUMAN HEALTH AND AIR POLLUTION

Air pollution is a major environmental risk to human health worldwide, and by reducing the levels of air pollutants countries can reduce the burden of disease from stroke, heart disease, lung cancer and respiratory diseases including asthma, both in adults and in children. Air pollutants go deep into the lungs and are taken up into the bloodstream and bodies. According to the World Health Organization, about one-third of premature deaths from stroke, chronic respiratory disease, and lung cancer as well as one quarter of deaths from heart attack are attributed to air pollution globally. In terms of health impacts associated with air pollution exposure, the World Health Organization has estimated that 7 million premature deaths are attributable to exposure to outdoor and household air pollution, including particulate matter and ground-level ozone exposure. Health impacts can result even from low levels of exposure to air pollution, signifying that any reduction in exposure would lead to benefits for human health. According to the WHO, in the Maldives, 48 premature deaths per year are attributable to air pollution exposure (World Health Organization 2016), which is approximately 25% of the number of deaths associated with smoking, according to the global burden of disease project (Vizhub.healthdata.org, 2019).

1.4 IMPORTANCE OF AIR QUALITY IN ACHIEVING THE SUSTAINABLE DEVELOPMENT GOALS

There is no headline goal on air pollution in the 2030 Agenda for Sustainable Development Goals or SDGs, which is a universal agenda for people, planet, prosperity and peace. However, air pollution is mentioned in 2 targets, under goal 3 on health and goal 11 on cities, and shares targets with other issues.

According to the national report, Data Updates on Sustainable Development Goals 2018, there is currently no mechanism established to compile data for the indicators 3.9.1 on mortality attributed to household and ambient air pollution, and 11.6.2 on annual mean levels of fine particulate matter in cities; and no nationally available indicator for these as well.

The following figure 1 by the Scientific Advisory Panel of the Climate and Clean Air Coalition (2016), demonstrates the importance of reducing air pollution and its contribution towards achieving the said goal.

FIGURE 1: THE CONTRIBUTION OF REDUCING AIR POLLUTION ON THE
PATH TO ACHIEVING THE SUSTAINABLE DEVELOPMENT GOALS. (CLIMATE AND CLEAN AIR COALITION, 2016)

1 NO POVERTY	Reducing air pollution can help families become healthier, save on medical expenses and improve productivity. Improving public health by reducing the burden of disease from air pollution also increases the resilience of populations to environmental shocks and disasters. Furthermore, improved air quality and decrease in the rate of global warming, through SLCP emissions reduction, could help reduce the rate of sea-level rise and the intensity and frequency of extreme weather events, which have been linked to air pollution climate change. This would allow vulnerable populations critical time to adapt.
2 ZERO HUNGER	Air pollution can cause crop damage and affect food quality and security. The UNEP/WMO assessment indicates that mitigating SLCPs emissions, in particular tropospheric ozone, can help avoid the loss of 52 million tons of four staple crops – maize, rice, soybean and wheat
3 GOOD HEALTH AND WELL-BEING	Air pollution is linked to respiratory infection and cardiovascular disease. It causes increases in population morbidity and mortality. Strategies to reduce use of diesel powered vehicles, and consequently reduce black carbon emissions, in cities and promote public transport from clean energy sources together with active travel (walking and cycling) can both reduce air pollution exposure and increase physical activity, thereby contributing to improved human health.
6 CLEAN WATER AND SANITATION	Pollutants such as sulfur dioxide (SO_2) and nitrogen oxides (NOx) from open fires and the combustion of fossil fuels mix with precipitation causing harmful acid rain that can compromise water quality. Untreated wastewater is also a significant source of methane emissions that contribute to the formation of tropospheric ozone, further impacting food security and public health.
7 AFFORDABLE AND CLEAN ENERGY	Electricity from renewable energy rather than fossil fuels offer significant public health benefits through a reduction in air pollution.
8 DECENT WORK AND ECONOMIC GROWTH	Air pollution impacts health, crop and forest yields, ecosystems, the climate and the built environment, with consequences for productivity and economic growth. Ambient and indoor air pollution also has negative effects on the working environment and its safety.
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE	Power generation, industry and transportation are large contributors to air pollution. A new focus on decreasing energy consumption and on improving sustainable and public transportation could progressively reduce pollution.
11 SUSTAINABLE CITIES AND COMMUNITIES	Urban areas significantly contribute to air pollution. Making cities sustainable could progressively improve the air quality.
12 RESPONSIBLE CONSUMPTION AND PRODUCTION	Chemicals released into the air increase air pollution and contribute to harmful effects on human health/ Responsible production and consumption could help to reduce these harmful chemicals.
13 CLIMATE ACTION	Combustion of fossil fuels play a key role in the process of climate change, which places food, air and water supplies at risk, and poses a major threat to human health.
14 LIFE BELOW WATER	Deposition of air pollutants on water may negatively affect its quality and life under water. It can lead to eutrophication and acidification of fresh water bodies and accumulation of toxic metals and Persistent Organic Pollutants (POPs) in fresh and marine areas.
15 LIFE ON LAND	Emissions from combustion of fossil fuels mixed with precipitation cause acid rain that poses a major threat to forests and ecosystems. Tropospheric ozone can also damage ecosystems, including forests.

1.5 AIR QUALITY IN
THE MALDIVES

Urban air pollution is a growing concern in the greater Male' region. The capital Male' (a small island with an area of 1.95 square kilometres) is extremely congested, with a population density of 78,925 people per square kilometre (in 2014). This, coupled with high-rise buildings in Male' has led to disruption of air circulation within the island. Air pollution in Male' is generally thought to stem from transport, waste and construction related activities. Continued open burning of waste in the nearby landfill island of Thilafushi also contributes to the deteriorating air quality of nearby islands.

A large seasonal impact on air quality in the Maldives was noted by Budhavant *et al* in 2015. This research provided the first year-round assessment of fine particulate matter (PM2.5), and demonstrated that even at a remote location such as Hanimaadhoo, the World Health Organization (WHO) recommended levels for fine particulate matter were breached in 36% of the observed cases.

According to their study, there was a considerable difference between the relative contribution of local pollution and long-range transboundary pollution to Male' in the southwest monsoon (the rainy season from May till December) and northeast monsoon (the dry season from January until March). The highest levels of pollution were observed in the northeast monsoon. The study also suggests that air quality in Male' is influenced by both domestic and long range transboundary sources, especially from incomplete combustion in shipping, transport and open burning of waste.

Annual average contribution to Male' PM2.5 is 30% from local sources and 70% from distant sources.
In the dry season, 90% of PM2.5 is from transboundary sources (Budhavant et al, 2015)

According to the WHO Global Data on Air Quality and Health, the annual level of PM2.5 (measured in μg/m3) exposure in Male' exceeds the WHO air quality guidelines (or what is considered the safe level of exposure) by 10%.

According to the "Male' Declaration 1998-2013: A Synthesis" report, there were significant increases over time in mean annual concentrations of NO2 and ground-level ozone in the Maldives during the period of 2003 to 2012 recorded in Hanimaadhoo. Highest levels in g/m3 of NO2 were recorded during November and the lowest was observed during June, using IVL Passive Samplers. From 2006-2012, the highest levels of ground level ozone concentrations (ppb) were recorded during September and the lowest levels measured during August. Maldives had low levels of SO2 (g/m3) throughout the year compared to other South Asian countries, with only significant levels being recorded during September, October and November from 2003 until 2012.

While transboundary air pollution has been monitored well in the Maldives, there are limited studies done on urban air quality with an absence of long term monitoring.

1.6 MANAGING AIR QUALITY
IN THE MALDIVES

Currently there is limited capacity, policies, information on, and mechanisms in place specifically for Air Quality Management. Addressing air pollution is indirectly covered in the National Environment Protection and Preservation Act, the National Solid Waste Management Bill, Waste Incineration Guideline, Concrete Batch Plant Guideline, and Vehicle Emission Standards.

The Maldives Constitution 2008 does not specifically mention air quality, however; Article 22 of the Maldives Constitution 2008 states that the State has a fundamental duty to protect and preserve the natural environment, biodiversity, resources and beauty of the country for the benefit of present and future generations, and that the State shall undertake and promote desirable economic and social goals through ecologically balanced sustainable development and shall take measures necessary to foster conservation, prevent pollution, the extinction of any species and ecological degradation from any such goals.

Enacted in the year 1993, Act number 4/93 (Environment Protection and Preservation Act) of Maldives is an act to empower the mandated Ministry to allow necessary regulations to protect the environment. Although the Act does not directly cover air quality, it confers powers on the government to terminate any project that may create an undesirable impact on the environment. Hence it is noted that the primary duty of preservation of the natural environment, biodiversity, natural resources of the country, that will have an impact on the overall air quality and climate, rests with the State.

Maldives has also ratified the Kigali Amendment to the Montreal Protocol, and will regulate and manage the import of HFCs in order to achieve the targets of the Kigali Amendment.

Air pollution control measures such as the existing Vehicle Emission Standards were developed without national data assessments and are currently not enforced.

The Regulation Number 2013/R-58 (Waste Management Regulation) was enacted in 2013 by the Ministry of Environment and Energy, under powers conferred to it under Act number 4/93 (Environment Protection Act) Section 7 and 8 to implement national policies regarding waste management. The Regulation states that hazardous waste shall not be burned under any circumstances and that waste that requires burning

shall be burnt only under circumstances where burning is necessary, and stipulates that measures to mitigate the impact of smoke must be considered.

The Waste Incineration Guideline (2016) is intended to facilitate the construction and operation of waste incinerators safely and to mitigate the adverse environmental and health impacts that may arise. This guideline should be considered minimum requirement applicable to all facilities.

Environment Guidelines for Concrete Batch Plants (2014) was formulated to guide operations of concrete batch plants in an environmentally friendly manner. It mentions that consideration should be given to the location of the plant to minimize spread of dust by natural means, such as prevailing winds, and artificial means.

The guiding principles of the Maldives Energy Policy and Strategy 2016 consists of, among others; reducing the reliance on fossil fuels through diversification of the energy sector, improving energy efficiency and energy conservation, and encouraging adoption of low-carbon and renewable technologies. The Maldives Scaling up Renewable Energy Programme Investment Plan (SREP IP) presents a plan to develop renewable energies on a large scale. The components under this plan consists of Accelerating Sustainable Private Investments in Renewable Energy Programme (ASPIRE), Preparing Outer Islands for Sustainable Energy Development Programme (POISED) and Technical Assistance for Renewable Energy Scale up Programme (TA).

The Climate Change Policy Framework 2015 urges the use of climate friendly technologies and outlines a policy on strengthening a low emission development future and ensuring energy security in the Maldives. The objectives of this policy include ensuring that transport and electricity systems have minimal undesirable impacts on the environment and society, and moving towards environment friendly modes of transport.

The current status for air quality management is summarized in Table 2.

TABLE 2: THE EXISTING FRAMEWORK FOR AIR QUALITY MANAGEMENT IN THE MALDIVES

1. Framework on legislation and policy	
Right to clean air formulated in the constitution	-
National legislation on environmental protection	-
Specific national legislation on air quality or clean air	-
National legislation/ strategy/ plan on mitigating greenhouse gases (GHGs) and/or air pollutants	+
Submitted Nationally Determined Contribution (NDC)	+
1.1 Multiple benefits of both GHG and air quality mitigation recognized in the following:	
In the National legislation on environmental protection	-
In the National legislation/ strategy/ plan on mitigating Greenhouse Gas emissions	-
In the Nationally Determined Contribution	-
In the National air quality legislation	-
2. Capacity to assess air quality	
Establishing national air quality monitoring mandated	-
Ambient air quality standards established	-
Ambient air quality standards regularly reviewed and updated	-
Ambient air quality standards linked to sectorial or national development plans	-
Compliance with ambient air quality standards assessed	-
3. Arrangements for multi-stakeholder involvement	
Existing process for multi-stakeholder consultation	+
Provisions for citizens to file appropriate action in courts	+
An authority where citizens can report concerns on air quality	+
4. National implementation measures	
Existing national air quality action plan with targets on pollutants aligned with national ambient air quality standards	-
Greenhouse gas emissions aligned with the national air quality plan	
One or more development plans include actions to prevent air pollution	+
One or more development plans include actions to prevent GHGs or SLCP emission reductions	+
Existing action plan is reviewed and updated based on:	
Updated emission inventory results	-
Scenario analysis	-
Development agenda	-
Has a national or regional emergency response plan for a high air pollution episode	-

Key: "+" existing, "-" does not exist or not available.

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1.7 MALE' DECLARATION ON CONTROL AND PREVENTION OF AIR POLLUTION AND ITS LIKELY TRANSBOUNDARY EFFECTS FOR SOUTH ASIA (MALE' DECLARATION)

In 1998, the United Nations Environment Programme, together with the Stockholm Environment Institute (SEI) drew attention to the possibility of the impacts of transboundary air pollution in South Asia. This initiative led to the adoption of the Malé Declaration on Control and Prevention of Air Pollution and Its Likely Transboundary Effects for South Asia, also known as the Malé Declaration. Its objective is to aid the process of providing a clean environment through clean air. The Declaration calls for regional cooperation to address the increasing threat of transboundary air pollution and its possible impacts.

1.8 MALDIVES CLIMATE OBSERVATORY IN HANIMAADHOO AND LONG RANGE TRANSBOUNDARY AIR POLLUTION

The Maldives Climate Observatory in Hanimaadhoo (MCOH) is an observatory for research on air pollution, climate and radiation. It is remotely located in the northernmost atoll of Maldives, about 400km to the north of Male'. MCOH is owned by the Government and jointly operated by the Maldives Meteorological Services and the MCOH international Science Team through an agreement with UN Environment.

The MCOH provides measurements of the composition of atmosphere over the Indian Ocean and is a receptor site of long-range transport of pollutants from emission regions of South Asia, Middle East and Africa. It is a key background site in South Asia and the Indian Ocean for atmosphere and climate studies in general, and particularly on monitoring how anthropogenic activities in the region are modifying air quality and climate.

The continuous measurements and studies at this observatory include characterization of aerosols and rainwater including their content of black carbon, key gas species such as ozone and carbon monoxide, aerosol

optical properties in the entire column and various aspects of solar radiation reaching the surface, a critical parameter determining the impact of pollution aerosols in brown clouds on regional climate. Black carbon is measured using the Aethalometer and automatic rain water collector; carbon monoxide is measured using the CO gas analyzer; particulate matter and total suspended particles (TSP) is measured using the high volume sampler.

The Science Team at MCOH has provided expert advice to the Maldivian government on issues relating to air quality and climate on several occasions. This includes preparing the bid for the Maldives to join the Climate and Clean Air Coalition and in preparing documents for meetings of Small Island Developing States (SIDS) group.

1.9 DEVELOPING THE MALDIVES' NATIONAL ACTION PLAN ON AIR POLLUTANTS

The Maldives is a member of The Climate and Clean Air Coalition to Reduce Short Lived Climate Pollutants (CCAC), a coalition committed to accelerating and incentivizing action to address key SLCPs. The CCAC is assisting the Maldives on 'Supporting National Planning for Action on SLCPs', to promote implementation of SLCP mitigation at the national level through integration of SLCPs into relevant national planning processes and development of appropriate decision-making frameworks. This national planning process has helped Maldives to identify pathways for the implementation of actions to reduce air pollutants and SLCP emissions.

1.9.1 OBJECTIVES

The purpose of this national action plan is to identify the effectiveness of the planned and proposed mitigation measures to reduce air pollution emissions, which are aligned with the Maldives climate mitigation targets. This National Action Plan builds on existing plans and strategies in the Maldives that include mitigation measures (that can affect air pollution emissions), but for which the air pollution emission reduction potential has not yet been evaluated.

The priority mitigation measures identified in this plan are therefore compiled from existing plans and strategies, meaning that the National Action Plan on Air Pollution is completely aligned and complementary to the Maldives existing commitments on climate change mitigation.

An integrated emissions and scenario analysis for air pollutants, greenhouse gases and short-lived climate pollutants estimates the current and future national trends in air quality, followed by the air pollution, GHG and SLCP emission reductions that could result from the full implementation of the identified air pollution mitigation measures. Finally, specific actions to increase implementation of these air pollution mitigation measures are identified, as well as actions to improve air quality management in general in the Maldives.

The overall objectives of the Plan and the planning process are:

- To develop an integrated analysis of air pollutants, greenhouse gases and short-lived climate pollutants to identify the major sources sectors of air pollutants currently, and how they are likely to change in the future.
- To identify mitigation measures in existing plans and strategies that will be effective at reducing air pollution emissions while simultaneously mitigating greenhouse gas emissions.
- To identify additional mitigation measures that could be taken to further reduce air pollution emissions.
- To quantify the multiple benefits of the identified mitigation measures for improving air quality and mitigating climate change.
- To identify possible ways to further mainstream action on air and climate pollutants into existing planning processes.
- To prioritize action and pave the way for coordinated air quality management.
To encourage planned implementation of existing plans and in creating new action in different sectors.

1.9.2 METHODOLOGY FOR DEVELOPING THE NATIONAL ACTION PLAN ON AIR POLLUTANTS

To develop the National Action Plan on Air Pollutants it was necessary to develop quantitative analysis of air pollution and climate change emissions in the Maldives to identify current sources, and to evaluate the effect of the different mitigation measures included in the plan. In addition, because of the range of sources that emit pollutants in the Maldives, engagement with a wide range of stakeholders was needed to develop this plan.

1.9.2.1 DEVELOPING AN INTEGRATED AIR POLLUTION AND CLIMATE CHANGE ANALYSIS

As part of the National Planning process, the CCAC assisted the Maldives to use LEAP (Long-range Energy Alternatives Planning) Integrated Benefits Calculator (IBC) software to start compiling air pollutant emission inventories, generating mitigation scenarios and estimating benefits of action. The key feature of the LEAP software is its low initial data requirements. It is an excellent tool for organizing, developing and analysing energy and environmental data in a wide variety of settings. This tool makes it easy to develop different policy scenarios and select best solutions based on cost benefits analysis.

While greenhouse gas (GHG) emission inventories have been developed and updated in the Maldives over the past years, there have been no emission inventories developed for air pollutants such as black carbon, fine particulate matter, organic carbon, volatile organic compounds, carbon monoxide, sulphur dioxide and ammonia. The LEAP software was used to build a national air pollutant emissions inventory, with efforts made to harmonize the data with the national GHG database.

The approach was to incorporate this process within the Ministry team involved in developing the Biennial Update Report inventory, so that the air pollutant inventory would be created in harmony with the GHG inventory; and also to make the process of updating and maintaining the air pollutant inventory more sustainable and effective. A country-specific dataset, with a complete emission inventory for the base year and baseline scenario to estimate emissions of SLCPs and air pollutants was developed in order to accommodate the necessary emission projections and mitigation scenarios. The baseline was set to the year 2010, but does not limit the addition of historical data.

While many of the air pollutants also have an effect on climate (e.g. black carbon is a warming aerosol), some pollutants such as organic carbon and sulphur dioxide have a cooling effect on the climate. Therefore, in order to understand the overall effect of a mitigation measures on climate-relevant emissions, it is essential to align the air pollution inventory and scenario analysis, with analyses performed for GHGs.

Hence the analysis developed for this National Air Pollution Action Plan not only used data from the national GHG database, but also estimated the emissions of air pollutants and GHGs in an integrated analysis. Annex A tabulates the data collected and key assumptions made in developing the dataset for the base year.

1.9.2.2 STAKEHOLDER ENGAGEMENT

The Plan was developed in collaboration with the sectors in charge of developing and executing the mitigation measures listed in the Maldives Nationally Determined Contribution (NDC). Bilateral stakeholder consultations were carried out throughout the process to identify the existing plans and for data collection.

1.9.3 CHALLENGES IDENTIFIED DURING THE FORMULATION OF THE ACTION PLAN

The following challenges were identified during the development of this plan:

- Limited data on pollutant sources, emissions and levels of air quality to subsequently identify measures to mitigate concentrations. Therefore international default data in air pollution emission factors were employed in the absence of certain local data.
- Lack of human resources and technical expertise within the government with regards to air quality management.
- Difficulty in securing commitment from stakeholders in developing and implementing new actions for the Plan. Even though air quality management is a cross-cutting issue, many stakeholders do not see the benefits of air quality in contributing towards their development goals. (Formulation of new actions without support may also lead to an absence of ownership by the lead stakeholders. This would hinder the Plan from being adopted and implemented.)
- Absence of advocacy groups with a specific interest in air quality. This may be linked to a lack of public interest, which may be influenced by lack of awareness on the linkages of air pollution and health.
- Lack of a clear framework for implementation and enforcement at (and between) authorities, including regulatory and government requirements, institutional arrangements, and enforcement procedures.
- Absence of a national policy or strategy on air quality, leading to the absence of incorporation of air quality issues within climate change policies. Air quality management and climate change mitigation strategies must go hand in hand, especially in sectors with apparent overlaps e.g.: energy, transport and waste.

In a local survey carried out for a study on Persistent Organic Pollutants (MEE, 2016a), only 11% of participants considered air pollution the biggest environmental threat to the Maldives, whereas 47% of respondents believed it was global warming.

02

EMISSION SOURCE SECTORS AND PROGRESSION OF POLLUTANTS

This chapter describes the pollutants in detail, including the magnitude of emissions of different pollutants in the Maldives currently, and their likely progression into the future. The major sources sectors of emissions of each pollutant in the Maldives such as transport and electricity generation are also identified.

2.1 NATIONAL TOTAL EMISSIONS

National total emissions were estimated from all major energy and non-energy sectors for the Maldives for all major air pollutants (nitrogen oxides, volatile organic compounds, ammonia, fine particulate matter (PM2.5), organic carbon and carbon monoxide), short-lived climate pollutants (black carbon and methane), and greenhouse gases (carbon dioxide). Table 3 displays how the national emissions of these pollutants were projected to progress over the years from 2010 until 2030 under a business as usual scenario taking into account future projections of population and economic growth in the Maldives. Table 4 shows, for the base year 2010, the pollutant emissions split by major source sectors.

In general, the largest sources of air pollutants and short-lived climate pollutants in the Maldives are the waste and transport sectors, and electricity generation for some specific pollutants e.g. SO_2 and NOx, and greenhouse gases like CO_2. This shows that several air pollutants and SLCPs have common sources, therefore designing mitigation strategies has the potential to lead to the simultaneous reduction of multiple pollutants, and greenhouse gases. Between now and 2030, emissions of key pollutants are expected to increase substantially if policy measures to reduce emissions are not implemented (under business as usual scenario), due to the growth of population and the Gross Domestic Product (GDP). The following sections describe in detail the major sources, and future projections of each air pollutant and SLCP in turn.

TABLE 3: TOTAL EMISSIONS FROM 2010 TO 2030

| | Baseline: (kMT), Summary | | | | | | | | | | | |
	Organic Carbon	Black Carbon	Particulate Matter PM2.5	Particulate Matter PM 10	Ammonia	Sulphur-dioxide	Nitrogen Oxides	Non Methane-Volatile Organic Compounds	Methane	Carbon Monoxide	Carbon Dioxide
2010	0.91	0.24	1.78	2.12	0.20	310.82	4.22	7.24	0.91	23.71	965.22
2012	0.96	0.29	1.91	2.26	0.21	319.43	4.92	8.11	0.94	27.55	985.86
2014	1.00	0.29	1.98	2.35	0.22	373.17	5.19	9.03	0.99	32.96	1,169.01
2016	1.05	0.31	2.08	2.46	0.23	409.86	5.71	10.57	1.04	41.27	1,286.98
2018	1.12	0.33	2.20	2.60	0.24	459.68	6.37	11.98	1.11	50.92	1,445.81
2020	1.18	0.35	2.32	2.75	0.26	512.95	7.02	13.34	1.17	60.46	1,616.84
2022	1.24	0.37	2.44	2.89	0.27	570.36	7.69	14.70	1.24	70.01	1,804.37
2024	1.30	0.39	2.57	3.04	0.29	630.51	8.37	16.07	1.31	79.57	2,002.66
2026	1.36	0.41	2.69	3.18	0.30	690.56	9.05	17.42	1.38	89.11	2,201.43
2028	1.42	0.43	2.80	3.31	0.32	758.70	9.75	18.77	1.44	98.64	2,433.63
2030	1.48	0.45	2.92	3.45	0.33	835.34	10.49	20.11	1.51	108.18	2,699.81

TABLE 4: NATIONAL TOTAL EMISSION OF AIR POLLUTANTS, SHORT-LIVED CLIMATE POLLUTANTS AND GREENHOUSE GASES IN 2010 IN THE MALDIVES BY SECTOR.

Branches	Organic Carbon (MT)	Black Carbon (MT)	Particulates PM2pt5 (MT)	Ammonia (MT)	Sulfur Dioxide (MT)	Particulates PM10 (MT)	Nitrogen Oxides (MT)	Non Methane Volatile Organic Compounds (MT)	Methane (MT)	Carbon Monoxide (MT)	Carbon Dioxide KmT
Fishing Trips	43.04	68.35	124.47	0.0	21.83	124.48	1,038.04	213.91	7.18	545.71	88.05
Guest Houses and Hotels	0.01	0.0	0.03	0.0	-	0.03	0.08	1.71	-	1.36	0.27
Resorts	0.19	0.0	172.12	0.0	-	0.99	2.74	58.27	0.15	46.18	9.25
Transport	69.87	75.04	172.12	3.69	75.87	172.12	1,831.90	3,451.91	46.89	17,238.43	176.24
Waste	794.60	98.01	1,477.62	168.87	75.39	1,794.25	738.81	3,407.57	831.29	5.73	-
Electricity Generation	0.75	2.50	7.46	21.75	172.10	29.86	606.49	7.46	27.99	151.16	691.40

2.2 AIR POLLUTANTS

2.2.1 PARTICULATE MATTER

The classification of particles in air by size and composition are known as particulate matter or PM. It is not a single pollutant, but made of multiple components and is produced from emissions from multiple emission sources. The different sizes of aerosols are:

 - Total Suspended Particles or TSP (aerodynamic diameter < 30 µm)
 - PM10 or course particulate matter (aerodynamic diameter < 10 µm)
 - PM2.5 or fine particulate matter (aerodynamic diameter < 2.5 µm)

The PM size affects its lifetime in the atmosphere, distribution and indoor-outdoor ratio. PM2.5 is extremely harmful to human health at high levels of short-term exposure and from prolonged exposure even to low concentrations.

PM is also among the most significant sources of air pollution affecting human health according to WHO. In 2012, the International Agency for Research on Cancer (IARC) classified the exhaust from diesel engines, which consist mostly of particles as a group 1 carcinogen for humans. PM is made up of different pollutants that are emitted from a wide variety of sources. Some sources of PM2.5 are directly emitted into the atmosphere. These include black carbon and organic carbon, which are emitted during incomplete combustion, including from the use of diesel power generation, and waste burning as is common in the Maldives. Other components of PM2.5 are formed from emissions of gases, such as nitrogen oxides, sulphur dioxide, ammonia and organic compounds. These gases react in the atmosphere to form small particles that contribute to PM2.5. Therefore, in order to reduce PM2.5 concentrations in the Maldives, mitigation strategies that target the major sources of all of these pollutants are required.

A continuous measurement of PM2.5 at the MCOH had provided a first long-term local record of PM2.5 levels in the Maldives. While this location is generally clean and far from any major local sources of air pollution, it was found that PM2.5 levels in background Maldivian air is near and many times above the recommended guidelines from WHO.

In terms of direct PM2.5 emissions (not including emissions of gases which form PM2.5 in the atmosphere, which are described in the next sub-sections), Figure 2 shows the trend in emissions by their source sectors between 2010 and 2030 under the business as usual scenario. The largest emission source of direct PM2.5 emissions comes from the waste sector. Direct emissions of PM2.5 from the waste sector come from the open burning of waste that occurs on islands such as Thilafushi. The second largest source of primary PM2.5 emissions are from the transport sector, which is split 34.86% (60.66MT) from land transport and 65.14% (11.46MT) from marine transport.

FIGURE 2: TOTAL PRIMARY FINE PARTICULATE MATTER (PM2.5) EMISSIONS IN THE MALDIVES BETWEEN 2010 AND 2032 DISAGGREGATED BY MAJOR SOURCE SECTORS

Particulate Matter. PM2.5 in MT: Baseline
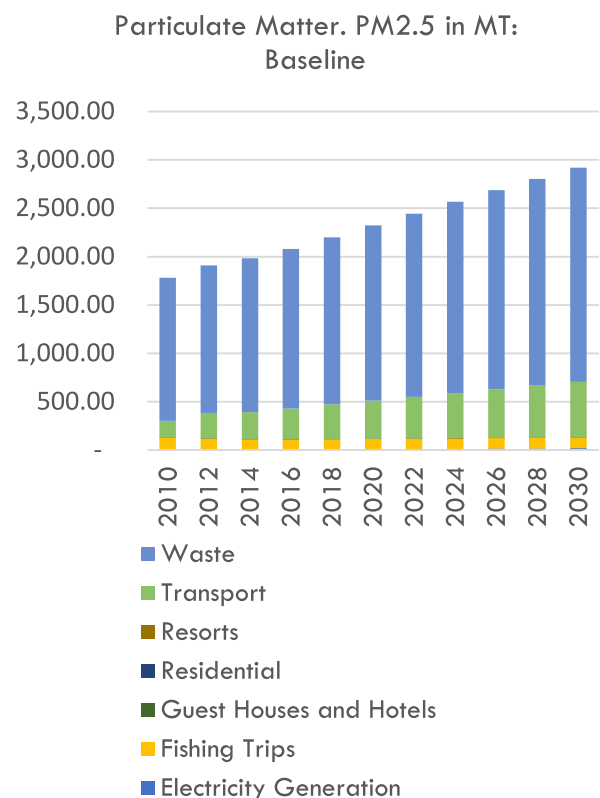
2.2.2 NITROGEN OXIDES

Oxides of Nitrogen are released from vehicle emissions, burning of biomass and forests. High levels of nitrogen oxides contribute to the formation of acid rain, which in turn damages vegetation, buildings and pollute water bodies. Nitrogen oxides at high concentrations are also harmful lung irritants and can cause respiratory diseases including bronchitis and wheezing. They also react with volatile organic compounds to form tropospheric ozone, which is toxic to human health.

Figure 3 below displays the trend of NOx emissions by source sector between 2010 and 2030 under the business as usual scenario. The greatest levels of NOx was observed from the transport sector, with a significant projected increase. Electricity generation is also a large source of NOx that is projected to increase in the future if future increases in electricity demand are met with increases in diesel use for electricity generation.

FIGURE 3: TOTAL NITROGEN OXIDE EMISSIONS IN THE MALDIVES BETWEEN 2010 AND 2032 DISAGGREGATED BY MAJOR SOURCE SECTORS

Nitrogen Oxides (NOx) . Baseline
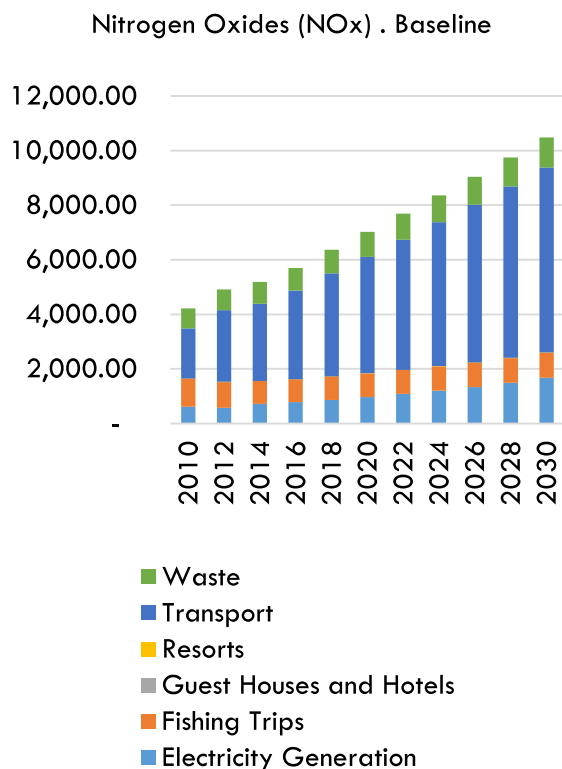
2.3 short-lived climate pollutants (slcps)

2.3.1 black carbon

Black carbon or soot, is a component of particulate matter (PM) and, therefore, behaves much differently than GHGs. It does not mix well in the atmosphere; therefore its particles remain suspended in the air until they settle back on the surface, or become washed out by rain, or contribute to cloud formation. The average atmospheric lifetime of a single soot particle is only a few days. As a dark mass, black carbon particles absorb abundant amounts of energy, trapping heat and warming the climate. Like methane, for the equivalent mass emission, black carbon warms the climate more intensely than CO_2 over a short time frame, and to greater extremes. Despite lasting in the atmosphere for a few days, one ton of black carbon has a warming effect equal to 1,000 -2,000 tons of CO_2 over a 100 - year period.

Black carbon is co-emitted with other forms of PM, some of which have significant cooling impacts that offset a portion of black carbon's full warming impact. The emissions ratio of black carbon to cooling particulates varies by source, giving some mitigation strategies (i.e. cleaner diesel engines) a greater potential climate impact. It is important to note that all PM reduction strategies, however, provide important public health benefits by reducing PM2.5 concentrations that have negative health impacts.

Black carbon emissions are the result of incomplete combustion of biomass or fossil fuels. Major sources of black carbon include biomass cooking stoves, diesel and two-stroke engines, and open-air-burning of waste. Figure 4 displays the trend in emissions of black carbon by their source sectors between 2010 and 2030 under the business as usual scenario. There is a marked increase in emissions from the transport sector noticed over the years, whereas there is a smaller increase in emissions from the waste sector. The major sources of black carbon emissions in the transport sector are from the use of diesel engines both in marine and land transport. Black carbon emissions in transport come 19.72% from land transport and 80.28% from marine transport.

FIGURE 4: TOTAL BLACK CARBON EMISSIONS IN THE MALDIVES BETWEEN 2010 AND 2032 DISAGGREGATED BY MAJOR SOURCE SECTORS

Black Carbon in MT . Baseline

Legend:
- Waste
- Transport
- Resorts
- Guest Houses and Hotels
- Fishing Trips
- Electricity Generation
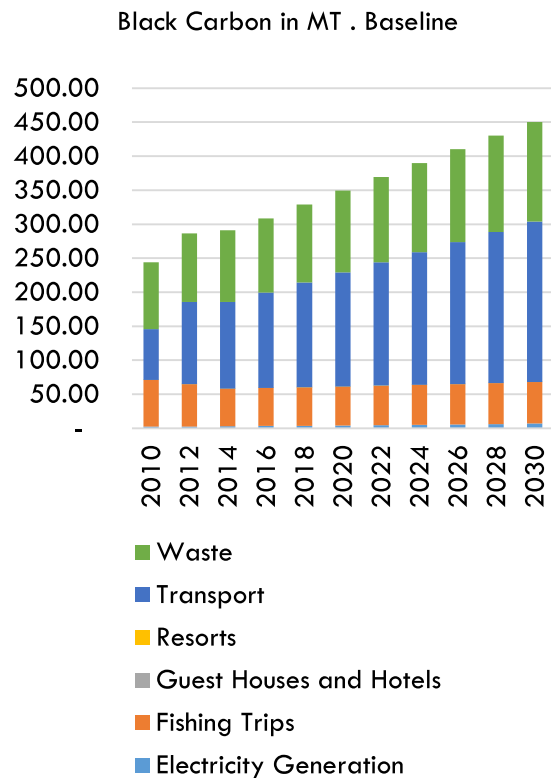
2.3.2 METHANE

Methane (CH4) has an atmospheric lifetime of 12 years, but it has significant warming potential during that time. The Global Warming Potential or GWP of one ton of methane is equivalent to 21 tons of CO_2 over 100 years and equivalent to 75 tons of CO_2 over 20 years. GWPs allow comparisons of the warming impacts of different gases by measuring how much energy 1 ton of any given gas absorbs over a period of time, compared to 1 ton of carbon dioxide. Besides having a high warming impact of its own, methane also serves as a major contributor to the production of tropospheric ozone, (which is also a short lived climate pollutant, and warms the atmosphere).

The largest contributor to global methane emissions is the production of oil and gas, and other major contributors include wastewater, landfills, and agriculture (e.g. through food and agricultural waste). Figure 5 below shows that the waste sector generates the most significant amount of methane in the Maldives, under the business as usual scenario.

2.3.3 TROPOSPHERIC OZONE

Unlike the other GHGs, tropospheric or ground level ozone (a primary component of smog) is not directly emitted. Instead, it is the product of the atmospheric reaction of a number of precursor pollutants, including methane, nitrogen oxides (NOx), volatile organic compounds (VOCs), and carbon monoxide (CO). Tropospheric ozone has an atmospheric lifetime of approximately 3 weeks. The major emission sources of ozone precursors methane and NOx are shown above. Figure 6 shows that for VOCs, which also contribute to ozone formation, the major source is the transport sector (Table 4).

Apart from affecting global warming, tropospheric ozone affects impacts evaporation rates, cloud formation, precipitation levels, and wind patterns. It also impairs the ability of plants to absorb carbon, thereby suppressing crop yields and subsequently harming ecosystems. These impacts mainly occur within the regions where tropospheric ozone precursors are emitted.

FIGURE 5: TOTAL METHANE EMISSIONS IN THE MALDIVES BETWEEN 2010 AND 2034 DISAGGREGATED BY MAJOR SOURCE SECTORS.

Methane in MT. Baseline

FIGURE 6: TOTAL NON-METHANE VOLATILE ORGANIC COMPOUND (VOC) EMISSIONS IN THE MALDIVES BETWEEN 2010 AND 2032 DISAGGREGATED BY MAJOR SOURCE SECTORS.

Non-Methane VOCs in KMT. Baseline
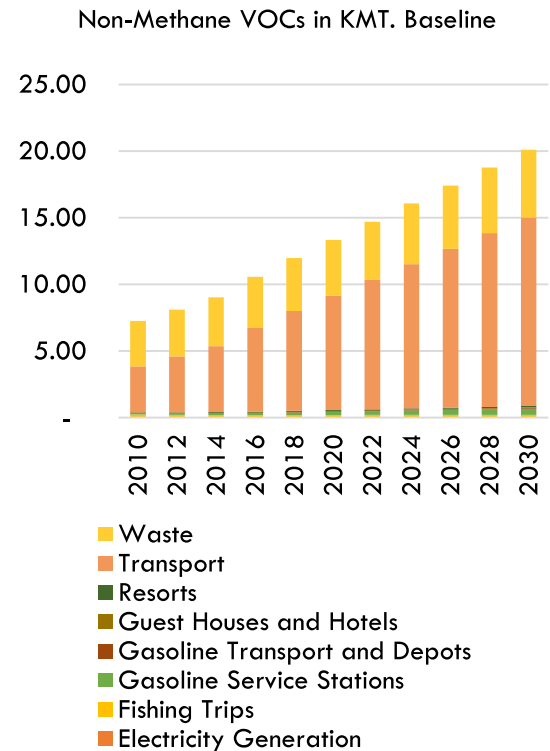
2.3.4 HFCs

Hydrofluorocarbons (HFCs) are a group of chemicals manufactured for use in refrigeration, insulation foam, and aerosols. They were created to replace ozone-depleting chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs), which were phased out as part of the Montreal Protocol. There are many varieties of HFCs, each with a different atmospheric lifetime and warming impact. The average HFC lifespan, weighted by their respective emissions, is 15 years.

HFCs are the fastest growing set of GHG emissions, on pace to double within a decade. HFC emissions can be reduced through the use of lower-GWP substitutes, coolant leakage repairs, and refrigerant reclamation programs. Most HCFCs and HFCs have GWPs that are thousands of times higher than the GWP of CO_2. For example, according to the IPCC Fifth Assessment Report, HFC-134a has a GWP of 4,800. This means that the emission of 1 tonne of HFC-134a will create the same contribution to global warming as the emission of 4,800 tonnes of CO_2.

FIGURE 7: TOTAL HFC EMISSIONS IN THE MALDIVES BETWEEN 2010 AND 2032 DISAGGREGATED BY MAJOR SOURCE SECTORS.

100-Year GWP Direct (At Point of Emissions) in KMT: Baseline

Legend:
- Waste
- Transport
- Resorts
- HFCs
- Guest Houses and Hotels
- Fishing Trips
- Electricity Generation
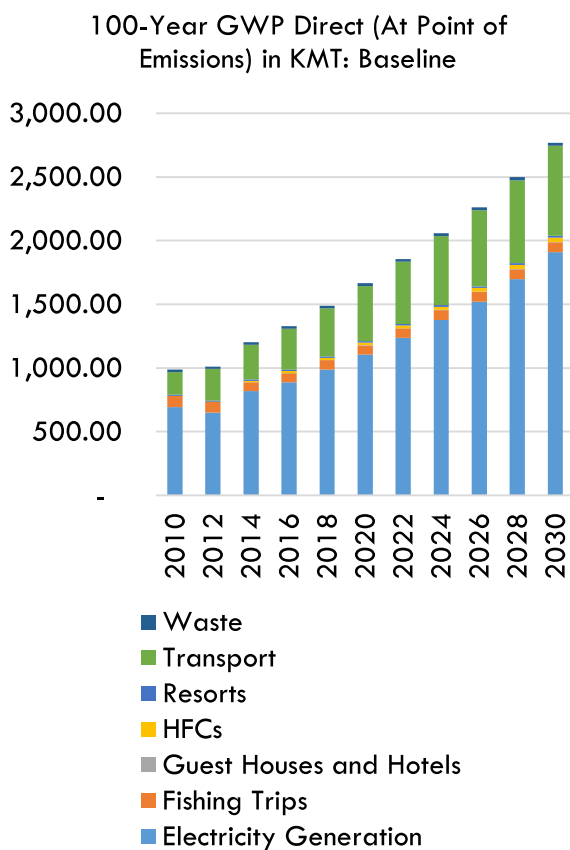
2.4 greenhouse gases (GHGs)

GHGs, which trap heat in the atmosphere, are the principal cause of climate change. Carbon dioxide (CO_2) makes up for an estimated 76 percent of anthropogenic GHG emissions globally, followed by methane and nitrous oxide. Methane emissions in the Maldives are described above as it is also a short-lived climate pollutant. CO_2 has a much longer lifetime than Methane, and remains in the atmosphere for around a hundred years.

In the Maldives, the analysis has shown that the major sources of greenhouse gases are also major sources of air pollutants. Electricity generation is the major source of CO_2, and is simultaneously a major source of SO_2 and NOx. Waste is the major source of methane, and is also a major source of many other air pollutants. Therefore, there is a large potential for developing integrated strategies to simultaneously improve air quality and reduce the Maldives' very small contribution to global warming. Like air pollutants and SLCPs, emissions of GHGs are also projected to grow substantially in the future due to increase in population, and demand for energy.

2.4.1 carbon dioxide

Fossil fuels usage is the primary source of carbon dioxide emissions globally. Figure 8 below also shows that fossil fuel use in electricity generation (mainly diesel fuel used for electricity generation) is by far the largest contributor of national CO_2 emissions under a business as usual scenario between 2010 and 2034.

FIGURE 8: TOTAL CARBON DIOXIDE EMISSIONS IN THE MALDIVES BETWEEN 2010 AND 2034, DISAGGREGATED BY SECTOR.

Carbon dioxide (Non-biogenic) in KMT: Baseline
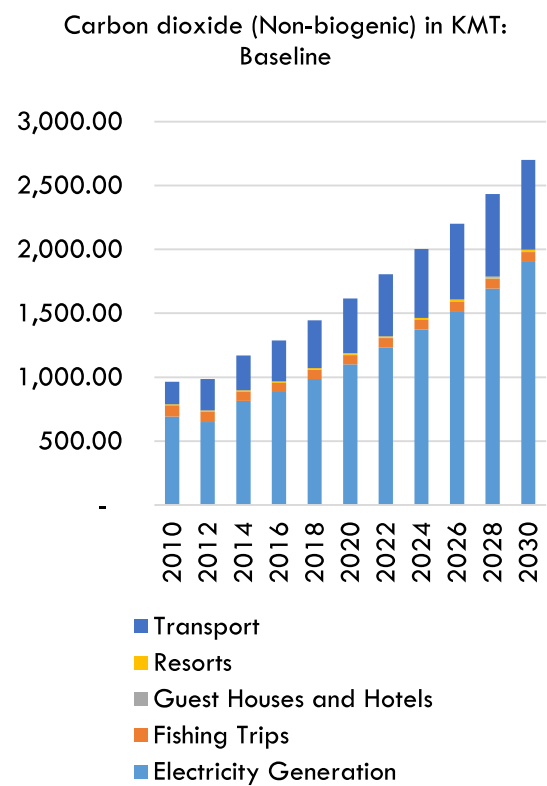
2.5 EMISSION SOURCE SECTORS

Having described the main pollutants considered in this plan in Sections 2.2-2.4 above, the major source sectors identified, specifically transport, power generation and waste, are now considered in more detail in turn in the sub-sections below.

2.5.1 TRANSPORT

Following the growth in population and urbanization, there has been a rapid increase in the number of vehicles imported into Maldives, both for land and marine transport. According to the State of the Environment 2016, the total registered vehicles have increased more than 262.2% from 2004 to 2014. The total number of vessels registered had increased from 7,016 in 2005 to 11,913 in 2014 by approximately 70% (MEE, 2014).

Energy consumption for sea transport in the atolls for passengers and goods has risen from 9 kilotonnes of oil equivalent in 2002 to nearly 50 kilotonnes of oil equivalent in 2009, and is one of the fastest growing emissions sectors in Maldives (Fenhann, J.V. and Ramlau, M., 2014). Marine transport is estimated to contribute 155 kilotonnes of CO_2 equivalent (ktCO_2e) emissions, which accounts for 12% of total greenhouse gas emissions in Maldives, and is the largest source of GHG emissions among the sub categories of the transport sector (Fenhann, J.V. and Ramlau, M., 2014).

The domestic aviation industry has also expanded and the numbers of aircrafts have increased from 40 in 2009 to 79 in 2015 (MEE, 2017). Domestic aviation in Maldives has been a considerably small sector in terms of energy consumption and GHG emissions. In 2009 the contribution of domestic aviation or air transport was just 5% of total GHG emissions in Maldives (Fenhann, J.V. and Ramlau, M., 2014). It can be foreseen that aviation fuel consumption will increase at a faster rate in the short term and then level out in the mid-term after market saturation. This is due to the new regional airports, and as tourists are increasingly switching to larger land-based flights, which consume less fuel per passenger, rather than going by seaplanes (which comparatively consume more fuel per passenger).

Not much available for the aviation sector in terms of mitigation. None of these plans and applicable laws and regulations in the Maldives requires specific measures to mitigate emissions from the transport sector as a whole.

When considering air pollutant, SLCP and greenhouse gas emissions together, the results from the analysis developed for this plan show that marine transport makes a larger contribution to emissions than road transport, but the emission estimates for marine emissions are more uncertain due to uncertainties in the emission factors for the engines used for marine vehicles in the Maldives. Road transport emissions occur in congested urban areas, and are dispersed over a smaller area. Finally, substantial growth in marine and road transport emissions is expected, if mitigation measures are not applied.

The figure 9 shows how the different transport sectors contribute to emissions of different pollutants in the base year 2010. For instance, the highest share of direct PM 2.5 emissions were contributed from the marine transport of passengers and cargo, and from road transport emissions in the greater Male area. Note that fishing vessels are accounted under Industry sector, because its under the fishing industry and not used to transport goods or passengers.

FIGURE 9: CONTRIBUTION OF TRANSPORT SECTORS TO TOTAL TRANSPORT EMISSIONS IN THE MALDIVES IN 2010

Shipping: Tourism
Shipping: Passengers and cargo
Road: Greater Male
Road: Other Atolls

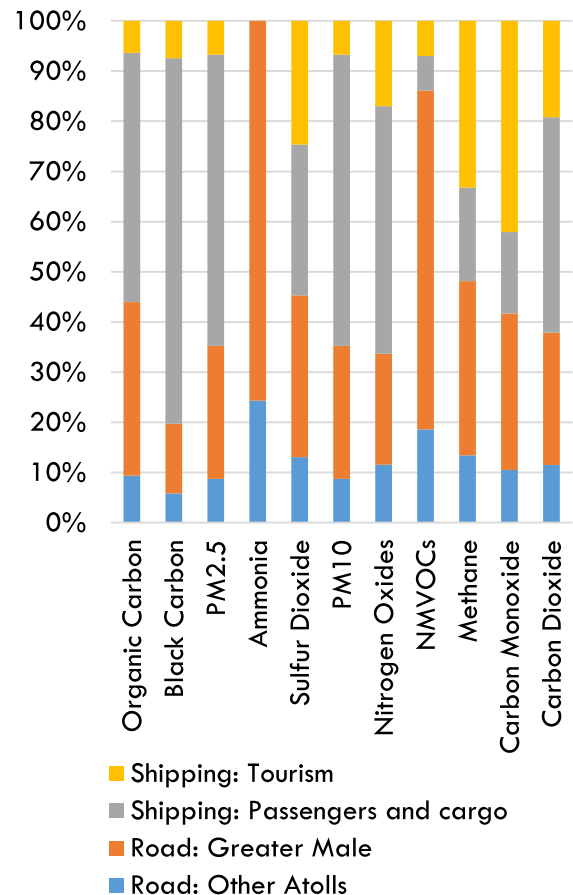Figure 10 below focuses on direct PM2.5 emissions and the emission trend for the different transport sectors between 2010 and 2032 under a business as usual scenario. Due to expected increases in economic growth and population, emissions from both marine and road transport emissions are expected to increase substantially into the future.

Particulate Matter Pm2.5 in MT: Baseline

■ Tourism
■ Passengers and cargo
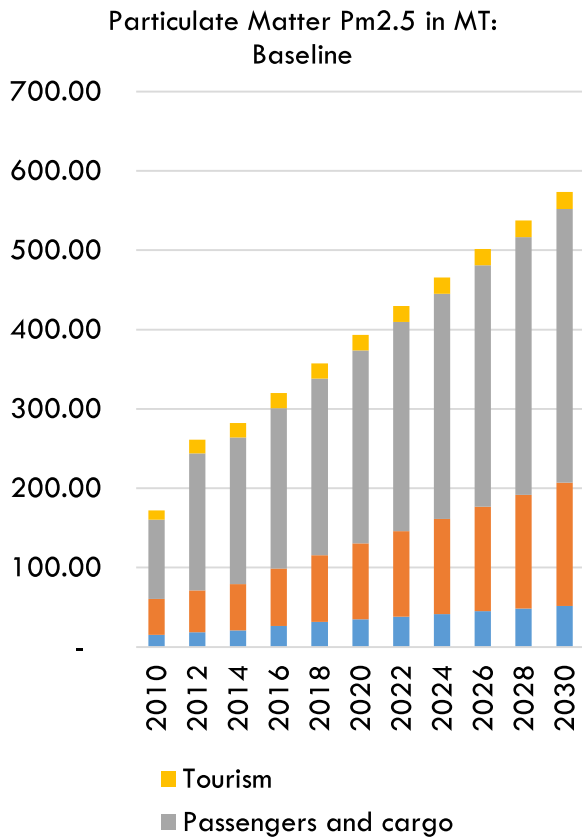
2.5.2 ENERGY DEMAND AND POWER GENERATION

Electricity generation is the fastest growing and largest consumer of imported diesel. More than 44% of diesel imported is used to generate electricity (MEE, 2017). The dispersed nature of the islands and the fact that there is no existing national grid, requires that each of the islands to have individually operated powerhouses.

The Maldives' Energy Supply & Demand Survey of 2010 reports that approximately 313 kilo tonnes of oil equivalent of electricity were consumed in the Maldives that year, of which over 80% was generated from imported diesel oil. According to that report, this 313 kilo tonnes of oil equivalent contributed to around 1.04 million tonnes of CO2 emissions in 2011. Despite the Maldives high dependence on fossil fuels, its contribution to global CO2 emissions in 2011 was less than 0.0035% (MEE, 2016).

The results from the analysis to prepare this plan shows that electricity generation is a major source of GHG emissions (71.6% of total CO2 emissions) but also a significant sources of some air pollutant emissions from use of diesel to generate electricity. The sectors that have largest demand for electricity are resorts, residential and commercial and public services. Electricity demand is expected to increase substantially into the future, with a resulting increase in air pollutant and GHG emissions without a change in the electricity matrix or action to control emissions from power generation.

Figures 12 and 13 below shows the increase in carbon dioxide and direct $PM_{2.5}$ emissions from generating electricity in the Maldives and Figure 11 shows that the projected consumption of electricity for different sectors is highest in the for the residential sector between 2010 and 2032 under a business as usual scenario, but includes a substantial contribution from tourism and commercial and public services sectors.

FIGURE 11: ENERGY DEMAND SPLIT BY DEMAND SECTOR

Energy Demand Final Units Thousand GigaJoules: Baseline

Legend:
- Guest Houses and Hotels
- Fishing Trips
- Resorts
- Industry
- Transport
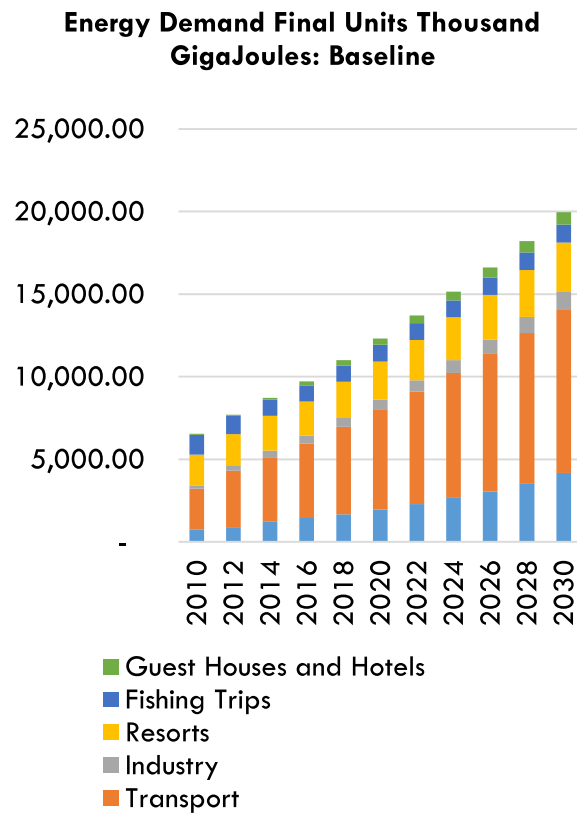
FIGURE 12: PROGRESSION OF CARBON DIOXIDE EMISSIONS FROM ELECTRICITY GENERATION.
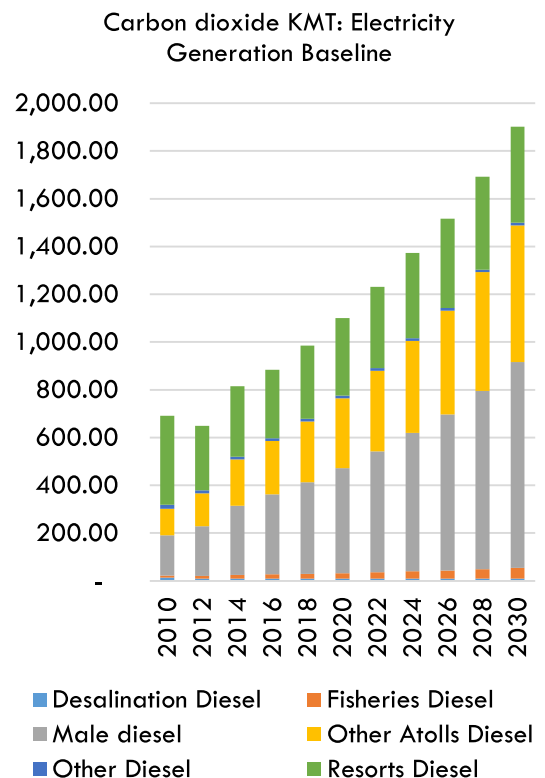
Carbon dioxide KMT: Electricity Generation Baseline

Legend:
- Desalination Diesel
- Fisheries Diesel
- Male diesel
- Other Atolls Diesel
- Other Diesel
- Resorts Diesel

Nitrogen Oxides (NOx) MT: Electricity
Generation Baseline

Legend:
- Desalination Diesel
- Fisheries Diesel
- Male diesel
- Other Atolls Diesel
- Other Diesel
- Resorts Diesel
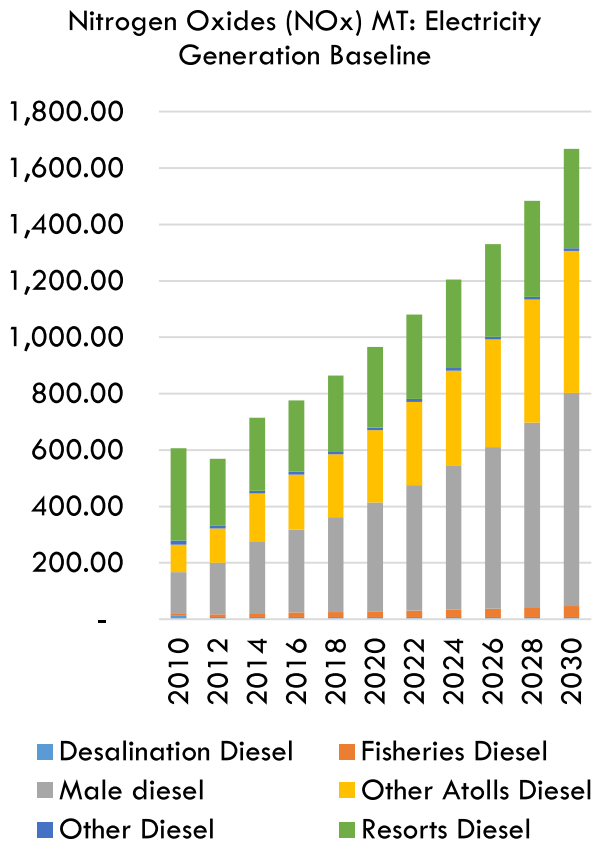
2.5.3 WASTE

The Maldivian population and an estimated one million tourists that visit Maldives every year produce large amounts of waste, with tourists producing waste nearly six times that of the local population, mostly in the resort islands and at the international airport.

Therefore, Maldives is significantly challenged to sustainably manage and reduce the amount of waste it generates. An estimated 860 metric tons per day (mtpd), or 312,075 metric tons (mt) per year, of solid waste is discarded in the Maldives, with about 21% attributed to tourism and the balance divided among urban areas (65%) and island communities (35%) (MoT, 2015).

The bulk of the waste generated in the greater Male' region is transported daily by boat to Thilafushi, an island close to Male, and deposited on land where it is openly burned. Other inhabited islands follow a similar practice of open burning and, or dumping into the open sea.

Resort islands also ship their waste to Thilafushi, or they treat their waste through methods such as local incineration and composting. While resorts are required by law to have on-site incineration facilities, the majority of resorts do not operate the incinerators that they have set up.

The open burning of waste at Thilafushi and other islands across the archipelago can release highly toxic gases that include carcinogenic substances that impact air quality and public health and additionally threatens the country's' image as an environmentally sustainable high-end tourism destination. Due to the salty nature of the soil and the salt water table close to the surface, it is unlikely that this provides for proper conditions for anaerobic degradation and hence methane emissions would be relatively small.

A survey conducted by MEE to assess Persistent Organic Pollutants (POPs) had revealed a low level of awareness on health issues associated with open burning of waste. The following are some key findings from the survey conducted for workers and occupants at Thilafushi island.

- Masks or respiratory protection was not used (even when provided).
- Some workers resided less than half a mile from the open burning area.
- Workers expressed difficulties in breathing.
- Mean number of years for workers employed at Thilafushi is 6.2 (among those surveyed).

Figure 14 below displays the projected trend in methane emissions from the waste sector between 2010 and 2032 in a business as usual scenario. Without any mitigation measures, there is a constant increase in methane emissions estimated over the years especially from incinerating waste. Figure 15 demonstrates the progression of direct PM2.5 emissions from uncontrolled waste burning over the years. From this analysis, it is clear that the waste sector is a major source of GHGs, SLCPs and air pollutants. In the waste sector, waste incineration is the dominant source of these emissions in addition to methane emissions from domestic wastewater. The expected increase in emissions if driven by expected increases in population and waste generation

FIGURE14: PROGRESSION OF METHANE EMISSIONS FROM THE WASTE SECTOR BETWEEN 2010 AND 2032
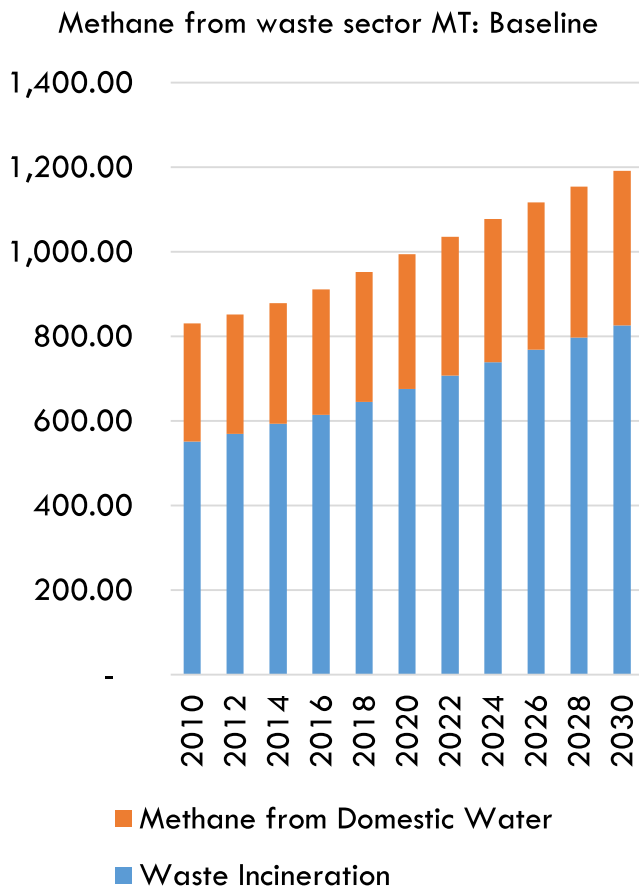
Methane from waste sector MT: Baseline

Particulate Matter Pm2.5: Waste Sector Baseline

03
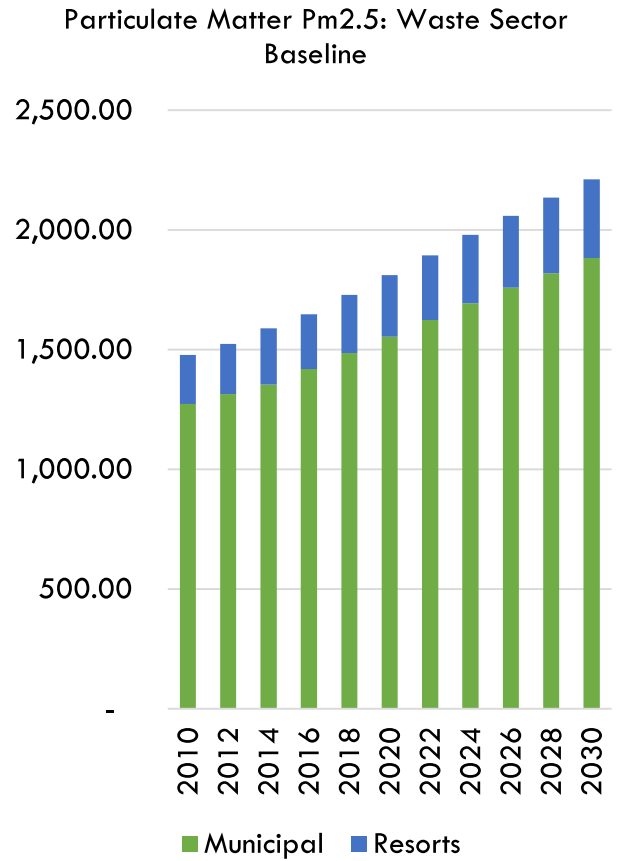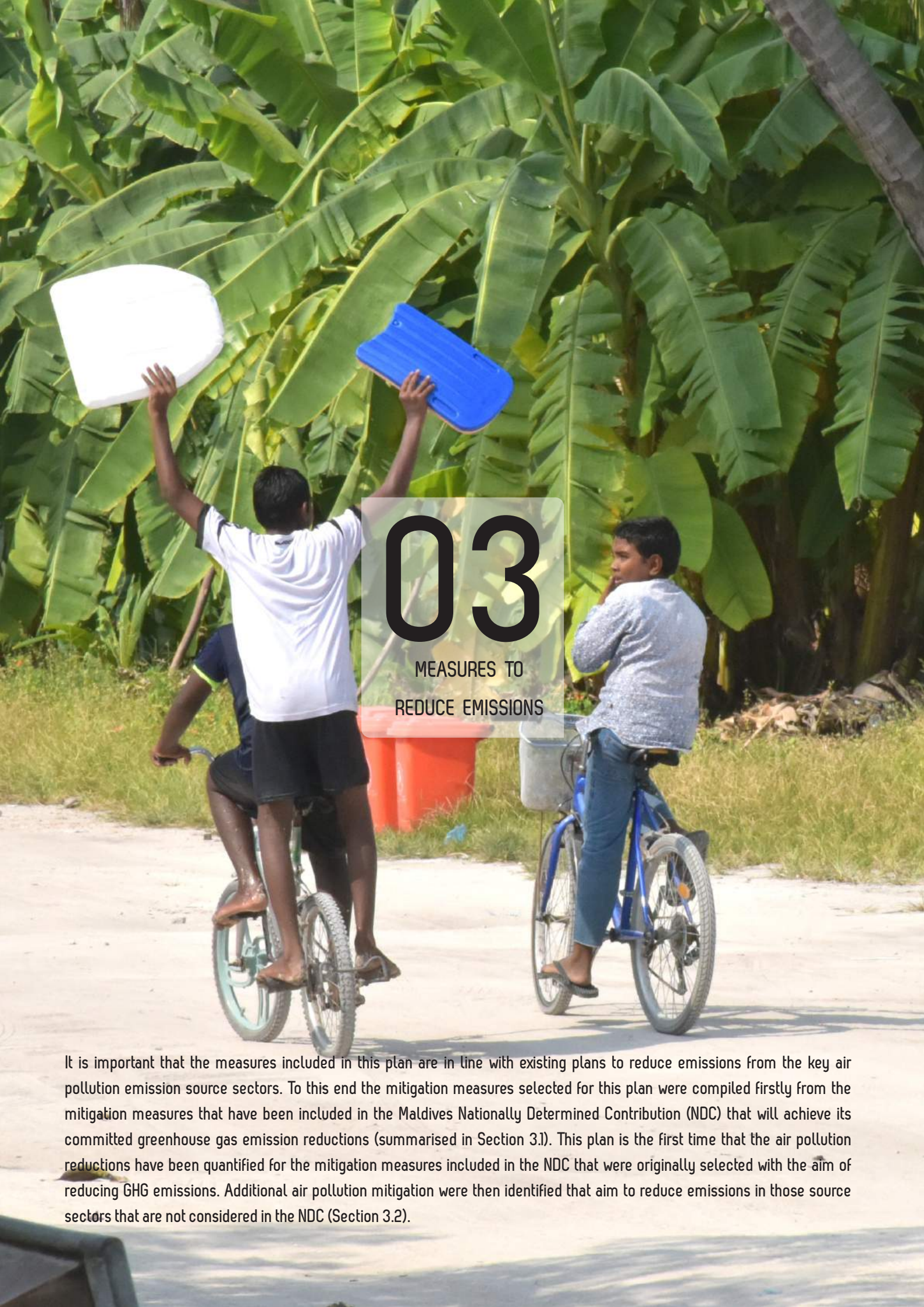
MEASURES TO REDUCE EMISSIONS

It is important that the measures included in this plan are in line with existing plans to reduce emissions from the key air pollution emission source sectors. To this end the mitigation measures selected for this plan were compiled firstly from the mitigation measures that have been included in the Maldives Nationally Determined Contribution (NDC) that will achieve its committed greenhouse gas emission reductions (summarised in Section 3.1). This plan is the first time that the air pollution reductions have been quantified for the mitigation measures included in the NDC that were originally selected with the aim of reducing GHG emissions. Additional air pollution mitigation were then identified that aim to reduce emissions in those source sectors that are not considered in the NDC (Section 3.2).

3.1 MALDIVES' NATIONALLY DETERMINED CONTRIBUTION

In the Maldives' long term climate goals, also known as the Nationally Determined Contributions (NDC), it was communicated that it intends to unconditionally reduce 10% of its greenhouse gases for the year 2030 compared to a business as usual scenario; and that this 10% reduction could be increased up to 24% in a conditional manner, in the context of sustainable development, supported and enabled by availability of financial resources, technology transfer and capacity building.

After analysing the key sectors of the economy, 22 mitigation options were presented. The following methodology was adopted in the NDC to assess the mitigation options.
- Establishing an energy balance as disaggregated as possible, based on the latest available data which was derived from 2011. The energy balance was converted to GHG-emissions for 2011 by use of IPCC conversion factors.

- Energy balance of 2011 was projected to 2030 under a BAU scenario. Under this scenario, energy services by 2030 were assumed to be produced and consumed with the same technologies and efficiencies as were assumed for the 2011 energy balance. The growth assumptions used for Maldives national planning were taken into account in developing the 2030-projection.

- Based on inter alia existing studies mitigation options in various sectors of the economy were identified and further analysis was undertaken by the "Greenhouse Gas Costing Model" (GACMO).

For each option selected, mitigation technology and baseline technology were identified and described in terms of capital costs, operational costs, energy demands and GHG emissions. These data were collected in GACMO and abatement costs per mitigation option were calculated accordingly.

TABLE 5: THE 22 MITIGATION MEASURES INCLUDED IN THE NDC THAT ARE INCLUDED IN THE
NATIONAL AIR POLLUTANT ACTION PLAN

	Source sector	Mitigation Measure (Description, Target, Timeline)	Conditional or Unconditional measure
1	Renewable energy	Install 15MW PV systems in greater Male' region : This referred to the Malé region solar PV programme involving installation of minimum 15 MW PV systems (11 MW for Malé and 4 MW for Hulhumalé) and implemented under a FIT-scheme	Unconditional
2	Renewable energy	Install additional 15MW PVs in the greater Male' region	Conditional
3	Renewable energy	PVs with net metering: Introduces solar PVs for residential applications under net metering scheme. The option assumes 1000 residential applications of 1kWp each will be implemented by 2030.	Unconditional
4	Renewable energy	PVs in outer islands: Solar PV systems will be implemented in the islands to cater for 30% of the daytime peak electricity demand of the islands.	Unconditional
5	Renewable energy	PVs in small islands, 100% solar: Under the SREP Investment Plan, 10 island grids are envisaged to be targeted full transformation to solar PVs with storage. For this option, this was extended to comprise totally 60 islands categorized as small islands.	Conditional
6	Renewable energy	PVs on resorts: Larger solar water heaters with electrical back-up has been identified as a replacement for electrical water heating at hotels and at resorts to reduce emissions	Conditional
7		Large solar water heater	
8	Renewable energy	20MW wind power and 25MW LNG: STELCO is envisaging a wind/gas hybrid system with up to 25 MW LNG plant for base load and up to 20 MW wind power.	Conditional
9	Waste-to-Energy	Thilafushi waste to energy: This project on establishment of a waste-to-energy (WTE) plant at Thilafushi with installed capacity for electricity generation of around 4 MW is envisaged under the SREP Investment Plan.	Conditional
10	Waste-to-Energy	Regional waste to energy projects: The projects on establishment of new regional waste facilities in Hithadhoo and Vandhoo are envisaged under the SREP Investment Plan. The two facilities are supposed to receive about 100 tonnes of waste per day and to jointly provide for 2 MW installed electricity generation capacity.	Unconditional
11	Energy efficiency	Upgrades of system efficiencies in diesel powerhouses: The present thermal efficiencies of diesel generators at outer islands were understood to be 26% on average and distribution losses to be 20%, hence leading to overall system efficiencies of 32%. The generation efficiency can be improved by replacement of inefficient generators, careful combination of the generators during the time of the day to match the demand of the island, and better maintenance of the generators. Similarly, the distribution losses can be improved by upgrading the grids to ensure that the correct sizes of cables and transmission equipment are being used in the distribution	Unconditional
12	Energy efficiency	Energy efficient air conditioning at resorts: replace conventional air conditioners used in the tourism sector with more energy efficient ones	Unconditional
13	Energy efficiency	Efficient air-conditioning in households: The purpose of the project is to replace conventional air conditioners used in residential areas with more energy efficient ones.	Conditional
14	Energy efficiency	Energy efficient refrigerators: For this option annual electricity demand of energy efficient refrigerators was assumed to be 0.3 MWh versus 0.86 MWh of conventional types. The entire stock in 2012 was estimated to comprise some 80,000 refrigerators of which 70% was assumed being conventional types with low energy efficiency. For the mitigation option conventional types were envisaged being replaced by energy efficient types.	Unconditional
15	Energy efficiency	LEDs for domestic lighting: Compact Fluorescent Lights (CFLs) are mainly used for lighting in households and businesses. CFLs have a useful lifetime of 6000 operating hours equalling 2.3 years. In this option all CFLs were envisaged being replaced with Light Emitting Diodes (LED) consuming 40% less electricity than CFLs and with lifetime equalling 10 years.	Unconditional

16	Energy efficiency	LED tubes for public sector: Replace conventional tubes in public service buildings with LED tubes. Replacing conventional tubes in public service buildings with LED tubes reduce energy consumed for lighting	Unconditional
17	Energy efficiency	Centralized cooling systems in new buildings: Replace conventional air conditioners used in the commercial sector with more energy efficient centralized air conditioning systems. It has been shown that such systems can reduce input energy by about 38%.	Conditional
18	Energy efficiency	LED tubes for street lighting: There are around 2200 such applications of Sodium Vapour Lamps for street lighting including 1500 at harbours. For this option, LED tubes were envisaged for all 2200 applications plus for new applications required as per the growth rate assumed for electricity	Unconditional
19	Energy efficiency	Energy efficient water pumping: Conventional pumps are envisaged being replaced with energy efficient pumps offering efficiency gains at 60% over conventional pumps.	Conditional
20	Transport	Better maintenance of motorbikes: In 2012 there were about 36,000 motor bikes on Malé and about 10,000 motor bikes on other islands. Their estimated petrol demand was around 17 million litres which may grow to 25 million litres according to growth expectation for the transport sector. For this option energy consumption was assumed to decrease by means of improved maintenance.	Conditional
21	Bioethanol	Bioethanol 15% blend in all gasoline: Follows the target in the National Strategy for Sustainable Development (NSSD) of 20% biofuel in transport in 2020. In this option we assume that 15% of the gasoline is replaced by bioethanol, in order to stay below the blend wall, the maximum amount of ethanol that can be blended given the legal and practical constraints.	
22	Biodiesel	Biodiesel 20% blend in diesel: follows the target in the National Strategy for Sustainable Development (NSSD) of 20% biofuel in transport in 2020. In this option we assume that 20% of the diesel for road and sea transport is replaced by biodiesel	

3.2 AIR QUALITY STRATEGY
AND SECTORIAL MEASURES

An draft Ministry of Environment document for air quality strategy was drawn up with a focus on the following strategies:

- Preparing and maintaining air pollutant emission inventories.
- Establishing systems to monitor ambient air quality.
- Shifting towards cleaner technologies, fuels and practices.
- Fostering research, development and impact assessments of air pollution regionally and nationally.
- Human resource development for effective air quality management.
- Global participation and collaboration for air quality management.
- Development of sustainable financing mechanisms for air quality management.

Mitigation actions within the draft air quality strategy that could be analysed using LEAP software, were included in this Action Plan.

TABLE 6: THE 3 MITIGATION MEASURES INCLUDED IN THE AIR QUALITY STRATEGY THAT ARE INCLUDED IN THE NATIONAL AIR POLLUTANT ACTION PLAN

Source sector	Mitigation Measure	Conditional or Unconditional measure
Transport	Revise and set vehicle emission standards: Where all vehicles meet the equivalent of the Euro IV emission standards by 2030, and 2. Where all vehicles meet the equivalent of Euro VI emission standards by 2030.	N/A
Transport	Develop marine engine emission standards	N/A
Energy and Transport	Set fuel quality standards	N/A

The following measures were identified as planned and/or mitigation measures from sectors, but which were not part of the NDC.

For the purpose of simplicity, these sectorial measures below were grouped as 'air quality' measures in comparing them with the NDC measures.

TABLE 7: THE 3 MITIGATION MEASURES FROM KEY SECTORS THAT ARE INCLUDED IN THE NATIONAL AIR POLLUTANT ACTION PLAN

Source sector	Mitigation Measure	Conditional or Unconditional measure
Refrigeration and Cooling	Sensitizing fisheries sector on HFC phase-down and Kigali Amendment: Prepare the fisheries sector for the introduction and diffusion of HFC alternatives	N/A
Refrigeration and Cooling	Sensitizing tourism sector on HFC phase-down and Kigali Amendment: Prepare the tourism sector for the introduction and diffusion of HFC alternatives	N/A

3.3 EMISSION REDUCTIONS FROM PRIORITY AIR POLLUTION MEASURES

The table 8 below summarizes the all the avoided emissions according to the action plan, compared with the baseline emissions.

TABLE 8: SUMMARY OF BASELINE AND NATIONALLY AVOIDED EMISSIONS

	Whole of Maldives										
	Organic Carbon (MT)	Black Carbon (MT)	Particulate Matter PM2.5 (MT)	Particulate Matter PM10 (MT)	Ammonia (MT)	Sulphur-dioxide (MT)	Nitrogen Oxides (KMT)	Non Methane Volatile Organic Compounds (KMT)	Methane (MT)	Carbon Monoxide K(MT)	Carbon Dioxide (KMT)
Baseline emissions 2030/ unit	1,476.98	450.36	2,918.17	3453.67	334.17	943.05	10.49	20.11	1,511.85	108.18	2,699.81
Air quality strategy measures (2030)/ unit	764.70	296.56	1,482.22	1740.01	174.01	295.17	8.36	15.46	1,010.03	98.60	2,621.93
NDC measures (2030)/ unit	899.28	376.93	1,891.08	2123.66	191.47	654.14	9.43	17.70	1,060.99	105.04	1,978.93
Implementation of all mitigation measures 2030	571.71	270.57	1,170.53	1278.70	113.07	224.43	7.66	14.71	831.25	98.24	1,922.59
Total emission reductions (Baseline emissions - all mitigation measures)	905.28	179.43	1747.64	2174.97	221.10	718.62	2.83	5.40	680.60	9.94	777.22
% reduction	61.29	39.92	59.89	62.98	66.17	76.02	26.97	26.85	45.02	9.18	28.79

The effect on emissions of implementing all measures (All measures), as well as the NDC measures (NDC measures, Conditional NDC, Unconditional NDC), and the Air Quality Strategy measures individually was evaluated and the emission reduction potentials for the different pollutants is shown in Figure 16-20.

For the pollutants PM2.5 (Figure 16), black carbon (Figure 17), and NOx (Figure 18), the full implementation of all measures could reduce emissions by 59.3%, 39.9%, and 26.97% in 2030 compared to the baseline scenario. Both the air quality strategy measures (related to the transport sector), and NDC measures (related to the waste sector) contribute to this substantial reduction. Hence, this plan clearly shows that implementation of the NDC measures, which are designed to reduce GHGs, will also deliver substantial reductions for air pollutants and are key to improving air quality in the Maldives. For CO_2, the implementation of all measures would reduce its emissions by 28.79% in 2030 (Figure 19). This is mainly from full implementation of the NDC measures. The implementation of the air quality strategy measures result in a small additional reduction in CO_2 emissions, showing that taking additional actions to improve air quality can be done without increasing GHG emissions. Finally, implementation of the mitigation measures in this plan will also reduce methane emissions by 45% by 2030 (Figure 20).
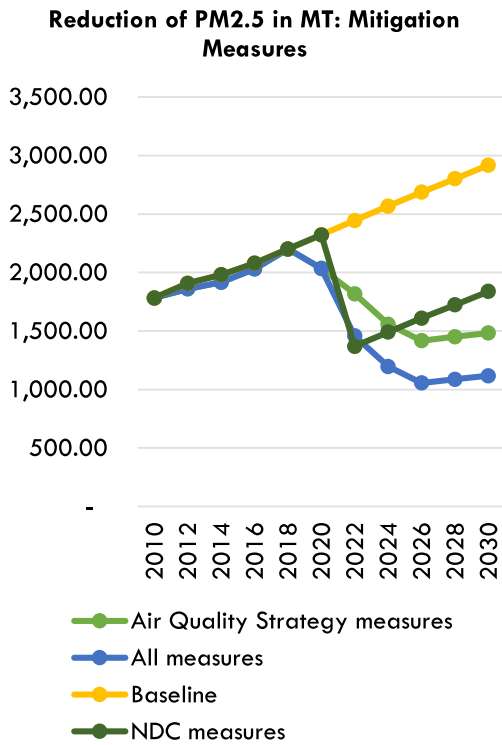
Reduction of PM2.5 in MT: Mitigation Measures

Nitrogen Oxides (NOx) Reductions MT: Mitigation Measures

Black Carbon reductions MT: Mitigation Measures
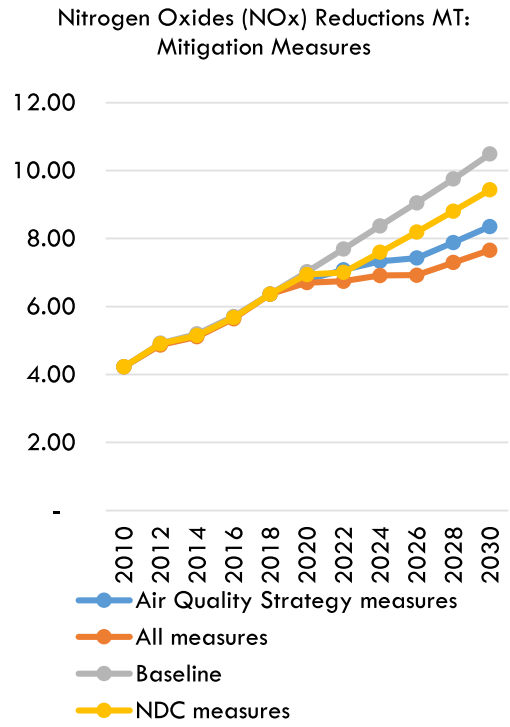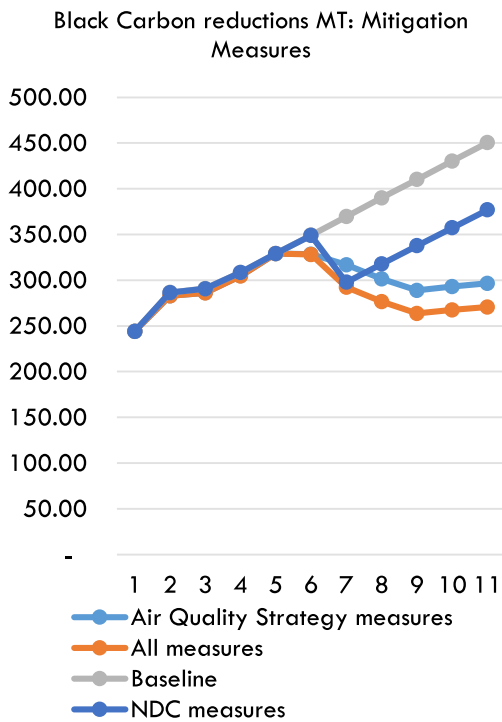
Reductions of Carbon dioxide KMT: Mitigation Measures

FIGURE 20: REDUCTION OF METHANE FROM MEASURES

Methane reductions MT from mitigation measures

Legend:
- Air Quality Strategy measures
- All measures
- Baseline
- NDC measures
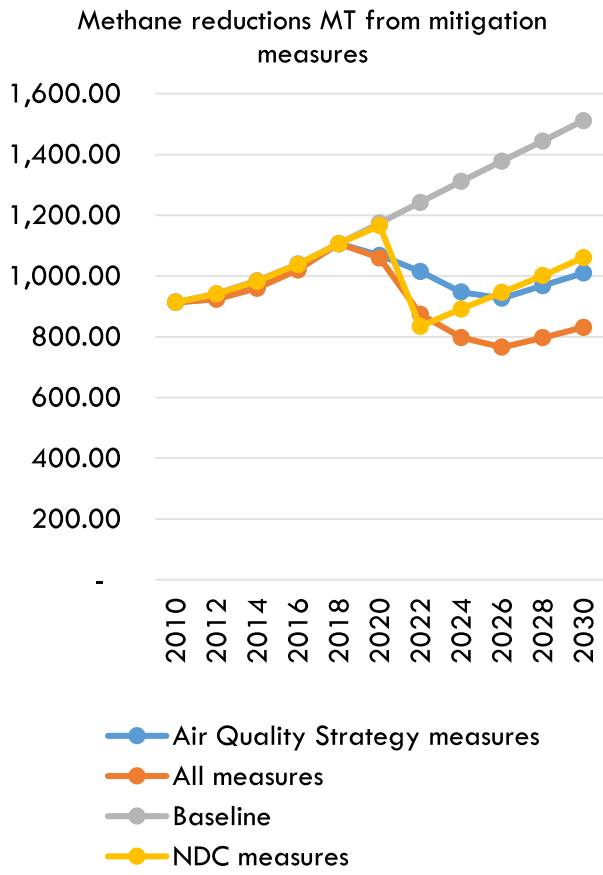
3.4 EXPECTED CHANGES IN AIR POLLUTION CONCENTRATIONS AND IMPACTS

Section 3.3 shows that the implementation of the mitigation measures included within this plan could lead to substantial reductions in emissions of air pollutants, short-lived climate pollutants and greenhouse gases. The effect that these emission reductions would have on the concentration of fine particulate matter (PM2.5) in the Maldives, and the health impacts associated with exposure to PM2.5 depends on several factors.

The first factor is the contribution of emissions from activities in the Maldives to PM2.5 concentrations in the Maldives. The magnitude of PM2.5 concentrations in the Maldives are determined not just by emissions in the country, but also by the transport of emissions from other countries, from international shipping, and from natural sources. There has been limited monitoring of PM2.5 in the Maldives, but one study, Budhavant et al. (2015) measured PM2.5 concentrations in Male' and at the Maldives Climate Observatory at Hanimaadhoo (MCOH) in 2013. Annual average PM2.5 concentrations in 2013 were 19 µg m-3 in Male', and 13 µg m-3 at MCOH; and were higher during the dry season compared to the wet season. They also calculated within the span of the year, 30% of the PM2.5 concentration in Male' was due to local pollution, and the remainder was from long-range trans boundary pollution. During the dry season, the local contribution decreased to 8% on average, and increased to 50% during the wet season. Therefore, while the implementation of the measures to reduce air pollution and SLCP emissions in the Maldives could make a substantial contribution to r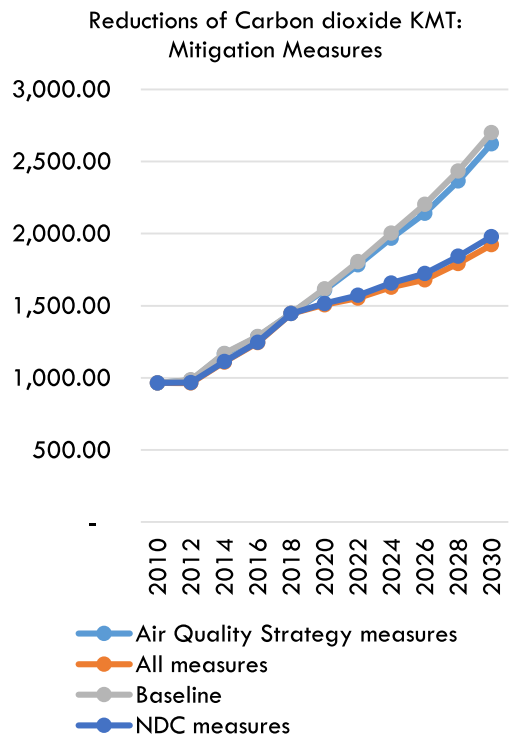educing PM2.5 concentrations in the Maldives, e.g. to meet the WHO air quality guidelines; regional emission reductions can also make a substantial contribution to achieving this as well.

The second factor that determines how the implementation of these measures will affect PM2.5 concentrations in the Maldives is the contribution that emissions of black carbon, organic carbon, NOx, SO_2, NH3 and natural sources make to PM2.5 concentrations in the Maldives. Currently there is no measurement of the composition of PM2.5 in the Maldives to understand this contribution. However, the analysis in this Plan shows that each of these pollutants would be substantially reduced (by 30-60% in 2030 compared to the baseline scenario) by implementing these measures, and therefore a reduction in PM2.5 concentrations would be expected.

For both of these factors, continuous monitoring of air pollution at monitoring sites in the Maldives would allow the effect of implementing these measures to be monitored and long-term trends in PM2.5 concentrations tracked over time.

Finally, the third factor that determines the effectiveness of these measures is the relationship between exposure to air pollution and negative health impacts in the Maldives. There have been no studies conducted in the Maldives that assess this relationship, but there is a large body of evidence from international studies conducted in North America, Europe, Asia and Latin America that show that exposure, even at low levels of PM2.5 is associated with a wide range of negative health effects, including premature mortality from respiratory and cardiovascular diseases, and lung cancer, and non-fatal health outcomes including asthma and other respiratory conditions in adults and children. In their most recent comprehensive review of health effects of air pollution, the WHO concluded that for long and short-term exposure to PM2.5, there is evidence of harmful health effects at even very low levels of PM2.5 exposure (eg: below 10 µg m-3); and that in the absence of a threshold for harmful health effects, public health will benefit from any reduction in PM2.5 concentrations (The Regional Office for Europe of the World Health Organization, 2013).

This infers that by implementing the above measures which target the emissions sources of PM2.5, any reduction in PM2.5 concentration as a result from implementation will improve public health in the Maldives.

04

ACTION PLAN TO

REDUCE AIR

POLLUTANTS

The following section breaks down the sectorial actions for the implementation of the mitigation measures identified and evaluated above that lead to reductions in emissions of air pollutants, short-lived climate pollutants and/or greenhouse gases.

The main area of focus for NDC actions is switching to alternative energy options for electricity generation, and this is challenged by the limited availability of space, geographic dispersion of population and isolation of islands. The measures in the air quality strategy focus on the main sources of air pollution, including the transport (land and marine) and waste sectors.

4.1 TRANSPORT

4.1.1 EMISSION REDUCTION POTENTIAL OF TRANSPORT MITIGATION MEASURES

Implementation of the mitigation measures in the transport sector could reduce transport sector emissions by 20.67% by 2030 for primary PM2.5, by 23.77% for black carbon, 19.92% for NOx and 21.53% for CO_2. The air pollution reductions occur mainly due to the measures outlined in the air quality strategy measures such as setting emission standards for vehicles. CO_2 emission reductions from the transport also occur mainly from measures under the air quality strategy.

TABLE 9: EMISSION REDUCTIONS FOR TRANSPORT MITIGATION MEASURES BY POLLUTANT

	Transport										
	Organic Carbon (Mt)	Black Carbon (Mt)	Particulate Matter PM2.5 (Mt)	Particulate Matter PM 10 (Mt)	Ammonia (Mt)	Sulphur-dioxide (Mt)	Nitrogen Oxides (Mt)	Non Methane Volatile Organic Compounds (KMt)	Methane (Mt)	Carbon Monoxide (KMt)	Carbon Dioxide (KMt)
Baseline emissions 2030	247.03	235.77	573.42	573.42	13.87	337.52	6,777.99	14.55	238.43	98.61	700.99
Air quality strategy measures (2030)	231.66	179.72	454.88	454.88	1.82	204.60	5,427.17	12.55	220.61	94.08	623.11
NDC measures (2030)	247.03	235.77	573.42	573.42	13.87	288.00	6,777.99	14.15	201.79	98.61	606.43
Implementation of all mitigation measures 2030	231.66	179.72	454.88	454.88	1.82	161.71	5,427.17	12.55	188.87	94.08	550.09
Emission reduction (Baseline emissions - all mitigation measures)	15.37	56.05	118.53	118.54	12.05	175.81	1,350.82	1.60	49.56	4.53	150.90
% reduction	6.22	23.77	20.67	20.67	86.87	52.09	19.92	11.30	20.78	4.60	21.53

Particulate Matter PM2.5 Reductions MT: Mitigation Measures

FIGURE 21: PM2.5 REDUCTIONS FROM TRANSPORT MEASURES

4.1.2 ACTIONS TO IMPLEMENT TRANSPORT MITIGATION MEASURES
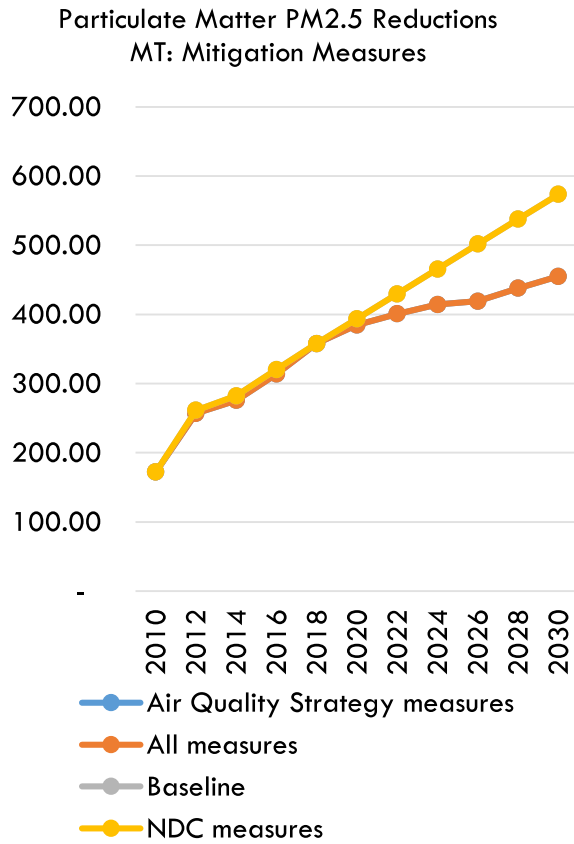
There is a lack of data on vehicle emissions in the Maldives, and the current emission standards are not enforced. Therefore the actions in the action plan are to undertake a measurement study, to revise the standards, and to develop an effective enforcement mechanism.

There is also an absence of a transport master plan, however the following actions are in line with the broader government policies eg: on biofuels in transport, and based on activities which can further increase mitigation efforts, such as introducing vessel emission standards and fuel standards.

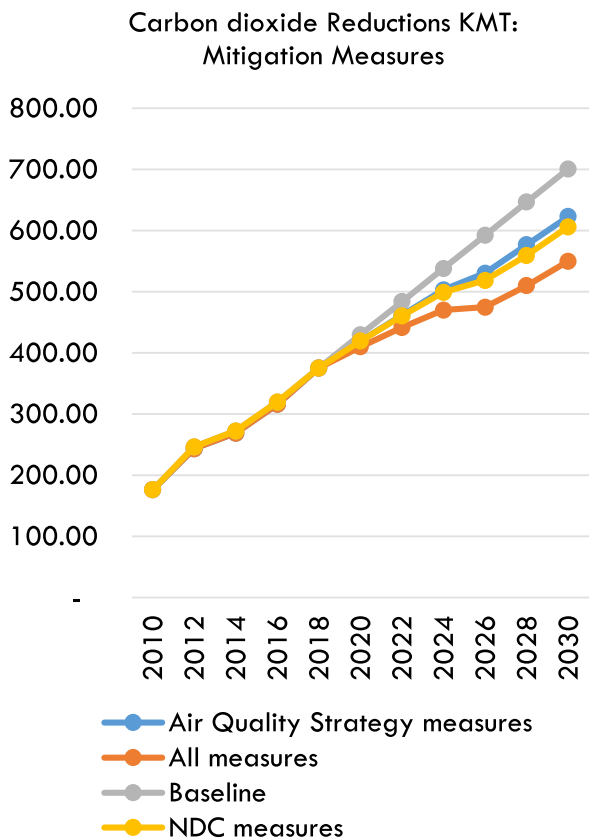FIGURE 22: CARBON DIOXIDE REDUCTIONS FROM TRANSPORT MEASURES

Carbon dioxide Reductions KMT: Mitigation Measures

No.	Source sector	Control measure	Expected reduction and Expected reduction and impacts impacts	Actions to implement the measure	Requirement of financial resources	Time target for implementation	Responsible agency(ies)	Other information
1	Land transport	Revise and set vehicle emission standards	S1: 69.3 kMt CO2/ 2030 219 Mt BC /2030 S2: 69.3 kMt CO2 / 2030 219 Mt BC / 2030	Collect primary and secondary data Build national vehicle emissions inventory, test emissions using PEMs Revise vehicle emission standards Propose enforcing mechanism and provide training to enforcers	US$ 95,000	2020-2030	MEE, MTA, EPA	1. Where all vehicles meet the equivalent of the Euro IV emission standards by 2030, and 2. Where all vehicles meet the equivalent of Euro VI emission standards by 2030.
2	Marine transport	Develop marine engine emission standards	<BC 37.3 Mt> PM2.5 or NOx	Collect primary and secondary data Build national vessel emissions inventory Develop vessel emission standards Propose enforcing mechanism	US$ 100,000	2020-2030	MEE, MTA, EPA	N/A
3	Energy and Transport	Set fuel quality standards	-	Stakeholder meetings Detailed survey and/or analysis of imported fuel quality Develop fuel quality standards Develop roadmap	US$ 100,000	2020-2030	MEE, MEA	N/A
4	Transport/ Conditional NDC measure	Better maintenance of motorbikes	77.0 kMt CO2/ 2030 BC: -	Explore best maintenance practices for motorbikes Conduct an awareness campaign to promote benefits of improved maintenance of motorbikes Establish maintenance service providers that are easily accessible in all parts of the country.	0.0	2017-2027	MTA	In 2012 there were about 36,000 motor bikes on Malé and about 10,000 motor bikes on other islands. Their estimated petrol demand was around 17 million litres which may grow to 25 million litres according to growth expectation for the transport sector. For this option energy consumption was assumed to decrease by means of improved maintenance.
5	Bioethanol	Bioethanol 15%	29.1 kMt CO2	Explore financial scheme to finance bioethanol blend	0.0 (Capital	2020-2025	MEE and	Follows the target in the National Strategy for

		blend in all gasoline	reductions in 2030	Promote bioethanol fuel to use in transport instead of gasoline Introduce mechanism for import and distribute bioethanol fuel	costs unknown)		STO	Sustainable Development (NSSD) of 20% biofuel in transport in 2020. In this option we assume that 15% of the gasoline is replaced by bioethanol, in order to stay below the blend wall, the maximum amount of ethanol that can be blended given the legal and practical constraints.
6	Biodiesel	Biodiesel 20% blend in diesel		Explore financial scheme to finance bioethanol blend Promote biodiesel fuel to use in transport instead of diesel Introduce mechanism to import and distribute biodiesel fuel		2020-2025	MEE and STO	follows the target in the National Strategy for Sustainable Development (NSSD) of 20% biofuel in transport in 2020. In this option we assume that 20% of the diesel for road and sea transport is replaced by biodiesel

4.2 ELECTRICITY GENERATION

4.2.1 EMISSION REDUCTION POTENTIAL OF ELECTRICITY GENERATION MITIGATION MEASURES

Implementation of the mitigation measures in the power generation sector could reduce the power sector emissions by 33% by 2030 for primary PM2.5, by 27.57% for black carbon, by 31% for NOx and by 32.92% for CO_2 (Table 11). These emission reductions can be brought about by renewable energy and more energy efficient methods. Importantly, for both air pollutants and GHGs (NOx and CO_2), it is the unconditional NDC measures which produce the largest reductions in emissions.

TABLE 11: EMISSION REDUCTIONS FOR ELECTRICITY GENERATION MITIGATION MEASURES BY POLLUTANT

	Electricity Generation										
	Organic Carbon (MT)	Black Carbon (MT)	Particulate Matter PM2.5 (MT)	Particulate Matter PM10 (MT)	Ammonia (MT)	Sulphur-dioxide (MT)	Nitrogen Oxides (MT)	Non Methane Volatile Organic Compounds (MT)	Methane (MT)	Carbon Monoxide (MT)	Carbon Dioxide (KMT)
Baseline emissions 2030	2.07	6.88	20.54	82.14	59.83	473.45	1,668.51	20.54	77.01	415.84	1,902.10
Air quality strategy measures (2030)	2.07	6.88	20.54	82.14	59.83	24.62	1,668.51	20.54	77.01	415.84	1,902.10
NDC measures (2030)	1.43	4.98	13.86	55.18	39.77	288.80	1,149.46	180.99	63.55	1440.95	1,275.78
Implementation of all mitigation measures 2030	1.43	4.98	13.86	55.18	39.77	15.02	1149.6	180.99	63.55	1440.95	1,275.78
Emission reduction (Baseline emissions - all mitigation measures)	0.64	1.90	6.68	26.96	20.06	458.43	518.91	-160.45	13.45	-1025.11	626.32
% reduction	30.79	27.57	32.52	32.83	33.53	96.83	31.10	-781.16	17.47	-246.52	32.92

Nitrogen Oxides (NOx) reductions in MT: Electricity Generation Mitigation Measures

- Air Quality Strategy measures
- All measures
- Baseline
- NDC measures

4.2.2 ACTIONS TO IMPLEMENT ELECTRICITY GENERATION MITIGATION MEASURES

The Maldives SREP Investment Plan is currently the most comprehensive plan supporting renewable energy investments for the greater Male' region and outer islands. The current initiatives to introduce renewable energy are important steps in transforming the country into a low carbon development economy which is a lot less reliant on fuel imports.

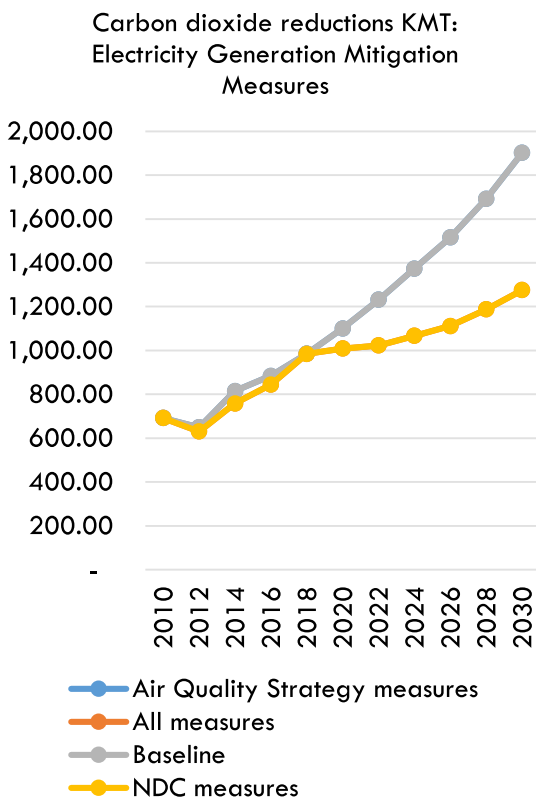FIGURE 24: CARBON DIOXIDE REDUCTIONS FROM ENERGY MEASURES

Carbon dioxide reductions KMT: Electricity Generation Mitigation Measures

- Air Quality Strategy measures
- All measures
- Baseline
- NDC measures

TABLE 12: ACTION PLAN FOR ELECTRICITY GENERATION SECTOR — MEASURES

No.	Source sector	Control measure	Expected reduction and impacts	Actions to implement the measure	financial resources	Time target for implementation	Responsible agency(ies)	Other information
7	Renewable energy/ Unconditional NDC measure	Install 15MW PV systems in greater Male' region	28.0 kMt CO2 / 2030 Reductions 0.07Mt BC / 2030 reduction 20 MT NOx	• Conduct study to explore availability of roof tops • Explore and introduce financing mechanisms for installation of solar PV. • Design and implement solar PV systems	US$22.5 million for 15MW peak solar	2017-2025	MEE, STELCO	This referred to the Malé region solar PV programme involving installation of minimum 15 MW PV systems (11 MW for Malé and 4 MW for Hulhumalé) and implemented under a FIT-scheme
8		Install additional 15MW PVs in the greater Male' region	28.0 kMt CO2 / 2030 Reductions 0.1 Mt BC/2030 reductions	• Conduct study to explore availability of roof tops • Explore and introduce financing mechanisms for installation of solar PV. • Design and implement solar PV systems	US$22.5 million for 15MW peak solar	2020-2025	MEE, STELCO	15 MW solar PV for utility scale was considered
9	Renewable energy / Unconditional NDC measure	PVs with net metering	1 Mt CO2 / 2030 BC reductions -	• Conduct an awareness campaign target to households on the financial and environmental benefits of installing solar PV in homes. • Explore and introduce financing mechanisms in households for installation of solar PV	Estimated US$1.5 million for 1MW solar PV	2020-2025	MEE	Introduces solar PVs for residential applications under net metering scheme. The option assumes 1000 residential applications of 1kWp each will be implemented by 2030.
10	Renewable energy/ Unconditional NDC measure	PVs in outer islands	178.3 kMt CO2/ 2030 0.6 Mt BC/ 2030	• Identify islands where solar PV systems can be implemented • Identify power demand of the islands and growth • Introduce financial schemes • Design and implement solar PV systems for the islands	Estimated US$13.8 million for 9.2 MW peak solar	2020-2025	MEE and utilities	Solar PV systems will be implemented in the islands to cater for 30% of the daytime peak electricity demand of the islands.
11	Renewable energy/ conditional NDC measure	PVs in small islands, 100% solar	14.8 kMt CO2/ 2030 0.3 Mt BC/ 2030	• Design and implement solar PV systems	US$ 109.11 million	2016-2022	MEE	Under the SREP Investment Plan, 10 island grids are envisaged to be targeted full transformation to solar PVs with storage. For this option, this was extended to comprise totally 60 islands categorized as small islands.
12	Renewable energy/ conditional NDC measure	PVs on resorts	57.2 kMt CO2/ 2030 0.2 Mt BC/ 2030	• Review related government policies • Promote use solar PV through government policies and financial schemes • Explore and introduce financing mechanisms for installation of solar PV. • Design and implement solar PV systems	US$ 167.35 million	2020-2030	MEE, MoT, and resorts	solar PV corresponding to 30% of installed capacity of resort islands grids was explored. It is assumed more than 30MW solar PV will be installed in resorts by 2030

13	Renewable energy/ conditional NDC measure	Large solar water heater	2 kMt CO2/ 2030 <BC reductions 0>	• Conduct a detailed study on current water heaters used in hotels and resorts • Create awareness on benefits of using solar water heaters • Promote use solar waters through government policies and financial schemes • Develop and implement a plan to phase out or reduce conventional water heaters with discussion among hotel and resort owners or management	Estimated US$ 670,000 for 100 units	2017-2025	MoT	Larger solar water heaters with electrical back-up has been identified as a replacement for electrical water heating at hotels and at resorts to reduce emissions
14	Renewable energy/ conditional NDC measure	20MW wind power and 25MW LNG	41.3 kMt CO2/ 2030 0.1 Mt BC/ 2030	• Explore financial scheme to finance LNG and wind system • Design and implement LNG and wind power system	Estimated US$97 million	2020-2025	MEE, STELCO	STELCO is envisaging a wind/gas hybrid system with up to 25 MW LNG plant for base load and up to 20 MW wind power.
15	Energy efficiency / Unconditional NDC measure	Upgrades of system efficiencies in diesel powerhouses	710.2 kMt CO2/ 2030 2.6 MT BC/ 2030	• Conduct a detailed study of Power Houses on the efficiency of the power houses. • Conduct an awareness campaign targeted to utilities on efficient operation of power houses. • Explore and introduce financing mechanisms for utilities for projects to improve efficiency in the power system	US$ 61.07 million	2017-2021	FENAKA	The present thermal efficiencies of diesel generators at outer islands were understood to be 26% on average and distribution losses to be 20%, hence leading to overall system efficiencies of 32%. The generation efficiency can be improved by replacement of inefficient generators, careful combination of the generators during the time of the day to match the demand of the island, and better maintenance of the generators. Similarly, the distribution losses can be improved by upgrading the grids to ensure that the correct sizes of cables and transmission equipment are being used in the distribution
16	Energy efficiency / Unconditional NDC measure	Energy efficient air conditioning at resorts	63.2 kMtCO2/ 2030 0.2 Mt BC/ 2030	• Conduct an awareness campaign to raise awareness of the benefit of more energy efficient air conditioners • Explore ways to increase availability of efficient air conditioners at more affordable prices	US$ 4.73 million	2017-2021	MoT	replace conventional air conditioners used in the tourism sector with more energy efficient ones

17	Energy Efficiency/ Condition al NDC measure	Efficient air-conditioning in households		• Conduct an awareness campaign to raise awareness of the benefit of more energy efficient air conditioners • Explore ways to increase availability of efficient air conditioners at more affordable prices. • Explore and introduce financing mechanism for purchasing more efficient air conditioners	US$ 15.05 million	2017-2021	MEE	The purpose of the project is to replace conventional air conditioners used in residential areas with more energy efficient ones.
18	Energy efficiency / Unconditio nal NDC measure	Energy efficient refrigerators	234.6 kMt CO2/ 2030 <0.8 Mt BC / 2030>	• Conduct a study on various types of refrigerators used in households and businesses. • Conduct an awareness campaign target to aware benefit of more energy efficient refrigerators. • Explore and introduce a financing mechanism for replacement of refrigerators. • Explore ways to increase availability of affordable refrigerators in the market	US$ 62.55 million	2017-2021	MEE	For this option annual electricity demand of energy efficient refrigerators was assumed to be 0.3 MWh versus 0.86 MWh of conventional types. The entire stock in 2012 was estimated to comprise some 80,000 refrigerators of which 70% was assumed being conventional types with low energy efficiency. For the mitigation option conventional types were envisaged being replaced by energy efficient types.
19	Energy efficiency / Unconditio nal NDC measure	LEDs for domestic lighting	12 kMt CO2/ 2030 BC reductions -	• Conduct a detailed study on the bulbs used in lighting in household and businesses • Conduct an awareness campaigns to aware benefit of more energy efficient lighting • Explore and introduce financing mechanism for replacement of bulbs. • Explore ways to increase availability of affordable LED bulbs and lights	US$ 42.37 million	2017-2021	MEE	Compact Fluorescent Lights (CFLs) are mainly used for lighting in households and businesses. CFLs have a useful lifetime of 6000 operating hours equalling 2.3 years. In this option all CFLs were envisaged being replaced with Light Emitting Diodes (LED) consuming 40% less electricity than CFLs and with lifetime equalling 10 years.
20	Energy efficiency / Unconditio nal NDC measure	LED tubes for public sector	1 kMt CO2/ 2030 BC reductions -	• Conduct a detailed study on the bulbs used in lighting in public service buildings • Explore financing mechanism for replacement of the conventional lighting. • Develop and implement a plan to phase out conventional lighting.	0.0 (implem entation costs are zero)	By 2030	MEE	Replace conventional tubes in public service buildings with LED tubes. Replacing conventional tubes in public service buildings with LED tubes reduce energy consumed for lighting
21	Energy efficiency / Condition	Centralized cooling systems in new buildings	39.8 kMt CO2/ 2030 0.1 BC /	• Estimate potential monetary savings from installing centralised cooling systems	US$ 42.37	By 2030	MEE	Replace conventional air conditioners used in the commercial sector with more energy efficient centralized

4.3 WASTE

4.3.1 EMISSION REDUCTION POTENTIAL OF WASTE MITIGATION MEASURES

Implementation of the mitigation measures in the waste sector could reduce the waste sector emissions by 74.78% by 2030 for primary PM2.5, by 74.79% for black carbon, and by 74.79% also for NOx (Table 13). There is a large reduction in all pollutants in 2021 due to the implementation of a measure that would stop burning on Thilafushi. This is a very effective measure for reducing emissions in this sector and results in an immediate reduction in emissions from the waste sector. The main waste sector reductions come from implementing the NDC measures, with additional benefits from the air quality strategy measures.

TABLE 13: EMISSION REDUCTIONS FOR WASTE MITIGATION MEASURES BY POLLUTANT

	Organic Carbon (MT)	Black Carbon (MT)	Particulate Matter PM2.5 (MT)	Particulate Matter PM10 (MT)	Ammonia (MT)	Sulphur-dioxide (MT)	Nitrogen Oxides (MT)	Non Methane Volatile Organic Compounds (MT)	Methane (MT)	Carbon Monoxide (kMT)
Baseline emissions 2030	1189.07	146.66	1138.08	2685.00	252.71	112.82	1105.59	5099.24	1191.87	8573.95
Air quality strategy measures (2030)	492.16	60.70	915.21	1111.33	104.60	46.69	457.60	2110.59	707.87	3548.77
NDC measures (2030)	612.01	75.48	1138.08	1381.95	130.07	58.07	569.04	2624.54	791.10	4412.95
Implementation of all mitigation measures 2030	299.80	36.98	557.51	676.98	63.72	28.44	278.75	1285.69	574.28	2161.77
Emission reduction (Baseline emissions - all mitigation measures)	889.27	109.68	580.57	20008.02	188.99	84.38	826.84	3813.55	617.59	6412.18
% reduction	74.78	74.79	51.01	74.79	74.79	74.79	74.79	74.79	51.81	74.79

Particulate Matter PM2.5 MT: Waste Sector Mitigation Measures

Legend:
- Air Quality Strategy measures
- All measures
- Baseline
- NDC measures

Methane Reductions MT: Waste Sector Mitigation Measures

Legend:
- Air Quality Strategy measures
- All measures
- Baseline
- NDC measures

4.3.2 ACTIONS TO IMPLEMENT WASTE SECTOR MITIGATION MEASURES

The National Solid Waste Management Policy 2008 indicates that regional waste management centres will be demonstrating sustainable solutions with economic and environmental benefits, and that waste to energy is an attractive option in terms of addressing emissions as well as managing waste. The developments of these regional waste management facilities are currently ongoing.

TABLE 14: ACTION PLAN FOR WASTE SECTOR – MEASURES
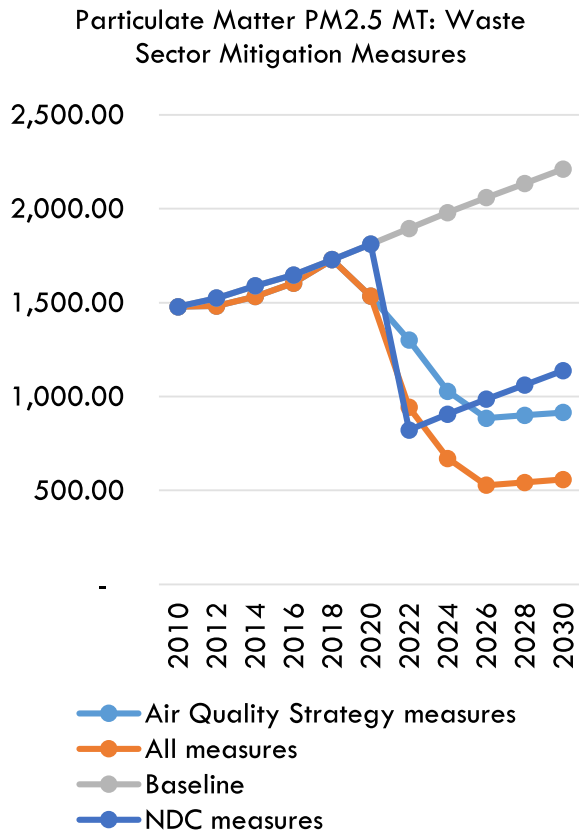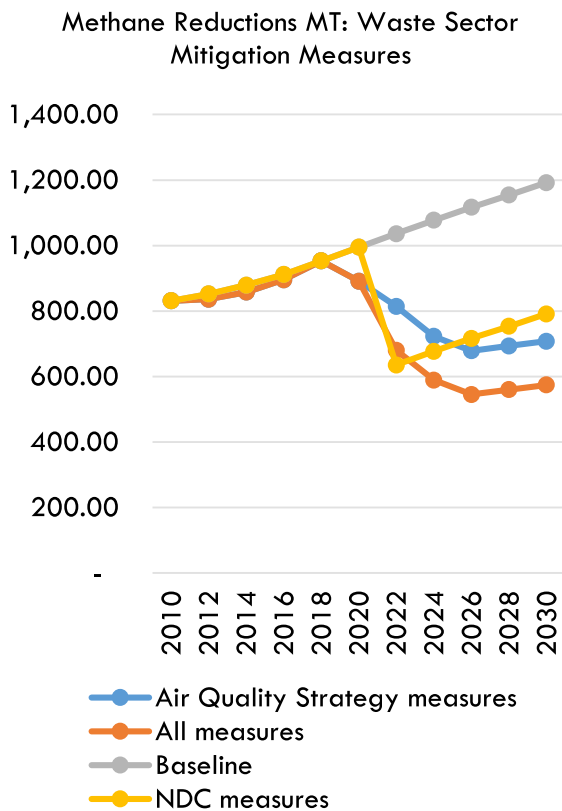
No.	Source sector	Control measure	Expected reduction and impacts	Actions to implement the measure	Requirement of financial resources	Time target for implementation	Responsible agency(ies)	Other information
24	Waste	Stop open burning in Thilafushi	86 Mt BC/ 2030	• Procurement of incinerators.	N/A	By mid 2019	MEE	The waste generated in the region and brought to Thilafushi will be baled to prevent open burning and spontaneous combustion. This baled waste will be used in Measure 25 in order to generate energy.
25	Waste-to-Energy/ Conditional NDC measure	Thilafushi waste to energy	25.6 kMt CO2/ 2030 Mt47.2 Mt BC/ 2030	• Explore and introduce a financing mechanism to implement a WTE plant • Design and implement a WTE system	US$ 57.78 million	2023	STELCO, TFC	This project on establishment of a waste-to-energy (WTE) plant at Thilafushi with installed capacity for electricity generation of around 4 MW is envisaged under the SREP Investment Plan.
26	Waste-to-Energy/ Unconditional NDC measure	Regional waste to energy projects	4.1kMtCO2/ year 23.7 BC reductions	• Explore and introduce a financing mechanism to implement a WTE plant • Design and implement a WTE system	US$ 10.42 million	2023	MEE, WAMCO	The projects on establishment of new regional waste facilities in Hithadhoo and Vandhoo are envisaged under the SREP Investment Plan. The two facilities are supposed to receive about 100 tonnes of waste per day and to jointly provide for 2 MW installed electricity generation capacity.

4.4 HFC Mitigation Measures

The consumption level of HCFCs at the end of 2015 was at 40% while HFCs account for 60% of the total refrigerant consumed in the country (MEE, 2017a). According to a survey conducted on the use of ODS alternatives in the Maldives; there is a projected overall growth of 15% per annum for the period of 2016-2030. The tourism sector was found to be the largest consumer of refrigeration and air conditioning equipment and refrigerants in the Maldives. More than 13% of the total ODS alternatives imported into the country is directly imported by the tourist establishments and a large amount imports by the local suppliers are also consumed in tourism sector. Furthermore, 16% of the ODS alternative refrigerant imported into the county is for use in fisheries sector.

With the Kigali Amendment, Maldives would need to address the issue of the increasing use of HFCs and institutionalize policies creating a more conducive environment to implement the provisions under the Amendment. The primary object of these proposed mitigation measures are to facilitate the ratification and early implementation of the Kigali Amendment. In this regard, the activities outlined in are designed to enhance the capacity of the country to implement, monitor and report as well as generate broad based support from relevant stakeholders most importantly the fisheries and tourism sector and the public for the Kigali Amendment.

TABLE 15: ACTION PLAN FOR COOLING AND REFRIGERATION SECTOR

No.	Source sector	Control measure	Actions to implement the measure	Requirement of financial resources	Time target for implementation	Responsible agency(ies)	Other information
27	Cooling and Refrigeration	Sensitizing fisheries sector on HFC phase-down and Kigali Amendment	• A detailed survey of all the marine and land vessels in the fisheries sector for the use of HFC and alternatives and identifying the barriers • Sector specific training for the fisheries sector technicians and RAC servicing technicians on theory and practical aspects. • Develop technical guidelines on the safety and handling of HFC alternatives • Revise the proposed bank loans scheme to include options for promoting HFC alternatives, conduct additional consultation and raise awareness on bank loans (an output being developed through GEF funded low-carbon development project, focusing also on RAC sector) to encourage private companies to switch over to low GWP alternatives • Assist companies to come up with an internal plan for switching to low GWP alternatives and to prevent introduction of HFCs in the sector.	US$ 40,000	10% phase down of HFCs by 2029, 30% by 2035, 50% by 2040 and 80% by 2045	MEE	Prepare the fisheries sector for the introduction and diffusion of HFC alternatives
28	Cooling and Refrigeration	Sensitizing tourism sector on HFC phase-down and Kigali Amendment	• Conduct a high-level meeting for the managers of the resort to inform and discuss the Kigali amendment a way forward • Signing with interested resorts on partnering (MOUs) with NOU on phasing down HFCs • Initiate the ozone and climate friendly resort award • Sector specific training for the sector technicians and RAC servicing technicians on theory and practical aspects.	US$ 16,000	10% phase down of HFCs by 2029, 30% by 2035, 50% by 2040 and 80% by 2045	MEE	Prepare the tourism sector for the introduction and diffusion of HFC alternatives

05

Implementation and
Monitoring the Measures
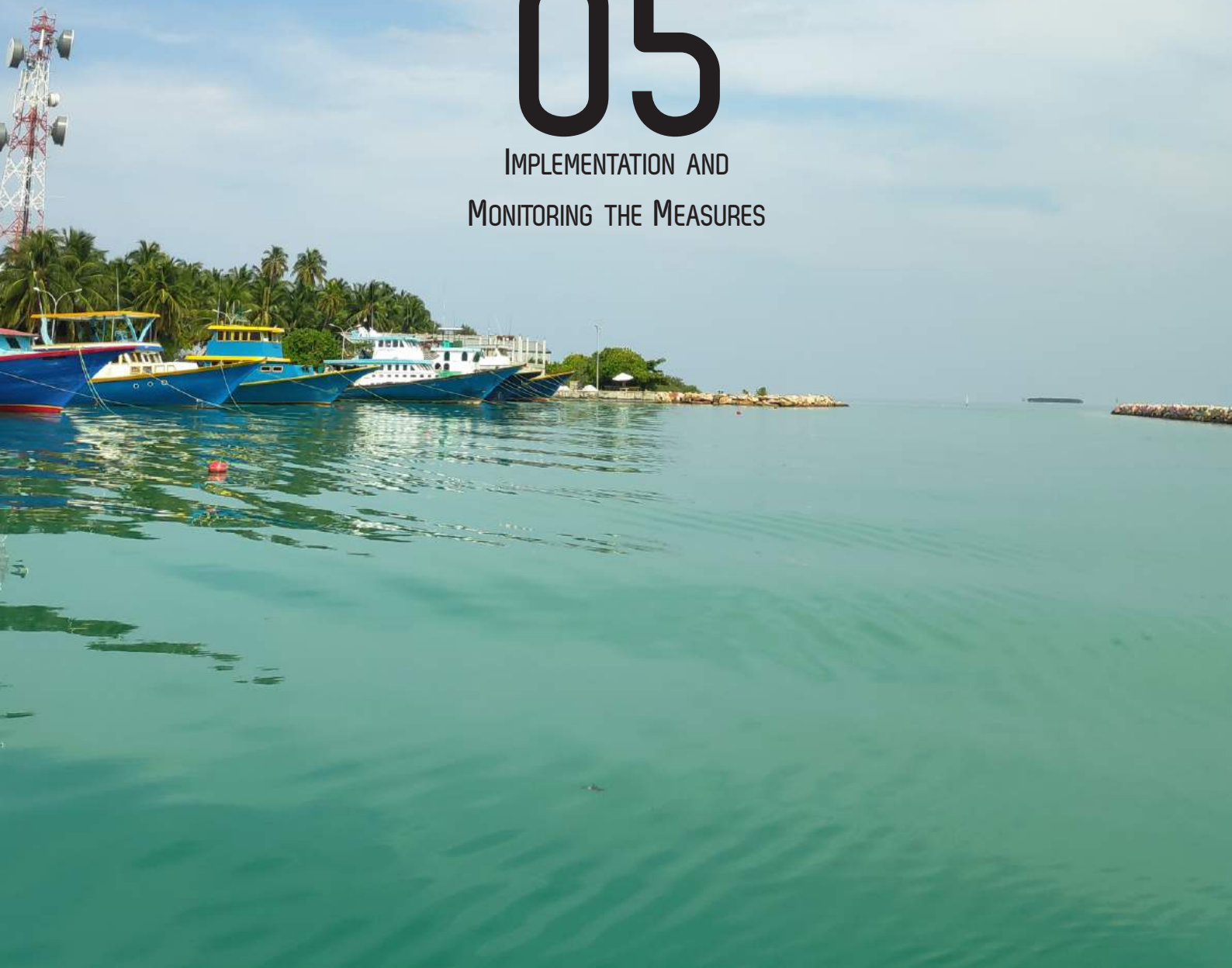
As a Non–Annex 1 Party to the UNFCCC, Maldives will be reporting on its NDC measures. A monitoring, reporting and verification (MRV) framework will be implemented to account and compare the progress of the NDC measures with the business as usual (BAU) scenario. Relevant MRV methods will be proposed for each measure proposed in the NDC and the implementing agency will be responsible in undertaking the MRV process for all the NDC measures. Although it would be ideal to incorporate air quality emission monitoring into the NDC MRV framework, there are barriers to achieving this, including lack of real–time monitoring of ambient air quality and an absence of national emission factors to produce the best available data for this purpose.

In the absence of national emissions factors however, the current air pollutant inventory will still be able to provide an indicative value of the co–benefits of mitigation. But detailed assessments and continuous data collection still needs to be done before air pollutant monitoring can be incorporated into the NDC MRV framework. Since measuring air pollutants is less straightforward compared with measuring carbon dioxide emissions, more data is required to measure, report and verify other air pollutant emissions.

Nevertheless, it is still possible to incorporate certain air pollution indicators into the MRV process, such as the health benefits of reduced pollution levels. Coordination with academia may be established and strengthened in order to perform such localized air pollution studies, which can then feed data into the MRV process.

The approach to monitoring the air quality measures can be separately undertaken in parallel to the timeline for the Biennial Update Reporting on the NDCs, and without an overlap, since the air quality monitoring framework will only monitor the remaining measures that are not covered by the MRV framework for the NDC mitigation measures.

A monitoring framework for air quality measures will be developed in 2020 and will be used by the implementing agency to measure the progress and level of success of these measures. The air pollutant inventory will be re-evaluated by the Ministry of Environment every two years in harmony with the biennial update reporting, based on the updated availability of any new data gathered and new sectorial mitigation measures and projects.
Based on the re-evaluation, the projection of air pollutants will be reassessed to indicate the progress in achieving reductions in emission levels.

Similarly, GHG emissions will continue to be characterized alongside air pollutant emissions in the inventory, in order to quantify the co–benefits of implementing the mitigation measures. However, it will be emphasized that these will not be the official GHG estimates.

As part of the GEF–6 pipeline project on Integrated, Sustainable and Low Emissions Transport in the Maldives an MRV framework for sustainable low emissions transport will be designed and made operational, using the existing emission inventories as baselines.

5.1 PROPOSED ROADMAP FOR AIR QUALITY MANAGEMENT FOR THE MALDIVES

1. Characterizing the nature of the air pollution problem

If real-time ambient air quality monitoring stations can be established, these can provide useful information in order to understand fine particle compositions and source sectors; to map trends and seasonal variations in air quality, to inform the public to take action on days with high levels of pollution, and to evaluate the impacts on air quality from mitigation measures.

The GEF-6 project on Integrated, Sustainable and Low Emissions Transport in the Maldives includes a component on procuring, installing and operating equipment to monitor GHG and air pollutant emissions.

2. Identifying the air quality goal and timeframe for achievement

There is a need to establish specific air quality goals nationally or for key regions. For instance, a reduction of x percentage of ambient PM2.5 concentration over 2018-2030 in the greater Male' region.

3. Developing an emission inventory

While an emission inventory was developed during this process of national planning, further refinement, completion and regularly updating the emissions inventory for Maldives is a critical step in monitoring, evaluating, reviewing and updating the air quality plan. This step is closely linked with the next step 4.

4. Conducting air quality modelling and identifying new emission reduction strategies in order to achieve the air quality goal

Air quality modelling, like the modelling undertaken for this document, will help to understand how the implementation of programs in place can contribute towards achieving the air quality goal. If the measures in existing sectorial strategies fall short of achieving a nationally identified goal, then modelling can assist in identifying additional emission reduction strategies that can assist in reaching this target.

5. Formulating and adopting enforceable national requirements

In addition to setting an emission limit or standard, regulations should reflect best available control technology, and needs to include source monitoring and reporting requirements.

Proposed regulations would initially need to undergo a commenting period and draft approval by the Ministry and relevant stakeholders. After a subsequent stage of public consultation, the draft regulation would then be sent for clearance by the Attorney Generals Office, and finally by the Presidents Office.

relevant stakeholders and subsequently a stage of public consultation.

6.. Implementing effective programs for permitting and enforcement

A permit program is an effective tool in ensuring that emission source sectors have an understanding of air pollution control requirements that may apply e.g. renewing permits for vehicles that comply with the national vehicle emission standards or importing fuel that conform to fuel quality standards. These programs can play an important role in regulating emissions from major source sectors.

7.. Monitor implementation of air pollution mitigation measures identified in this Plan

8.. Review and update National Air Pollution if Action Plan every 5 years based on progress made in implementing mitigation measures and updated analysis of priorities to improve air quality in the Maldives.

TABLE 16: NATIONAL AIR POLLUTION ACTION PLAN ROADMAP: ACTIVITIES, ORGANIZATIONS AND TIME LINES.

Activity	Sub-actions	Organizations Involved	Time Frame
Ambient air quality monitoring to characterize nature of the air pollution problem	• Establish monitoring station(s) in key areas • Map trends and seasonal varieties in ambient air quality • Publish daily air quality data to the public	• Ministry of Environment • Environmental Protection Agency	By 2020
Identify ambient air pollution concentration goal and timeline for achievement		• Ministry of Environment	By 2021
Improve and maintain air pollution and GHG emission inventory and projections	• Continue to develop existing LEAP-IBC analysis in the Maldives • Conduct studies of air pollution emission factors • Strengthen links to local academia	• Ministry of Environment • Maldives National University • Environmental Protection Agency	2019 - 2030
Mainstream air pollutants and SLCPs into NDC MRV and implementation	• Monitor implementation of NDC measures and quantify their air pollutant emission reductions	• Ministry of Environment	2020 - 2030
Coordinate implementation of air quality strategy measures	• Formulating and adopting enforceable national requirements on emission limits and standards • Implement effective programs for permitting and enforcement • Strategy to deploy electric vehicles developed including financial mechanisms to support implementation and potential for using solar PV for charging facilities • Demonstration project on 75 electric motorcycles and 200 electric bicycles	• Ministry of Environment • Ministry of Transport and Civil Aviation • Maldives Transport Authority • Maldives Energy Authority • Environmental Protection Agency	2019 onwards
Monitoring and Evaluation of National Air Pollutant Action Plan	• MRV framework for sustainable low emissions transport • Monitor implementation of mitigation measures identified in Plan • Review and update National Air Pollution Action Plan every 5 years	• Ministry of Environment	2020 - 2030

ANNEXES

ANNEX A: ASSUMPTIONS

Category	Data Source	Assumptions and comments
Population:	-Maldives Population projections 2014-2054, *National Bureau of Statistics*	
GDP	-2017 Article IV Consultation – Press release; staff report; and statement by the Executive Director for Maldives, *International Monetary Fund*	
Commercial and Public Services	- Maldives Energy Supply and Demand Survey 2010 – 2012, *Ministry of Environment*	
Transport Sector: Road Transport and Marine Transport	- Maldives Energy Supply and Demand Survey 2010 – 2012, *Ministry of Environment* - Maldives Transport Authority -EMEP/EEA Air pollutant emission inventory guidebook 2016, European Environment Agency	The data was projected using the average rate of increase of the respective vehicle/vessel category.
Industry	- Maldives Energy Supply and Demand Survey 2010 – 2012, *Ministry of Environment*	
Tourism Sector: Resorts, Guesthouses and hotels	- Maldives Energy Supply and Demand Survey 2010 – 2012, *Ministry of Environment* - Tourism Yearbook 2015, *Ministry of Tourism* - Tourism Yearbook 2017, *Ministry of Tourism* - Fourth Tourism Masterplan 2013- 2017. Volume 2. Background and analysis *Ministry of Tourism* -	
Residential	- Maldives Energy Supply and Demand Survey 2010 – 2012, *Ministry of Environment* - National Bureau of Statistics	
Fishing Trips	- Maldives Energy Supply and Demand Survey 2010 – 2012, *Ministry of Environment* - Basic Fishery Statistics 2010 - Basic Fishery Statistics 2011 - Basic Fishery Statistics 2012 - Basic Fishery Statistics 2013 *Ministry of Fisheries and Agriculture*	
Refrigeration and Air-conditioning	-Customs import data, *Maldives Customs Service*	
Waste	-National Implementation Plan of the Stockholm Convention on Persistent Organic Pollutants, *Ministry of Environment*	

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