LOW CARBON STRATEGY *for the* TRANSPORT SECTOR

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LOW CARBON STRATEGY *for the* TRANSPORT SECTOR

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This report presents the Low Carbon Strategies for the Transport Sector of the Maldives. The analysis is based on information received, as of September 2014, from relevant stakeholders and GIZ. Sections on international developments are based on information obtained from publications of reputable international organizations, such as the IPCC, and other international sources. The views expressed in this report are those of the consultant and do not necessarily represent those of the source of data. The consultant thanks all those who have contributed to the compilation of this report including the provision of the information contained herein.

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LOW CARBON STRATEGY *for* TRANSPORT SECTOR

EXECUTIVE SUMMARY

The Republic of Maldives is highly vulnerable to the negative impacts of climate change and there is a matching sense of urgency of action as well as a strong political will for climate change adaptation and mitigation. Transport sector in the Maldives is considered as one of the most energy consuming sectors and it is estimated that 25% of GHG emissions in the Maldives are accounted for the transport sector. Furthermore, GHG emissions in the transport sector is increasing rapidly, mainly due to increased economic development and continued increase in aviation, sea and land transportation. In fact, the total registered vehicles have jumped more than 295% from 2007 to 2014, and the vessel registrations have increased by approximately 70% during the period 2005 to 2014.

Maldives is committed to ensuring that sustainable transport, carbon awareness and smarter choice travel principles are at the heart of people's everyday lives. The Low Carbon Strategies proposed illustrate how the transport network will face the challenges while at the same time make significant improvements to the quality of life for all who live, work and travel in the Maldives.

The Low Carbon Strategies for Transport Sector consist of 18 GHG mitigation strategies as well as 8 adaptation strategies. Reducing the need to travel, promoting eco-driving behavior supported by an effective mechanism for the collection, management and sharing transport information have been identified as short term mitigation strategies. Promoting low carbon technology for vehicles, vessels and aircrafts as well as encouraging low carbon modes (in other words "Smart Choices") of transport are mitigation strategies to be implemented in the short to medium term.

Development of transport sector through urban transport planning, traffic management and the establishment of integrated transport networks (for land, maritime and air) are mitigation strategies to be implemented in the short to medium term. Furthermore, promoting the use of low carbon fuel technology and alternatives to fossil fuels, along with increasing fuel economy and energy efficiency are proposed GHG mitigation strategies. Long term GHG mitigation strategies include the introduction of limits on the importation and use of vehicles and vessels, development of an eco-friendly vehicle rating system as well as the establishment of energy efficient infrastructure and re-engineering roads for low carbon transport.

The formulation of stringent laws, regulations, standards and plans to regulate low carbon transport, as well as the designation of realistic targets and the facilitation of public awareness programs on low carbon transport along with building human capacity at relevant government agencies are the adaptation strategies that are to be implemented as a matter or urgency in the short term. Establishment of a sustainable financing mechanism for low carbon technology, carbon trading and investment in research and development, as well as the introduction of subsidies, taxes and tax breaks to incentivize low carbon transportation are strategies to be implemented in the medium to long term.

LIST OF ACRONYMS

IPCC	*Intergovernmental Panel on Climate Change*
KW	*Kilo Watt*
LPG	*Liquid Petroleum Gas*
tCO2	*Tonnes of Carbondioxide*
tCO2e	*Tonnes of Carbondioxide equivalent*
q	
TJ	*Tera Joules*
toe	*Tonnes of Oil Equivalent*

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1. INTRODUCTION

The transport sector fulfills crucial economic and social functions, while other sectors as well as society as a whole are dependent on a well-functioning transport sector.[1] Transport plays an important role in people's lives, whether in providing access to jobs, services, education and leisure; in supporting economic growth; or through its capacity to affect their environment and health.[2]

There are few systematic studies of adaptation by the transport sector to the impacts of climate change. Compared to the voluminous research into the effects of climate change on ecosystems, there is very little on the adaptation that will be required by industry, settlements and society or changes that will need to be made to the built environment. This is despite the claim that the transport sector is particularly vulnerable to climate change. [3]

Recent climate projections reveal that further climate change is now unavoidable, no matter how successful we are at reducing greenhouse gas emissions in future.[4] If the livelihood of future generations is to be preserved, transport must make a significant contribution towards achieving the environmental protection and climate change objectives. To this end, CO_2 emissions from freight transport and our reliance on fossil fuels must be reduced.[5] In this challenging time, maintaining a successful and sustainable transport network will be one of the vital components in growing and strengthening the economy without losing sight of our environmental responsibilities.[6]

The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) concluded that evidence of warming is unequivocal and is caused primarily by human activities.[7] Evidence suggests that the global mean temperatures could increase by between 1.4 and 5.8 degrees Celsius by 2100.[8]

[1] Potsdam Institute for Climate Impact Research PIK (2011) *Adaptation to Climate Change in the Transport Sector: A Review*, No.122.

[2] WHO (2014) *Developing national action plans on transport, health and environment: A step-by-step manual for policy-makers and planners*, Regional Office for Europe.

[3] Potsdam Institute for Climate Impact Research PIK (2011) *Adaptation to Climate Change in the Transport Sector: A Review*, No.122.; The Study referred to IPCC, 2007; Arnell, 2010; Eddowes et al., 2003; and Savonis et al., 2008).

[4] UK Climate Impacts Program (2009) *Local Transport: Adapting To Climate Change*, September

[5] Federal Ministry of Transport, Building and Urban Development Germany (2010) *Freight Transport and Logistics Action Plan – Logistics Initiative for Germany*, December.

[6] Birmingham Low Carbon Transport Strategy (2012) Birmingham City Council.

[7] The IPCC states that there is compelling evidence that most warming observed in the last 50 years can be attributed to human activity. *See* Oregon Department of Transport (2012) *ODOT's Climate Change Adaptation Strategy Report*, April; See also Transport for London (2011) *Providing Transport Services Resilient to Extreme Weather and Climate Change*, Transport for London's Submission to Defra for the Adaptation Reporting Power, May; and Department of Transport London (2010) *Climate Change Adaptation Plan for Transport 2010-2012: Enhancing resilience to climate change*, March.

[8] Abdulla A.A. (2007) *In-Depth Technology Needs Assessment on Transport Sector*, Ministry Of Environment, Energy And Water, July; Projections for 2100 suggest a global mean sea level rise of a few decimeters and a greater frequency and intensity of extreme weather events. Even if emissions of greenhouse gases stop today, these changes would continue for many decades and in the case of the sea level for centuries. *See* PANC Belgium, *Waterborne*

Maldives is extremely vulnerable to the global problem of climate change. Transport sector in the Maldives is considered as one of the most energy consuming sectors and it is estimated that 25% of GHG emissions in the Maldives are accounted for the transport sector. Furthermore, GHG emissions in the transport sector is increasing rapidly, mainly due to increased economic development and continued increase in aviation, sea and land transportation. Climate change is expected to have a significant impact on local transport, however the Maldives is yet to place effective regulatory duties on the Transport Authority to have regard to government policies and guidelines on climate change mitigation and adaptation.

The total registered vehicles have increased more than 295% from 22,303 in 2007 to 65,932 in 2014. Majority (83%) of vehicles registered in the Maldives are motor cycles, followed by cars (6%). Furthermore, The total number of vessels registered has increased from 7,016 in 2005 to 11,913 in 2014 by approximately 70%.[9]

Maldives is committed to ensuring that sustainable transport, carbon awareness and smarter choice travel principles are at the heart of people's everyday lives. This report on Low Carbon Strategies shows how the transport network will face the challenges while at the same time make significant improvements to the quality of life for all who live, work and travel in the Maldives.

The Low Carbon Strategies are designed to ensure Maldives sustains itself as a vibrant and thriving economic hub and a beacon of low carbon travel, striving to enable everyone to get about in a more carbon efficient way, though effective planning, infrastructure and technology. The strategies will improve fuel economy, transportation systems and shifts in travel behavior on the reduction of man-made CO_2 emissions in urban areas.

A study by the Asian Development Bank suggested that, low carbon transportation strategies can be among the least costly ways to reduce GHG emissions when they are designed to reduce the need for travel, to shift trips to often less expensive low carbon modes, and to improve system management by reducing congestion and inefficiency in the use of transport capacity. These approaches can also produce disproportionate social and economic benefits for low-income people who are more dependent on walking, cycling, and public transport. [10]

The Asian Development Bank has estimated that the emissions from the transportation sector of the Maldives will reach nine hundred thousand tCO_2e by 2020, which will inflate further by an additional one million tCO_2e to 1.9 million tCO_2e by 2030.[11] This is a 624.6% increment compared to the GHG emissions in 2012. Mitigation through improved fuel economy can reach a savings amounts to US$10 million annually. [12]

transport, ports and waterways: A review of climate change drivers, EnviCom - Task Group 3. Climate Change and Navigation impacts, responses and mitigation.

[9] Abdulla A.A. (2007) *In-Depth Technology Needs Assessment on Transport Sector*, Ministry Of Environment, Energy And Water, July

[10] ADB (2010), Reducing Carbon Emissions from Transport Projects: Evaluation Report, July.

[11] ADB (2012) *Economics of Reducing Greenhouse Gas Emissions in South Asia: Options and Costs*, Financed under ADB-Australia South Asia Development Partnership Facility.

[12] Ministry of Environment and Energy (2014) *Maldives Low Carbon Development Strategy*, Joergen Fenhann from UNEP Risoe Centre (URC) and

1.1 OBJECTIVE OF REPORT

The Maldives is particularly vulnerable to projected adverse consequences of climate change, including sea-level rise. On climate change mitigation, the Maldives in not a major emitter of greenhouse gas emissions, but it is committed to achieve energy security through a low-carbon development path. The government has declared its intention to fight climate change over the next decade, including a vision to cut carbon emission to become a carbon-neutral nation.

Due to the geographical setting of the country and disbursed nature of the islands, Maldives heavily depends of sea transport although aviation has continued to raise recently after developing airports and expansion of tourism industry to all parts of the country. Similarly, vehicles are also increasing in larger islands particularly in the capital Male'. Maldives is working towards exploring ways and means of reducing CO_2 emissions thereby reducing its GHG emissions and addressing mitigation of climate change.

The primary objective of this report is to assist the Government of Maldives on its Low Carbon Strategies to be targeted for the transport sector. It will also address the potential for the transport sector to cost-effectively contribute to GHG reductions via-a-vis other sectors.

1.2 SCOPE AND STRUCTURE OF REPORT

The Low Carbon Strategy for Transport Sector will provide an comprehensive strategy for reducing GHGs emissions in the transport sector in the Maldives. The strategies are designed as means of reducing GHG emissions from transport sector thereby addressing overall climate change mitigation and adaptation initiatives of the Maldives. The report will address the work that is currently being undertaken for the Maldives adapting to climate change initiatives and other research that could in future provide valuable information in low carbon transport services.

The report will provide a background analysis of the impacts of climate change from the transport sectors, citing global GHG emissions and characteristics of the various types of transportation. The strategies will be formulated taking in to account the climate change governance in the Maldives, energy balances and energy consumption by the transport sector. The technologies for the mitigation of GHG emissions from transport sector as well as strategies for climate change adaptation including the assessment of barriers for technology transfer and economic measures will be addressed in this report.

1.2 METHODOLOGY AND LIMITATIONS

The Low Carbon strategies for transport sector are formulated based on targeted, detailed research studies in order to identify and recommend best options suited for the Maldives. The recommendations on specific technology based solutions are provided taking into account the unique characteristics of land (especially in the capital city Male'), maritime and air transportation in the Maldives. Proven and viable strategies and technology-based solutions are provided based on comprehensive literature review, focus group discussions, policy reviews,

Marianne Ramlau consultant to URC, June.

stakeholder consultations as well as reviews of the past assessments of GHG mitigation in the Maldives. This report provides the assessment of the current situation, in the following order.

- *First - literature review on adapting transport to climate change.*
- *Second - groups and systematize proposed adaptations and those already being made, as described in the literature.*
- *Third - identify the actors that are involved in adapting the transport sector to climate change.*

It is imperative to note that, reliable and accurate data on overall energy consumption by the transportation sector, trends in the registrations of vehicles, vessels and aircrafts as well as their usage in Maldives is not readily available.

2 TRANSPORT AND CLIMATE CHANGE: BACKGROUND

It is a consensus of the global community that anthropogenic emissions of greenhouse gases (primarily CO_2) to the atmosphere are upsetting the thermal balance of the planet and contributing to a global warming trend.[13] Scientists and policymakers around the world have acknowledged that global climate change is likely to disturb regional weather patterns and that these changes, although difficult to predict with any certainty, pose challenges and risks to human and natural systems.[14] Most climate change research seeks to better understand these impacts by elucidating the complex mechanisms that govern climatic conditions.[15]

The worldwide power sector accounts for 26% of emissions, with the majority of this being electricity generation from coal, gas and oil. Industry is the second largest sector at 19%, with the largest contributors being steel, cement, aluminum and pulp production. Forestry is the third largest sector, accounting for around 17% of emissions, with deforestation accounting for more annual emissions than the entire transport sector.[16] Emissions from transport sector are discussed in Section 2.1 below.

Transport infrastructure is affected by extreme weather and by continuous climate change. Transport delays and interruptions have high social costs. The ability of the transport sector to respond rapidly to climate change is constrained by its reliance on long-lasting infrastructure (e.g. roads, airports, seaports).[17] Therefore, anticipatory adaptation is needed. Furthermore, spatial development plans can not be revised at short notice, and transport infrastructure and services are often regulated. Thus timely adaptation of the wider institutional environment will be required.[18]

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[13] Abdulla A.A. (2007) *In-Depth Technology Needs Assessment on Transport Sector*, Ministry Of Environment, Energy And Water, July

[14] The Intergovernmental Panel on Climate Change (IPCC) has identified a range of gases that could contribute to global warming. In terms of anthropogenic emissions, carbon dioxide is the most important as it is produced in large quantities and remains in the atmosphere for long periods. Other important greenhouse gases include methane and nitrous oxide. Greenhouse gases trap the sun's heat as it is radiated back from the earth and cause global warming, which in turn leads to climate change. A proportion of greenhouse gases are produced anthropogenically. *See* Lazarowicz M. (2009) *Global Carbon Trading: A framework for reducing emissions*

[15] Abdulla A.A. (2007) *In-Depth Technology Needs Assessment on Transport Sector*, Ministry Of Environment, Energy And Water, July

[16] Lazarowicz M. (2009) *Global Carbon Trading: A framework for reducing emissions*

[17] See Stecker et al., 2011, for an assessment of infrastructure lifetimes, in Potsdam Institute for Climate Impact Research PIK (2011) *Adaptation to Climate Change in the Transport Sector: A Review*, No.122.

[18] Potsdam Institute for Climate Impact Research PIK

A significant portion of global CO_2 emissions is a byproduct of fossil fuel combustion from human activity. Most such combustion occurs in the production of energy, and about a third of this involves transportation.[19] According to the 2007 IPCC Fourth Assessment Report, the growth rate of greenhouse gas emissions in the transport sector is the highest among all the energy end-user sectors.[20] CO_2 reduction policy options in the transportation sector primarily focus on the reduction of manmade combustion through the reduction of the underlying activity (i.e. travel), or through reducing the amount of CO_2 in vehicle exhaust by mandating increased vehicle fuel efficiency.[21]

As illustrated in Table 1.1, the transport sector accounts for 22% of global energy use. Passenger transport accounts for about two thirds of the energy usage, with freight accounting for roughly one third. Reducing these emissions from transport must be an important part of the climate change mitigation programs both at local and national levels. [22]

TABLE 1.1

World Transport Energy Use by Mode

Mode	Energy Use (EJ)	Share
Road	59.4	77.3%
Passenger Transport		
Cars	34.2	44.5%
Buses	4.76	6.2%
Other (motorbikes etc.)	1.2	1.6%
Freight	19.25	25%
Rail	1.19	1.5%
Air	8.95	11.6%
Shipping	7.32	9.5%
Total	76.85	100%

Source[23]

2.1 SHARE OF GLOBAL GHG EMISSION BY THE TRANSPORT SECTOR

The increase in global emissions of carbon dioxide from fossil-fuel combustion and other smaller industrial sources slowed down in 2012, while the global average annual growth rate of 2.4 ppm in atmospheric CO_2 concentrations in 2012 was rather high. Actual global emissions increased by 1.4% over 2011, reaching a total of 34.5 billion tonnes in 2012. After a correction for the leap year 2012, this increase was reduced to only 1.1%, compared with an average annual increase of 2.9% since 2000.[24]

The CO_2 emission trend mainly reflects energy-related human activities which, over the past decade, were determined by economic growth, particularly in emerging

(2011) *Adaptation to Climate Change in the Transport Sector: A Review*, No.122.

[19] Hartgen D.T et al (2011) Impacts of Transportation Policies on Greenhouse Gas Emissions in U.S. Regions, Policy Study 387, November

[20] Newman P and Kenworthy J. (2011) *Evaluating the Transport Sector's Contribution to Greenhouse Gas Emissions and Energy Consumption*, in Technologies for Climate Change Mitigation for Transport Sector, UNEP and GEF

[21] Hartgen D.T et al (2011) Impacts of Transportation Policies on Greenhouse Gas Emissions in U.S. Regions, Policy Study 387, November

[22] Newman P and Kenworthy J. (2011) *Evaluating the Transport Sector's Contribution to Greenhouse Gas Emissions and Energy Consumption*, in Technologies for Climate Change Mitigation for Transport Sector, UNEP and GEF

[23] Newman P and Kenworthy J. (2011) *Evaluating the Transport Sector's Contribution to Greenhouse Gas Emissions and Energy Consumption*, in Technologies for Climate Change Mitigation for Transport Sector, UNEP and GEF

[24] See Trends in Global CO2 Emissions (2013) *Background Study Report 2013*, PBL Netherlands Environment Assessment Agency, Joint Research Center of European Commission.

countries. In 2012, an assessment of the increase in CO_2 emissions from global economic growth (in GDP) points to a shift towards less fossil-fuel intensive activities and to the more use of renewable energy and increased energy savings. [25]

It is a fact that economic development is essential for countries. At the same time, development could also lead to increased greenhouse gas pollution caused by the resulting growth in vehicular traffic, energy use, and other activities.[26] World transport energy use and emissions are projected to increase by more than 50% by 2030 and will more than double by 2050 in a business-as-usual scenario. The transport sectors accounts for more than half of the oil used worldwide and roughly a quarter of energy-related CO_2 emissions. In OECD countries, oil use shrinks in all sectors except transport. Virtually all (>95%) of transport energy comes from oil-based fuels, predominantly diesel and gasoline. [27]

While oil extraction is expected to peak and begin to decline in the near future, the shortfall is likely to be compensated with non-conventional oil (such as tar sands) and other fossil resources such as gas-to-liquids and coal-to-liquids. On average, these fuels are more carbon intensive than oil, further augmenting the sector's contribution to global warming.[28]

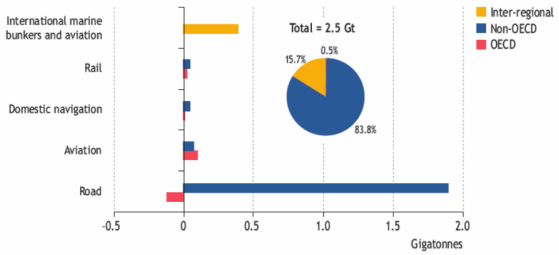
While international shipping and aviation contribute significantly to the projected rise in emissions, the highest share will still come from road transport, i.e. individual transportation and transportation of goods. Shifting towards a sustainable, low-carbon transport system is, hence, imperative for successful climate stabilization, and also for dealing with ever more problematic congestion challenges in a rapidly urbanizing world. [29]

Historically, fuel use and emissions were mostly bound to OECD countries. North America alone accounts for 33% of global transport CO_2 emissions while China contributes 6%. With their economic rise, future growth of fuel demand and emissions will be driven primarily by the developing world, most notably China and India. The main driver of this development is increased car ownership and use of increasingly affluent urban populations(see Figure 1.1). In fact, the vehicle stock is projected to triple between now and 2030 in non-OECD countries. As a result, some developing countries will observe exponential growth in transport fuel consumption.[30]

[25] Trends in Global CO2 Emissions (2013) *Background Study Report 2013*, PBL Netherlands Environment Assessment Agency, Joint Research Center of European Commission.
[26] ADB (2010), Reducing Carbon Emissions from Transport Projects: Evaluation Report, July.
[27] Creutzig, F., Flachsland, C., McGlynn, E., Minx, J., Brunner, S., Edenhofer, O. (2010). CITIES: Car industry, road transport and an international emission trading scheme – policy options.
[28] Creutzig, F., Flachsland, C., McGlynn, E., Minx, J., Brunner, S., Edenhofer, O. (2010). CITIES: Car industry, road transport and an international emission trading scheme – policy options.
[29] Creutzig, F., Flachsland, C., McGlynn, E., Minx, J., Brunner, S., Edenhofer, O. (2010). CITIES: Car industry, road transport and an international emission trading scheme – policy options.
[30] Creutzig, F., Flachsland, C., McGlynn, E., Minx, J., Brunner, S., Edenhofer, O. (2010). CITIES: Car industry, road transport and an international emission trading scheme – policy options.

FIGURE 1.1

Change in transport sector CO_2 emissions by mode and region in a business-as- usual scenario, 2006-2030, including passenger and good transport



Source [31]

According to a study by the Asian Development Bank, transportation sector is the fastest growing major contributor to global climate change, accounting for 23% of energy-related carbon dioxide emissions. Many experts foresee a three to five fold increase in CO_2 emissions from transportation in Asian countries by 2030 compared with emissions in 2000, if no changes are made to investment strategies and policies.[32] As stated in Table 1.2, 22% share of the total global CO_2 emissions in 2012 was contributed by the transport sector. Notably 16% of the 22% was contributed by the road transport sector.[33] This is driven by the anticipated six to eight fold increase in the number of light-duty vehicles and a large increase in the number of trucks, which could overwhelm even the most optimistic forecasts of improvements in vehicle fuel efficiency.[34]

TABLE 1.2

CO2 emissions from fossil-fuel combustion in 2010, per sector

	Total	Coal	Oil	Natural Gas	Other
Sector Total (Billion tonnes CO_2)	30.3	13.0	10.9	6.2	0.2
Main activity power generation*	11.4	8.4	0.7	2.2	0.1
Fuel production and transformation	2.8	0.8	0.9	1.0	0.1
Manufacturing Industry	6.1	3.3	1.5	1.3	0
Road Transport	5.0		4.9	0.1	
Other transport	1.7		1.6	0.1	
Residential Sector	1.9	0.3	0.6	1.0	
Other Sector	1.4	0.2	0.7	0.5	
Sector Total (% of Global Total)	100%	43%	36%	21%	1%
Main activity power generation*	38%	28%	2%	7%	0%
Fuel production and transformation	9%	3%	3%	3%	0%
Manufacturing Industry	20%	11%	5%	4%	
Road Transport	16%		16%	0%	
Other transport	6%		5%	0%	
Residential Sector	6%	1%	2%	3%	
Other Sector	5%	1%	2%	2%	

Source[35]

Furthermore, the growth in the maritime transportation sector will also increase the use of energy for its operations.[36] By using a

[31] Creutzig, F., Flachsland, C., McGlynn, E., Minx, J., Brunner, S., Edenhofer, O. (2010). CITIES: Car industry, road transport and an international emission trading scheme – policy options.

[32] ADB (2010), Reducing Carbon Emissions from Transport Projects: Evaluation Report, July.

[33] Trends in Global CO2 Emissions (2013) *Background Study Report 2013*, PBL Netherlands Environment Assessment Agency, Joint Research Center of European Commission; Transport emissions could become even more significant as other sectors are decarbonized. See Imperial College London (2010) *Road transport technology and climate change mitigation,* Grantham Institute for Climate Change, Briefing paper No 2, October.

[34] ADB (2010), Reducing Carbon Emissions from Transport Projects: Evaluation Report, July.

[35] Trends in Global CO2 Emissions (2013) *Background Study Report 2013*, PBL Netherlands Environment Assessment Agency, Joint Research Center of European Commission.

[36] The marine mode alone consumed 1.22 quadrillion Btu of energy in 2009. *See* The International Council

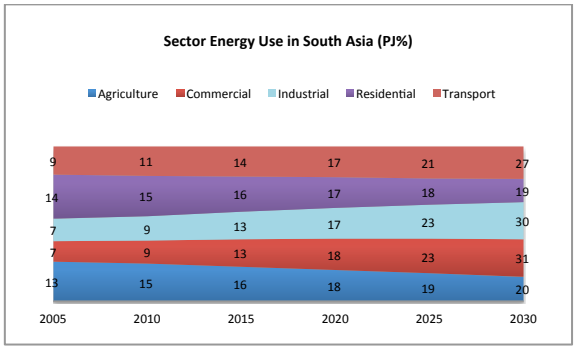
range of business-as-usual rapid ton-mile growth scenarios, a 2009 International Maritime Organization (IMO) study projects that by 2050 the baseline world international maritime CO_2 growth will range from 220–310%, with a 265% average. Without technology improvements, the high end estimate is a 723% CO_2 increase, providing a major incentive for improvement.[37]

2.2 SOUTH ASIAN PERSPECTIVE

The total energy consumption in the region, including India, would increase from 12,856.7 PJ in 2005 to 66,724.2 PJ in 2030, at a annual rate of 6.8%.[38] The share for the transport sector will be 27% of the total energy consumption (See Figure 1.2) The industrial, transport, and residential sectors (in this order) are consistently the top three major energy-consuming sectors in the region. The transport and industrial sectors are also the two fastest-growing sectors in terms of energy use, with a ratio of 6.6 and 5.8 (see Table 2.3).[39]

FIGURE 1.2

Sector Energy Use in South Asia (PJ)



Source: [40]

TABLE 1.3

Sector Energy Use in South Asia (PJ)

Sector	2005	2010	2015	2020	2025	2030	Ratio 2005/ 2030
Including India							
Agriculture	757.1	805.9	895.0	984.5	1030.8	1119.2	1.5
Commercial	411.2	547.2	778.2	1054.4	1460.0	2044.2	5.0
Industrial	6423.0	8921.0	12607.6	17892.7	25573.4	36976.8	5.8
Residential	2240.7	2906.9	3682.6	4654.8	5595.2	6634.7	3.0
Transport	3024.8	4712.2	7083.5	10094.4	14254.7	19949.4	6.6
Total	12856.7	17893.3	25047.8	34680.7	47914.7	66724.2	5.2
Excluding India							
Agriculture	45.3	52.3	58.5	63.4	67.8	72.5	1.6
Commercial	34.4	44.8	66.4	91.4	120.8	160.1	4.7
Industrial	352.1	463.7	633.4	852.4	1122.5	1472.7	4.2
Residential	900.0	981.0	1044.9	1096.0	1157.2	1233.7	1.4
Transport	219.6	274.2	342.8	422.9	522.0	648.3	3.0
Total	1552.3	1816.0	2146.0	2526.1	2990.3	3587.3	2.3

In terms of GHG emissions in South Asia, the Asian Development Bank has estimated that the emissions will reach a staggering 244.7 million tons of CO_2e in 2030 that is an increment more than four folds compared to the 2005 levels (See Figure 1.3). Out of which, the transport sector contributed 15.9

of Clean Transportation (2011) *Reducing Greenhouse Gas Emissions from Ships*, Cost Effectiveness of Available Options, July.

[37] US Department of Energy (2013) Transportation Energy Futures Series: Potential For Energy Efficiency Improvement Beyond The Light-Duty-Vehicle Sector, February

[38] ADB (2012) *Economics of Reducing Greenhouse Gas Emissions in South Asia: Options and Costs*, Financed under ADB-Australia South Asia Development Partnership Facility.

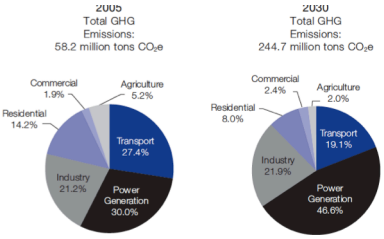
[39] ADB (2012) *Economics of Reducing Greenhouse Gas Emissions in South Asia: Options and Costs*, Financed under ADB-Australia South Asia Development Partnership Facility.

[40] ADB (2012) *Economics of Reducing Greenhouse Gas Emissions in South Asia: Options and Costs*, Financed under ADB-Australia South Asia Development Partnership Facility.

million tones CO_2e in 2005. It has been estimated that the share of GHG emissions from transport sector will exceed 46.7 million CO_2e by 2030. [41]

FIGURE 1.3

Sector Shares in GHG Emissions, South Asia (Excluding India) 2005 and 3030



Source[42]

3. CHARACTERISTICS OF MALDIVES: ITS DEPENDENCY ON TRANSPORT SECTOR

The Republic of Maldives is a small South Asian developing country with an archipelago, which consists of approximately 1200 islands. In fact it is the sixth smallest sovereign State in the world in terms of land area. The islands vary enormously in shape and size, ranging from 0.5 km^2 to 5.0 km^2, scattered along a chain of 20 administrative coral atolls, which makes Maldives among the most vulnerable and least defensible countries to the projected impact of climate change and associated sea level rise. [43]

The atoll chain is 860km long and 80-120km wide from latitude 706'35"N to 0042'24"S, and lying between longitudes 72033'19"E to 73046'13"E4.[44] The northern atolls are broad banks, discontinuously fringed by reefs with small reef islands and with numerous patch reefs and faros in the lagoon. In the southern atolls, faros and patch reefs are rarer in the lagoon, the continuity of the atoll rim is greater, and a larger proportion of the perimeter of the atolls is occupied by islands.

Maldives is located on the 1600km long Laccadives-Chagos submarine ridge extending into the central Indian Ocean from the south-west coast of the Indian sub-continent, and shares boundaries of its Exclusive Economic Zone (EEZ) with Sri Lanka and India.

Maldives faces the greatest threat from climate change, rise in sea level and global warming, such as all low-lying countries and small island states. The environment of the Maldives is extremely fragile and vulnerable as around 80% of the total landmass of the Maldives is less than 1 meter above sea level, which increases the vulnerability of extremely dispersed and fragmented island population. In spite of the overall positive development trends, the Maldives still faces several key development challenges. Hence Maldives has yet to make its best endeavor to adapt fuel efficient technologies to mitigate greenhouse gas emissions to reduce the impacts on climate change.

Land, sea and air transport environments has evolved in an ad hoc manner without a

[41] ADB (2012) *Economics of Reducing Greenhouse Gas Emissions in South Asia: Options and Costs*, Financed under ADB-Australia South Asia Development Partnership Facility.

[42] ADB (2012) *Economics of Reducing Greenhouse Gas Emissions in South Asia: Options and Costs*, Financed under ADB-Australia South Asia Development Partnership Facility.

[43] Abdulla A.A. (2007) *In-Depth Technology Needs Assessment on Transport Sector*, Ministry Of Environment, Energy And Water, July

[44] Abdulla A.A. (2007) *In-Depth Technology Needs Assessment on Transport Sector*, Ministry Of Environment, Energy And Water, July

comprehensive plan in the past.[45] However it plays an essential role in economic and social development in the society as it ensures access to jobs, housing, goods and services by providing mobility of people and for the opening up of peripheral and isolated geographic regions.

3.1 TRANSPORT SECTOR OF MALDIVES: AN OVERVIEW

Being a dispersed island nation, transport is an integral part of life in Maldives. Historically, Maldivians have used sail boats to travel long distances and oars to travel short distances. In the 1970s, Maldivian traditional way of transportation was changed with the introduction of mechanized boats and tourism. Overtime the mode of transport has changed completely to a fossil fuel based transportation mode. For this reason the transport sector is the second largest contributor to Maldives GHG-emissions after grid electricity.[46]

To date there is no sea-based integrated public transport network between the islands. People residing in the islands do not have affordable means of transport even to the neighboring islands. Chartering a boat to travel to a nearby island becomes unreasonably expensive for the general public.[47] Due to the limited inter-island transportation facilities, development has been concentrated solely on the capital Male', leading to congestion and resultant socio-economic problems.[48]

Island residents find it easier to travel long distance to male for basic services than to neighboring islands. The lack of a proper transportation system between islands and atolls has hindered and constrained involvement of island residents in contributing to national development and development their islands.[49] The dependency on transport is estimated to increase with the rise in demographics and Gross Domestic Product at a steady rate of 1.96% and 9% per annum respectively.[50]

Furthermore, a well organized and systematic land transport network is not present (both in Malé and outer atolls). As a result usage of privately owned cars and motorbikes, demand for fuel, cost of transport, air pollution and traffic congestions has increased drastically over the years. Although the energy requirement of the country is insignificant in comparison to the countries of the region or other developing countries, the country's demand for energy has been growing steadily.

The growth in demand for energy has a direct impact on the import of the fossil fuels thus increasing outflow of foreign exchange. This increase in burning of fossil fuels contributes, although insignificant, to the increasing emissions of pollutants to the

[45] Abdulla A.A (2007) *Human Resources Needs Assessment For Transport Sector*, Ministry Of Higher Education, Employment And Social Security, September

[46] Ministry of Environment and Energy (2014) *Maldives Low Carbon Development Strategy*, Joergen Fenhann from UNEP Risoe Centre (URC) and Marianne Ramlau consultant to URC, June

[47] National Assessment Report of Maldives (2010) Department Of Climate Change And Energy, Ministry Of Housing, Transport And Environment.

[48] National Assessment Report of Maldives (2010) Department Of Climate Change And Energy, Ministry Of Housing, Transport And Environment.

[49] National Assessment Report of Maldives (2010) Department Of Climate Change And Energy, Ministry Of Housing, Transport And Environment.

[50] Demand for Transport will grow faster than population and GDP in most developing countries. See Abdulla A.A. (2007) *In-Depth Technology Needs Assessment on Transport Sector*, Ministry Of Environment, Energy And Water, July

environment.

One of the five main pledges of the Government is to create a nationwide transport system. An integrated transport network is a top priority of the Government in order to foster regional development. The Government recognizes transport and connectivity as pivotal in fostering economic growth and social cohesion.[51]

3.2 LAND TRANSPORT IN THE MALDIVES

Land based public transportation is a priority for the country. The Government has the vision to minimize private vehicles, introduce green taxis and pedestrian friendly environment in order to reduce pollution and achieve carbon neutrality.[52]

The majority of the vehicles registered in the Maldives are operated in Male'. The Malé road system consists of a paved network of 59.5 kilometers of road, with carriageways of varying width. The number of vehicles is surprisingly large given the physical size of Male' and the existing problems of population congestion. This concentration of vehicles produces both air and noise pollution and imposes serious safety risks for both pedestrians and vehicle operators. A larger transport policy question is why so many vehicles are needed in such a limited geographical space in the first place.

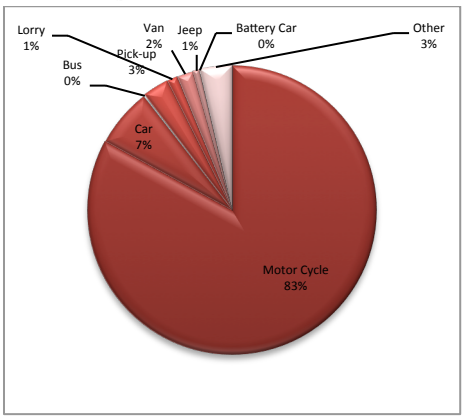
Male' has rapidly changed from a walking to a riding population and from bicycles to motorized vehicles. The small gains in speed and convenience are purchased at a high price in terms of health and the ambience of the community.

It will be difficult for Government to counter the individual preferences of so many consumers who wish to acquire and use motorized vehicles or upgrade to a higher standard of vehicle.[53]

The total registered vehicles have increased more than 295% from 22,303 in 2007[54] to 65,932 in 2014. Majority (83%) of vehicles registered in the Maldives are motor cycles, followed by cars (6%). See Figure 3.1 and Table 3.1.

FIGURE 3.1

Types of Vehicles in Male'



Source[55]

[51] National Assessment Report of Maldives (2010) Department Of Climate Change And Energy, Ministry Of Housing, Transport And Environment.

[52] National Assessment Report of Maldives (2010) Department Of Climate Change And Energy, Ministry Of Housing, Transport And Environment.

[53] Abdulla A.A. (2007) *In-Depth Technology Needs Assessment on Transport Sector*, Ministry Of Environment, Energy And Water, July

[54] Abdulla A.A. (2007) *In-Depth Technology Needs Assessment on Transport Sector*, Ministry Of Environment, Energy And Water, July

[55] Date provided to the Author by the Transport Authority on Maldives on 17 September 2014.

TABLE 3.1

Types of Vehicles in Male'

Vehicle Type	Number Registered	% Share
Motor Cycle	54676	83%
Car	4321	6%
Bus	143	0%
Pick-up	1935	3%
Lorry	775	1%
Van	1211	2%
Jeep	501	1%
Battery Car	31	0%
Other	2339	5%
Total	65932	100%

Source[56]

Present congestion is due to poor management of existing road space. There are an estimated 37,500 motor cycle, 12,500 car/taxi return trips per day and more than 1000 pedestrians per day. It is widely held that during school time this would increase further. The capacity utilization of the two way roads is poor due to the manner in which the one way roads have been deployed. The total cost for all household for personal travel is thus estimated at MVR108 million (approx. 1% of GDP).[57]

Mainly the congestion of traffic and the effluents from fossil fuel based vehicles are degrading the urban environment in Male'. Therefore, mitigation of GHG emissions in road transport would have multiple benefits.[58] To address the congestion issue, the city council introduced bus services for public transport. This service has been rather popular even when the bus services struggle to keep to a set schedule. It has also proven difficult to further expand bus services due to traffic congestion.

There are many economically attractive mitigation options in fields of modal transfers which may help solve congestion and improve urban life in Male'. The main challenge is to succeed in changing habits of motor bike and car users. Accordingly, it may also be politically sensitive to impose new regulations limiting traffic by cars and motor bikes and even to enforce existing regulation on parking.[59]

In 2009, road transport in Male' accounted for 77% of the total road transport in Maldives. It contributed with an estimated 57 $ktCO_2e$ which constituted about 4% of the total emissions. That is an increase from 25.5 $ktCO_2e$ estimated for 2003. In the past, the rate of growth for road transport remained high, but due to congestion and straining the carrying capacity of Male' that rate has been reduced considerably to below 5% per year.[60]

Most of the road transport emissions come from petrol fuelled vehicles like motor bikes and cars which accounts for about 80% of the emissions. In 2012, for every 3.5 persons living in Male' there was one motor bike, and one car for every 50 persons. Most of these

[56] Date provided to the Author by the Transport Authority on Maldives on 17 September 2014.

[57] Abdulla A.A. (2007) *In-Depth Technology Needs Assessment on Transport Sector*, Ministry Of Environment, Energy And Water, July

[58] Ministry of Environment and Energy (2014) *Maldives Low Carbon Development Strategy*, Joergen Fenhann from UNEP Risoe Centre (URC) and Marianne Ramlau consultant to URC, June

[59] Ministry of Environment and Energy (2014) *Maldives Low Carbon Development Strategy*, Joergen Fenhann from UNEP Risoe Centre (URC) and Marianne Ramlau consultant to URC, June

[60] Ministry of Environment and Energy (2014) *Maldives Low Carbon Development Strategy*, Joergen Fenhann from UNEP Risoe Centre (URC) and Marianne Ramlau consultant to URC, June

vehicles are old and inefficient. The road congestion further aggravates the inefficiencies. The fuel economy of these motor bikes was estimated to be 15km/l on average whereas the fuel economy for these vehicles estimated by manufacturer ranges from 35-55km/l. Thus there are potential improvements at hand with proper road management and through imposing specific standards on the vehicles.[61]

3.2.1 Pedestrians

Even though there is considerable pedestrian activity, facilities for pedestrians is grossly under provided. This has resulted in loss of quality of social interaction especially for children and the elderly in Male'. This also encourages unnecessary motorized travel and parking requirements.

3.2.2 Parking

66% of available road space is utilized by 4 wheeled (or larger) vehicles. This includes space for both circulation and parking. The net contribution to the transport effort by these vehicles is around 25%. The absence of a policy on parking has resulted in 1/4th of vehicles taking up 2/3rd of available road space.[62]

Over 70% of household do not have own parking for vehicles. Many office building and commercial establishments are putting up buildings without even a fraction of the required parking. Every new vehicle that is imported will need approximately two new parking spaces apart from space for circulation. There is no parking fee and no effective control of parking at the present times. The most single reason for the present congestion is the haphazard traffic management and lack of parking management.

3.2.3 Traffic Management

Many roads in Male' have been made one-way. There is evidence from traffic counts that this needs to be revised since directional splits in the two way roads are disproportionate indicating that road utilization has become poor. This would mean a system wide approach to road network planning. The entire system of one ways should be looked at after considering the capacity of roads links and junctions. There is also the need to consider some roads where pedestrian flows are dominant to be redesigned as pedestrian walkways with limited vehicular access. [63]

3.2.4 Urban Traffic Planning

In climate change mitigation, urban planning has become increasingly important. Urban planning has a direct impact on climate change because well-planned cities provide a better foundation for sustainable development than do unplanned cities.[64] Urban areas are major emitters of GHG, therefore having a significant impact on climate change.

In the effort to find out way people prefer using their own transport – cars and motorcycles (in case of Malé) – to public transport such as busses, one ought to

[61] Ministry of Environment and Energy (2014) *Maldives Low Carbon Development Strategy*, Joergen Fenhann from UNEP Risoe Centre (URC) and Marianne Ramlau consultant to URC, June

[62] Abdulla A.A. (2007) *In-Depth Technology Needs Assessment on Transport Sector*, Ministry Of Environment, Energy And Water, July

[63] Abdulla A.A. (2007) *In-Depth Technology Needs Assessment on Transport Sector*, Ministry Of Environment, Energy And Water, July

[64] Abdulla A.A. (2007) *In-Depth Technology Needs Assessment on Transport Sector*, Ministry Of Environment, Energy And Water, July

understand why people travel in the first place and the basis on which they choose one mode of transport over the other. Since travelling to school ranks next to travelling to the place of work as the most common purpose of travel, the modal choice whether school children use public transport (including school buses) or are ferried by their parents in cars of on motorcycles and so on – can have a substantial impact on the transport scenario in Malé.

Because parents' fear of traffic accidents and public transport might not arrive on time, children will be ferried around in cars and motorcycles in Male'.[65] This leads to the vicious circle in which the streets and public transport become even more dangerous leading to still greater dependency of private vehicles. As the cycle progresses from generation to generation, people develop new car-based cognitive maps of their surroundings further reinforcing the inevitability of car use.

3.2.5 Reducing Transportation Activity

The consultants of Domestic Transport Sector Development program (phase 1) carried out a study to briefly analyze the driving cycles at Malé. As expected, trips of city roads are far from smooth and efficient. Within the time it took to cover only 4 kilometers, a car had to repeat the entire cycle of picking up speed, driving at a steady speed, slowing down to a halt , and idling (waiting at traffic lights, for instance) as many as six times. [66]

In outer inhabited islands, a complex network of roads is found and is built generally with coral sand. The two most significant inter-island roads are found in Addu Atoll and Laamu Atoll, both approximately 14km in length.[67]

3.3 MARINE TRANSPORT

The Maldives possesses one of the most distinctive topographies and one of the most outstanding marine environments in the world, yet it is also one of the most environmentally-threatened countries.[68]

Domestic transport is predominantly by sea freight and passenger traffic is dominated by movements directly between Malé and individual small island communities. Marine transport has proved to be a cheaper option for most customers in comparison to aviation. Previous studies have tended to present the domestic maritime transport system as a "hub and spoke" system, with the hub in Malé and the spoke radiating out of male.[69] This has been an accurate description of the inter-island transport network in the past, but is becoming less so as the number of hubs increases.

The rapid development of the regional centers around the country largely cantered on the atoll capitals, has reduced the need for the atoll population to travel frequently to Male' as has been the case traditionally. However this de-centralization is hampered

[65] Abdulla A.A. (2007) *In-Depth Technology Needs Assessment on Transport Sector*, Ministry Of Environment, Energy And Water, July

[66] *See* Abdulla A.A. (2007) *In-Depth Technology Needs Assessment on Transport Sector*, Ministry Of Environment, Energy And Water, July

[67] National Assessment Report of Maldives (2010) Department Of Climate Change And Energy, Ministry Of Housing, Transport And Environment.

[68] The Maldives's 2009 Carbon Audit (2010) Ministry of Housing and Environment, November

[69] *See* Ministry of Housing and Environment (2010), *National Economic Environment Development Studies (NEEDS),* June; Abdulla A.A. (2007) *In-Depth Technology Needs Assessment on Transport Sector*, Ministry Of Environment, Energy And Water, July

by lack of basic infrastructure and poorly developed inter island transportation system.[70] Although a number of ferries are operated by island communities, private parties or the Maldives Transport and Contracting company, the scheduled ferry services network in the Maldives is still very limited.[71]

In 2009, a nationwide ferry transport system was introduced. These ferries reduced the costs of transport between islands and consequently increased commuting between the islands.[72] Inter-island transport services are operated almost entirely by the private sector, while the government provides essential infrastructure such as harbors and regulatory functions such as maritime safety. Cargo-come-passenger vessels carry most of the inter-island cargo and passenger traffic. Cargo vessels usually berth at the North Harbor in Male'. The average time at port is 7 days for 'front loading' cargo vessels while it is 17 days for 'side loading vessels'.[73]

Harbors have been established on several islands at huge financial cost even though these facilities cannot be utilized due to the lack of any effective inter island transportation. Populations of the nation are scattered into small islands with limited people. Hence traffic alone on any route may not be initially sufficient to make the whole transportation network feasible unless the transportation service providers have been given opportunities to operate ferry terminals and generate revenues.

However, a major constraint on the development of the sector is the dearth of investment capital. It is very important to source finance to the interested private sector parties for the development of the terminals and capital investment of boats to enhance the development. Private investors are reluctant to invest in inter-island transport due to the lack of a transparent legal framework for the sector.

Over time, diesel engines have replaced sails, fishing vessels have become larger and more far roaming, new tanker and cargo ships, and passenger vessels have appeared, larger and faster launches have been introduced, and safari boats and sport and pleasure craft are common sights in resort areas. The total number of vessels registered has increased from 7,016 in 2005[74] to 11,913 in 2014 by approximately 70%. See Table 3.2 and Figure 3.2.

TABLE 3.2

Vessel registration in the Maldives

Vessel Type	Number Registered	% Share
Dhoni	6826	57%
Launch	2488	15%
Boat	563	4%
Yacht	148	1%
Other	1888	13%
Total	11913	90%

[70] Even though various service centers have been established at regional level, an affordable transport system to access these services is lacking. *See* National Assessment Report of Maldives (2010) Department Of Climate Change And Energy, Ministry Of Housing, Transport And Environment.

[71] National Assessment Report of Maldives (2010) Department Of Climate Change And Energy, Ministry Of Housing, Transport And Environment.

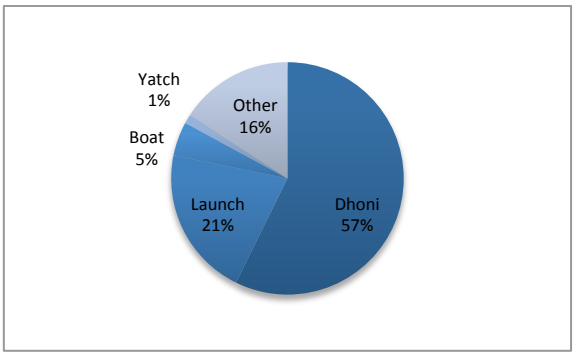
[72] Ministry of Environment and Energy (2014) *Maldives Low Carbon Development Strategy*, Joergen Fenhann from UNEP Risoe Centre (URC) and Marianne Ramlau consultant to URC, June

[73] National Assessment Report of Maldives (2010) Department Of Climate Change And Energy, Ministry Of Housing, Transport And Environment.

[74] Abdulla A.A. (2007) *In-Depth Technology Needs Assessment on Transport Sector*, Ministry Of Environment, Energy And Water, July

FIGURE 3.2

Vessel registration in the Maldives



International shipping and sea transport of freight has revealed a promising growth trend, and will remain as an important source of revenues for the national economy. Male' Commercial Harbor (MCH)[75] has been the only international seas port until December 2005 when two regional seas ports in Khulhuduffushi in the North and Hithadhoo in the South, were commissioned and opened for international service.[76]

The gradual relaxation of government regulation on the locations designated for international cargo landing has meant that international cargo enters the republic in different locations, making these sites into smaller transport hubs for cargo, thereby reducing the traditional dependence of Malé. Notwithstanding these facts, Malé still remains the center of commerce and the main transport hub in the country.

The Government is working with different development partners to improve the sector and reduce the emissions footprint in the sea transport sector. However, so far efforts have not materialized in any mitigation activities. The difficulty seems to rest with lack of capacity of the authorities regulating the sector as well as with the limited options available in terms of marine technology that can be applied. [77]

3.4 AIR TRANSPORT

The Government has recognized civil aviation as highly important to the development of the country and intends to provide aviation in a safe and economic manner. The aviation policy of the Maldives is based on the Convention on International Civil Aviation (the Chicago Convention). The Civil Aviation Act (02/2001) stipulates that all relevant rules and regulations have to be at or above the promulgated in the Annexes to the Chicago Convention Standards and Recommended Practices (SARPs). Each contracting state is audited to ascertain the level of compliance with ICAO Annexes under the Universal Safety Oversight Programme (USOAP). [78]

Air transport activities within the country are expected to grow with the introduction of medical evacuation services, helicopter operation and large jet aircraft.[79] At present 61 aircrafts are on the Maldivian Register utilized among 3 aircraft operators. In 2012, Maldives received services from 22 airlines originating from 15 countries. Out of the 22

[75] The Male Commercial harbor can accommodate vessels up to 15,000GT and has 1.7 Ha of open storage and 0.3hs of closed storage area.

[76] National Assessment Report of Maldives (2010) Department Of Climate Change And Energy, Ministry Of Housing, Transport And Environment.

[77] Ministry of Environment and Energy (2014) *Maldives Low Carbon Development Strategy*, Joergen Fenhann from UNEP Risoe Centre (URC) and Marianne Ramlau consultant to URC, June

[78] National Assessment Report of Maldives (2010) Department Of Climate Change And Energy, Ministry Of Housing, Transport And Environment.

[79] National Assessment Report of Maldives (2010) Department Of Climate Change And Energy, Ministry Of Housing, Transport And Environment.

airlines, 19 are scheduled flights and the remaining are charter flights.[80]

In line with the government policy recognizing that with increasing globalization, international connectivity is critical for sustaining economic growth,[81] there are 4 international and 5 domestic airports as well as 56 floating platforms in operation in the Maldives. A further twelve sites are identified for airport development. Male' International Airport with a runway of 32000m by 45m is the main gateway to the Maldives. In order to upgrade facilitates and relieve congestion a new development phase is underway at the Male International Airport. [82]

Island Aviation Services, a 100 percent State owned company and Villa Air (privately owned company) offer daily scheduled services to the regional airports. The Maldivian Air Taxi (MAT) provides seaplane operations for transfer of tourists from Male' International airport to tourist resort islands. They operate more that 40,000 flights per year. [83]

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 emissions in Maldives.[84] 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, as tourists are increasingly switching to larger land based DASH 8 flights rather than going by seaplane. DASH 8 flights consumes less fuel per passenger than twin Otters Sea Planes, namely 4.3 liters per passenger to travel 100 km for DASH 8 versus 7.5 liters per passenger to travel 100 km for twin Otters Sea Planes. [85]

The number of passengers per flight have increased from about 13 in 2009 to 24 in 2012. At the same time, it was observed that number of locals who travel by marine based transport to the islands near the newly built airports from and to Malé has reduced considerably, displacing a part of the emissions from marine transport to aviation.[86]

In terms of mitigation, there is not much available for the aviation sector. The development of energy efficient and fuel flexible engines are mostly concentrated on large scale commercial airlines. The only options would likely be to increase efficiency in operation and maintenance including through improvement of capacity utilization (number of passengers per flight). In addition to this, careful planning and design of regional airport hubs could be done so as to

[80] Civil Aviation Authority of Maldives (2013) Annual report of 2012.
[81] National Assessment Report of Maldives (2010) Department Of Climate Change And Energy, Ministry Of Housing, Transport And Environment.
[82] National Assessment Report of Maldives (2010) Department Of Climate Change And Energy, Ministry Of Housing, Transport And Environment.
[83] National Assessment Report of Maldives (2010) Department Of Climate Change And Energy, Ministry Of Housing, Transport And Environment.
[84] Ministry of Environment and Energy (2014) *Maldives Low Carbon Development Strategy*, Joergen Fenhann from UNEP Risoe Centre (URC) and Marianne Ramlau consultant to URC, June
[85] Ministry of Environment and Energy (2014) *Maldives Low Carbon Development Strategy*, Joergen Fenhann from UNEP Risoe Centre (URC) and Marianne Ramlau consultant to URC, June
[86] Ministry of Environment and Energy (2014) *Maldives Low Carbon Development Strategy*, Joergen Fenhann from UNEP Risoe Centre (URC) and Marianne Ramlau consultant to URC, June

reduce the number of flights. [87]

4. CLIMATE CHANGE GOVERNANCE IN THE MALDIVES

The global rise of greenhouse gas emissions and its potentially devastating consequences of global warming require a comprehensive regulatory framework for emissions, including those on the transport sector.[88] In the quest to mitigate effects of climate change, Maldives was the first country to sign the Kyoto Protocol and ratify it in 1998. The country is also a party to the United Nations Framework Convention on Climate Change (UNFCCC). As a non-Annex I party to the UNFCCC, the Maldives is not obliged to implement GHG measures, but the current national environmental policies are based on the need to take an integrated approach to environmental management and to work towards the goal of sustainable development.[89] To demonstrate compliance, domestic emissions can be established *inter alia* by use of guidelines for GHG inventories applied under the UNFCCC.[90]

The government has announced its targets to become carbon natural by 2020. The aim on carbon neutrality is essentially an emissions target capping eligible greenhouse gas emissions in 2020 at zero. The goal on carbon neutrality was stated in several governmental policies and following policy documents, strategies, actions and investment plans make reference to the goal:

- *The third National Environment Action Plan (NEAP) 2009-13 (2008);*
- *The Strategic Action Plan (SAP) 2009-2013 (2009);*
- *Maldives National Strategy for Sustainable Development (NSSD)(2009);*
- *Maldives National Energy Policy and Strategy (2010); and*
- *Maldives Scaling Up Renewable Energy Programme (SREP) Investment Plan, 2013-17 (2012).* [91]

The submission to the parliament of a bill on reaching carbon neutrality by 2020 was envisaged by *inter alia* the 3rd NEAP, but has so far not occurred and none of the current policies provides for a strategy for carbon neutrality covering the entire economy and all GHG emissions sources and sinks. Till now, national policies in Maldives provides for little guidance on how to understand the policy statements for carbon neutrality including whether offsetting is considered a valid option.

Documents that may guide decisions for climate change policy and projects during the period 2007-2013 are listed below. [92]

- **The National Adaptation Programme of Action (2007)** was one of the country's first documents focusing purely on adaptation and

[87] Ministry of Environment and Energy (2014) *Maldives Low Carbon Development Strategy*, Joergen Fenhann from UNEP Risoe Centre (URC) and Marianne Ramlau consultant to URC, June

[88] Creutzig, F., Flachsland, C., McGlynn, E., Minx, J., Brunner, S., Edenhofer, O. (2010). CITIES: Car industry, road transport and an international emission trading scheme – policy options.

[89] Abdulla A.A. (2007) *In-Depth Technology Needs Assessment on Transport Sector*, Ministry Of Environment, Energy And Water, July

[90] Ministry of Environment and Energy (2014) *Maldives Low Carbon Development Strategy*, Joergen Fenhann from UNEP Risoe Centre (URC) and Marianne Ramlau consultant to URC, June

[91] Ministry of Environment and Energy (2014) *Maldives Low Carbon Development Strategy*, Joergen Fenhann from UNEP Risoe Centre (URC) and Marianne Ramlau consultant to URC, June

[92] Data extracted from, Transparency Maldives (2013) An Assessment of Climate Finance Governance in Maldives.

listed the national interventions required. It was prepared under UNFCCC obligations and includes a costing of interventions and priority ranking of adaptation measures. It forms the basis of the plans that followed.

- **The Strategic Action Plan 2008-2013** is the current overarching development plan for the country and includes all broad activities for mitigation, adaptation and increasing resilience, as well as governance reforms needed.

- **The Third National Environment Action Plan** details the plan for environmental protection and management from 2009 - 2013, including a more detailed approach for the carbon neutrality goal, increasing the resilience of islands and capacity development plans. [93]

- **The Strategic National Action Plan for Disaster Risk Reduction and Climate Change Adaptation** (Draft) covers both disaster risk management and climate change adaptation measures for 2010 to 2020. A monitoring framework for this document is not included in the plan.

- **The Maldives National Strategy for Sustainable Development (2009)** also looks at carbon neutrality as well as the protection of islands for sustainable development, and considers food security and human health issues. Monitoring indicators and clear targets are outlined in the document, and a review is planned for every two years. No reviews have been published.

- **The National Energy Policy and Strategy** (2010) focuses on achieving carbon neutrality, energy conservation and efficiency, and increasing national security.[94]

- **The National Environmental, Economic and Development Studies** (2010) reprioritized mitigation and adaptation measures for the short, medium and long term with stakeholder consultations, provided a costing of these measures. It also looks at global financial avenues available to the Maldives and policy instruments and compares how other development targets can be aligned to climate change targets.

- **The Investment Plan for Scaling-up Renewable Energy** (2012) was prepared as an obligation for the Maldives to be eligible for US$ 30 million of funds earmarked to the country under the Scaling-up Renewable Energy Project. The investment plan envisages that an additional US$ 138 million is needed to implement the listed projects.[95] Full implementation of SREP is expected to yield an additional 16% of renewable energy into national energy production and reduce CO_2 emission by 27% compared to 2009

[93] Transparency Maldives (2013) An Assessment of Climate Finance Governance in Maldives.

[94] Transparency Maldives (2013) An Assessment of Climate Finance Governance in Maldives.

[95] Transparency Maldives (2013) An Assessment of Climate Finance Governance in Maldives.

rates for inhabited islands. Regular reviews of these documents are envisaged in many cases such as requirements for reporting to parliament on the Third National Environment Action Plan, and a two-yearly review of the National Strategy for Sustainable Development, but it is unclear whether either were completed.

- **A review of the Strategic Action Plan** begun in 2012 has not yet been completed. The draft plan for disaster risk reduction does not have a monitoring framework published. In terms of analyzing adherence to these strategic documents, one indication would be to look at their reflection in the national budget. Although the 2012 budget was very much linked to the Strategic Action Plan, after the transfer of power in 2012 the national budget for 2013 did not explicitly state any direct linkages, although according to the Ministry of Environment and Energy, the Strategic Action Plan was still adhered to. For the preparation of the budget for 2014, the ministry reported that instructions had been given to each institution to select the strategies that the institutional budgets would be aligned to.

The existence of a growing number of policy documents, the absence of adequate monitoring of these and the lack of an overarching climate strategy is worrying as this makes it more difficult for external monitoring of the use of climate funds.[96] The level of inclusion of stakeholders in preparing these documents is often dependent on finance available for consultation and the commitment of donors to ensure it. This is evident when comparing the consultation process of key documents - such as the National Environmental, Economic and Development Studies document - against the consultation process for the Scaling-up Renewable Energy Programme. Low-cost effective ways of broad-based participation need to be encouraged by donors and consistently maintained by government.[97]

The National Energy Policy and the National Energy Action Plan provide the principles for development of the renewable energy sector in the Maldives. To date, 2 MW of solar power has been installed in the country as pilot initiatives. Necessary policies to encourage private sector and individuals to invest in renewable energy have also been introduced.[98]

Under the current government, the Transport Authority is the regulatory body for the sector. Although the Transport Authority is keen to find options and opportunities to reduce emissions from the sector, there is a severe lack of capacity and technical knowhow. It is also to be noticed, that the sector lacks a development master plans much less a sector specific policy document which address the emissions issues in the sector.[99]

[96] Transparency Maldives (2013) An Assessment of Climate Finance Governance in Maldives.

[97] Transparency Maldives (2013) An Assessment of Climate Finance Governance in Maldives.

[98] These include zero import duty for renewable energy related merchandize imports and the feed in tariff regulations. *See* Maldives Economic Diversification strategy (2013) Ministry of Economic Development Maldives.

[99] Ministry of Environment and Energy (2014) *Maldives Low Carbon Development Strategy*, Joergen Fenhann from UNEP Risoe Centre (URC) and

A national transport master plan was drafted in 2003 and second document named 'Domestic Maritime Transport Master Plan' was compiled in 2009. However, the Transport Authority was unable to provide copies of these documents. None of these plans and, applicable laws and regulations in the Maldives stipulate specific measures to mitigate GHG emissions to curb climate change from the transport sector.

5. ENERGY DEMAND AND GHG EMISSIONS FROM TRANSPORT SECTOR

The Maldives has an extreme dependency on imported petroleum based fuels to provide for generation of electricity, maritime transportation; aviation; road transport, cooking (LPG), water production (diesel) and other uses (kerosene).[100] The total CIF value of imported petroleum products stood at US$486 million in 2012, which is a figure equivalent to around 23% of the GDP.[101] This dependency will increase in the future under a business as usual scenario. This will make the Maldives more energy insecure, economically vulnerable and burden the society. [102]

The main supply of energy includes Diesel, Petrol, Liquefied Petroleum Gas (LPG), Kerosene, Jet A1 fuel and solar energy. Diesel import was 84% in 2010, 80% in 2011 and 70% in 2012, and therefore is the most imported fuel type. Due to several installations of solar PVs in Greater Male' Region and some areas in the Other Atolls, a huge increase in the solar energy production from 2011 to 2012 is observed. A significant increase in the import of jet A1 fuel is also observed in 2012 compared to 2011. [103]

Emissions from the energy consumption showed an increasing trend per year. By end of year 2012, 1,229,615.5 tCO_2 was emitted. Among the main contributors, tourism sector shows to contribute the largest.[104] The major energy source in the demand side is electricity (38-40%) closely followed by diesel used for transport (28-31%).[105] The energy consumption in Male' accounts for approximately 72% of the power generated for inhabited islands. Power demand in Male' is expected to continue to grow at a rate of about 11% per year. [106]

Use of energy for the transport sector is determined by segregating the transport sector into three categories; i) transport for leisure and tourism; ii) transport of passenger and cargo; and iii) land transport. Transport for leisure activities within the tourism sector is more energy intensive than the energy used for transport by the Greater Male' Region and Other Atolls.[107] Prior to the analysis of the energy consumption and analysis of the transport sector, the trends in the imports

Marianne Ramlau consultant to URC, June

[100] Maldives Economic Diversification strategy (2013) Ministry of Economic Development Maldives.

[101] Tourism sector is the single most significant economic sector in terms of energy consumption. It accounts for 1/3 of the total energy consumption in Maldives. . Maldives Energy Authority (2014), Maldives Energy Balance 2010 to 2012.

[102] Maldives Economic Diversification strategy (2013) Ministry of Economic Development Maldives.

[103] Maldives Energy Authority (2014), Maldives Energy Balance 2010 to 2012.

[104] Maldives Energy Authority (2014), Maldives Energy Balance 2010 to 2012.

[105] Tourism sector is the single most significant economic sector in terms of energy consumption. It accounts for 1/3 of the total energy consumption in Maldives. . Maldives Energy Authority (2014), Maldives Energy Balance 2010 to 2012.

[106] Ministry of Housing and Environment (2010), *National Economic Environment Development Studies (NEEDS),* June

[107] Maldives Energy Authority (2014), Maldives Energy Balance 2010 to 2012.

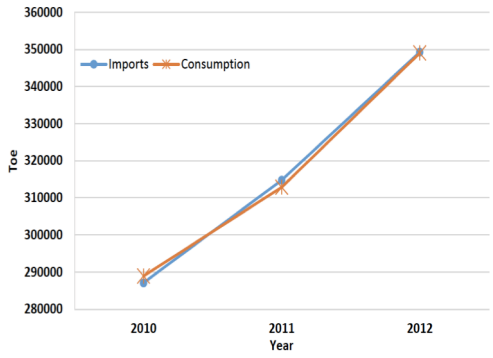
and consumption of the major fuel types are provided.

5.1 DIESEL

Among the most imported fuel types, diesel carries the largest share, in terms of local consumption. Diesel is mainly used for power generation and for transportation. Data for the import of all fuel types are well recorded by the Maldives Customs Service. Figure 5.1 shows the import and the consumption trend of diesel from 2010 to 2012. One notable feature is that the consumption levels in each year are similar to what is imported except for 2010 where consumption exceed the import amount. One of the reasons for this difference could be the consumption of stock left from 2009.[108]

FIGURE 5.1

Diesel Import and Consumption Trend from 2010 to 2012

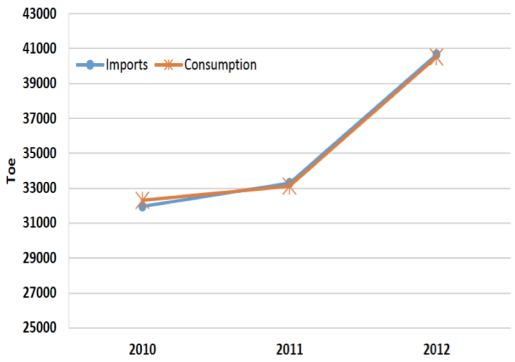


5.2 PETROL

Other than diesel, petrol carries the next largest share of imported fuel. Petrol and diesel consumption for transport grew at 4.5% per year.[109] Petrol is mainly used in transportation vehicles. Figure 5.2 shows the trend of import and consumption of petrol from 2010 to 2012. A similar trend of consumption and import usage is shown here.[110]

FIGURE 5.2

Import and Consumption trend of petrol from 2010 to 2012



5.3 JET A1 FUEL

Aviation fuel is a specialized type of petroleum used in the aviation industry.[111] Jet A1 fuel is the most imported in Maldives. A significant amount is re-exported for fuelling the international aircrafts. Figure 5.3 shows the import and consumption trends of jet A1. A significant increase in the import of jet A1 fuel is observed in 2012 compared to 2011. This is because in 2012 there was an increase in the amount of domestic airports. However, in 2012 there is only a slight increase in the consumption when compared

[108] Maldives Energy Authority (2014), Maldives Energy Balance 2010 to 2012.

[109] Ministry of Environment and Energy (2014) *Maldives Low Carbon Development Strategy*, Joergen Fenhann from UNEP Risoe Centre (URC) and Marianne Ramlau consultant to URC, June

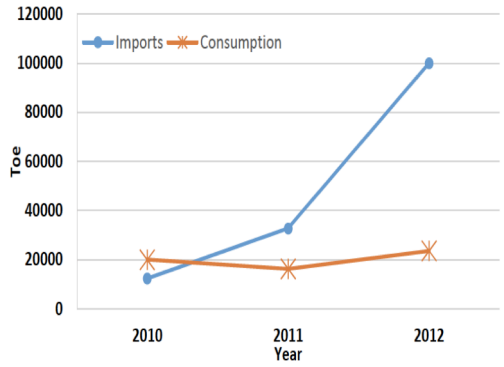
[110] Maldives Energy Authority (2014), Maldives Energy Balance 2010 to 2012.

[111] Maldives Energy Authority (2014), Maldives Energy Balance 2010 to 2012.

to 2011.[112]

FIGURE 5.3

Import and Consumption trend of Jet A1 from 2010 to 2012



5.4 TRANSPORT FOR LEISURE AND TOURISM

This section covers all energy uses in the transport mainly in tourism sector and for their leisure activities. It is one of the fastest growing emissions sectors in Maldives.[113] The sector is divided in to three end use transports types. They are; i) Energy used in transfer of tourists to and from airports, ii) Energy used in excursions and water sports; and iii) Energy used in Safari boats.[114] The Table 5.1, Table 5.2 and Table 5.3 below gives an outline of the energy used in the categories.

This sector contributed with 69 $ktCO_2e$ in 2009 which accounts for 5.5% of total emissions in the Maldives. However, the growth of this particular sector has been slow mainly because the development of tourist resorts has taken place in regions away from the main airport. Thus the part of the transfer of tourist has changed from marine based transport to aviation, especially after the development of new airports.[115]

The live-a-board vessels or safari boats also contribute to this sector. Since the number of vessels has only increased marginally in the past five years it seems reasonable to assume that GHG-emissions from safari vessels have also increased marginally during that period. According to the draft 4th Tourism Master Plan the most significant regulatory reforms required for the tourism sector in the environmental arena at present includes new environmental regulations for live-aboard vessels.[116]

TABLE 5.1

Energy Usage in Tourist Transfers

Year	2010	2011	2012
Type of Vessel	Speed Boat	Speed Boat	Speed Boat
No. of Registered Vessel	1379	1458	1519
% of active vessel	60%	60%	60%
No. of Active Vessels	827	875	911
Engine efficiency (l/km)	65	65	65
Total distance travelled (km)	210	210	210
Total Petrol Consumption (liters)	11,294,010	11,941,839	12,440,610
Total Petrol Consumption (toe)	9,064	9,584	9,984

[112] Maldives Energy Authority (2014), Maldives Energy Balance 2010 to 2012.

[113] Ministry of Environment and Energy (2014) *Maldives Low Carbon Development Strategy*, Joergen Fenhann from UNEP Risoe Centre (URC) and Marianne Ramlau consultant to URC, June

[114] Data extracted from, Maldives Energy Authority (2014), Maldives Energy Balance 2010 to 2012.

[115] Ministry of Environment and Energy (2014) *Maldives Low Carbon Development Strategy*, Joergen Fenhann from UNEP Risoe Centre (URC) and Marianne Ramlau consultant to URC, June

[116] Ministry of Environment and Energy (2014) *Maldives Low Carbon Development Strategy*, Joergen Fenhann from UNEP Risoe Centre (URC) and Marianne Ramlau consultant to URC, June

TABLE 5.2

Energy Used for Excursions and Water Sports

Year		2010	2011	2012
No of Resorts		98	101	105
Consumption/ resort (liters)	Diesel	108.7	108.7	108.7
	Petrol	22.9	22.9	22.9
Total Consumption (toe)	Diesel	11,024.5	11,361.9	11,811.9
	Petrol	2,396.6	2,469.9	2,567.7

TABLE 5.3

Energy Consumed by Safari Boats

Year		2010	2011	2012
Safari bed-nights		156,753	170,622	133,588
Energy Consumption/ bed night	Diesel (liters)	15.87	15.87	15.87
	LPG (kg)	0.20	0.20	0.20
	Petrol (liters)	1.06	1.06	1.06
Total Energy Consumption (toe)	Diesel (liters)	2163.0	2354.4	1843.4
	LPG (kg)	35.1	38.3	30.0
	Petrol (liters)	133.1	144.9	113.4

Source[117]

In 2012, the transport for leisure and tourism sector consumed the largest amount of energy. The energy consumption in 2012 is estimated to be 26,350 toe, which is a 6.2% increase compared to the 2010 level.

5.5 TRANSPORT FOR PASSENGER AND CARGO

This section covers transport of passengers and cargo between habitat islands. In this assessment, data of registered vessels was attained from Statistical year book for the period of 2010-2012. The energy balance was produced using the same assumption model in the energy balance of 2003-2005. Table 5.4 depicts use of energy in this sector.[118]

TABLE 5.4

Energy Usage for Transport of Passenger and Cargo

		Passenger		Cargo			
2010	Type of Vessel	Dhoni	Speed Boats	Dhoni	Bahtheli	Barge	Other
	Registered Vessels	1320	394	172	147	123	39
	% of Active Vessel	0.6	0.7	0.5	0.5	0.5	0.5
	Active Vessels	792	275.8	86	73.5	61.5	19.5
	Fuel Consumption (l/hr)	39	65	39	27	57	32
	Annual Hours of operation	625	210	500	375	375	375
	Diesel Consumed (toe)	16,782,46		1,457.87	646.95	1,142.79	203.42
		20,233.49					
	Petrol Consumed (toe)	3,197.60					
		3,021.23					

		Passenger		Cargo			
2011	Type of Vessel	Dhoni	Speed Boats	Dhoni	Bahtheli	Barge	Other
	Registered Vessels	1363	417	179	155	130	39
	% of Active Vessel	0.6	0.7	0.5	0.5	0.5	0.5
	Active Vessels	817.8	291.9	89.5	77.5	65	19.5
	Fuel Consumption (l/hr)	39	65	39	27	57	32
	Annual Hours of operation	625	210	500	375	375	375
	Diesel Consumed (toe)	17,329.16		1,517.2	682.15	1,207.83	203.42
		20,939.77					
	Petrol Consumed (toe)	3,197.60					
		3,190,60					

		Passenger		Cargo			
2012	Type of Vessel	Dhoni	Speed Boats	Dhoni	Bahtheli	Barge	Other
	Registered Vessels	1407	434	186	163	137	39
	% of Active Vessel	0.6	0.7	0.5	0.5	0.5	0.5
	Active Vessels	844.2	303.8	93	81.5	68.5	19.5
	Fuel Consumption (l/hr)	39	65	39	27	57	32
	Annual Hours of operation	625	210	500	375	375	375
	Diesel Consumed (toe)	17,888.57		1,576.53	717.36	1,272.87	203.42
		21,658.76					
	Petrol Consumed (toe)	3,327.96					
		3,327.96					

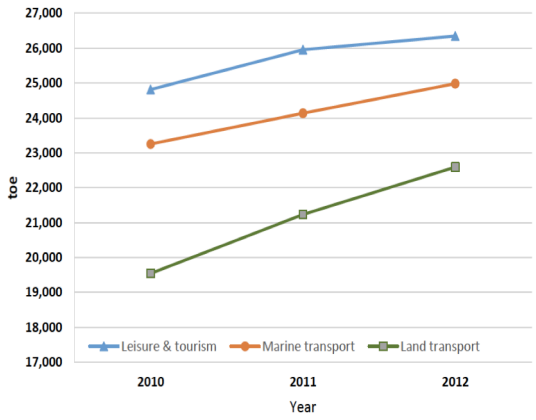
[117] Data extracted from, Maldives Energy Authority (2014), Maldives Energy Balance 2010 to 2012.

[118] Data extracted from, Maldives Energy Authority (2014), Maldives Energy Balance 2010 to 2012.

The second largest amount of energy is consumed by the transport for passenger and cargo sector at approximately 25 thousand toe, which is a 6% higher level compared to 2010 levels. See Figure 5.4 for a summary of the energy consumption in transport sector.[119]

FIGURE 5.4

Summary of the Energy Consumption by the Transport Sector



5.6 LAND TRANSPORT

Land transport sector consumes the least amount of energy. Assumption on mileage and engine efficiency is taken from the latest energy balance. The total consumption of energy for land transport is 16,377 toe for the Greater Male' region, while the energy consumption in other atolls is 7,213 toe in 2012. The energy consumption has increased at the rate of 14% and 40% compared to 2010 level for the Greater Male' Region and the outer atolls respectively. Table 5.5 shows the energy usage by the land transport in Greater Male' Region.

TABLE 5.5

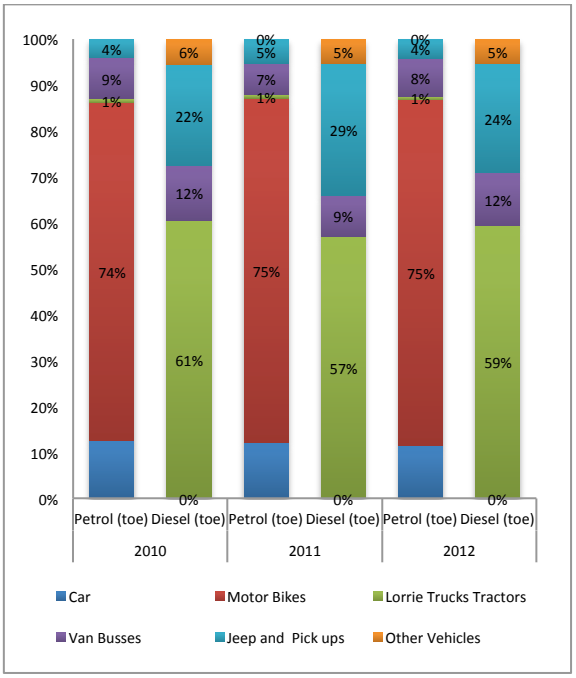
Energy usage by Land Transport for Greater Male Region

	Type of Vehicle	Car	Motor	Lorrie Trucks Tractors	Van Busses	Jeep and Pick ups	Other Vehicles
2010	Registered Vehicles	2543	30,960	846	625	1327	597
	Petrol	100%	100%	5%	75%	45%	0%
	Diesel			95%	25%	55%	100%
	Km/day	25	15	40	40	20	5
	Km/yr	9125	5475	14,600	14,600	7,300	1,825
	Petrol km/l	12	15	5	5	7	6
	Diesel km/l	14	20	8	8	10	8
	Petrol (toe)	1546.3	9068.6	99.1	1098.4	499.8	0.0
	Diesel (toe)	0.0	0.0	1275.2	247.9	463.2	118.4
2011	Type of Vehicle	Car	Motor	Lorrie Trucks Tractors	Van Busses	Jeep and Pick ups	Other Vehicles
	Registered Vehicles	2524	3278	827	494	17997	597
	Petrol	100%	100%	5%	75%	45%	0%
	Diesel			95%	25%	55%	100%
	Km/day	25	15	40	40	20	5
	Km/yr	9125	5475	14,600	14,600	7,300	1,825
	Petrol km/l	12	15	5	5	7	6
	Diesel km/l	14	20	8	8	10	8
	Petrol (toe)	1540.2	9601.7	96.7	868.2	677.5	0.0
	Diesel (toe)	0.0	0.0	1246.6	196.0	628.0	114.8
2012	Type of Vehicle	Car	Motor	Lorrie Trucks Tractors	Van Busses	Jeep and Pick ups	Other Vehicles
	Registered Vehicles	2670	36199	899	665	1557	613
	Petrol	100%	100%	5%	75%	45%	0%
	Diesel			95%	25%	55%	100%
	Km/day	25	15	40	40	20	5
	Km/yr	9125	5475	14,600	14,600	7,300	1,825
	Petrol km/l	12	15	5	5	7	6
	Diesel km/l	14	20	8	8	10	8
	Petrol (toe)	1629.3	10603.1	105.3	1168.74	586.4	0.0
	Diesel (toe)	0.0	0.0	1355.1	263.8	543.5	121.6

[119] Maldives Energy Authority (2014), Maldives Energy Balance 2010 to 2012.

FIGURE 5.5

Energy usage by land transport for greater male region



Source[120]

It is evident from the statistics above that 75% of petrol energy has been used by motor bikes and approximately 60% of diesel is consumed by lorries, trucks and tractors in the Greater Male' Region (See Figure 5.5). The proposed bridge connecting all islands in Greater Malé region holds a potential to scale up mitigation of transport in the region mainly due to modal change from the comparatively higher carbon intensive marine transport to land based transport. However, the mitigation potential can be fully realized if vehicles are converted to electric vehicles.[121]

Road transport in the atolls is considerably small in terms of energy consumptions and emissions. However, the decentralized development in the recent past has increased GHG-emissions from road transport in atolls. The emissions increased from 1.85ktCO_2e in 2003 to estimated 20ktCO_2e in 2012 in the outer atolls (i.e. at a much faster rate than in Malé). So far the road transport in atolls does not face the issues that Malé is facing at the moment, but there is possibility of the same issues being replicated in some of the islands if the sector is not regulated (See Table 5.6).[122]

TABLE 5.6

Energy usage by land transport for Outer Atolls

	Type of Vehicle	Car	Motor	Lorrie Trucks Tractors	Van Busses	Jeep and Pick ups	Other Vehicles
2010	Registered Vehicles	814	7900	436	459	745	387
	Petrol	100%	100%	5%	75%	45%	0%
	Diesel			95%	25%	55%	100%
	Km/day	25	15	40	40	20	5
	Km/yr	9125	5475	14600	14,600	7,300	1,825
	Petrol km/l	12	15	5	5	7	6
	Diesel km/l	14	20	8	8	10	8
	Petrol (toe)	496.7	231 4	51.1	806.7	280.6	0.0
	Diesel (toe)	0.0	0.0	657.2	182.1	260.1	76.8

	Type of Vehicle	Car	Motor	Lorrie Trucks Tractors	Van Busses	Jeep and Pick ups	Other Vehicles
2011	Registered Vehicles	981	9791	827	494	450	312
	Petrol	100%	100%	5%	75%	45%	0%
	Diesel			95%	25%	55%	100%
	Km/day	25	15	40	40	20	5
	Km/yr	9125	5475	14,600	14,600	7,300	1,825
	Petrol km/l	12	15	5	5	7	6
	Diesel km/l	14	20	8	8	10	8
	Petrol (toe)	598.6	2867.9	96.9	868.2	169.5	0.0
	Diesel (toe)	0.0	0.0	1246.6	196.0	157.1	61.9

[120] Analysis by Author. Data extracted from, Maldives Energy Authority (2014), Maldives Energy Balance 2010 to 2012.

[121] Ministry of Environment and Energy (2014) *Maldives Low Carbon Development Strategy*, Joergen Fenhann from UNEP Risoe Centre (URC) and Marianne Ramlau consultant to URC, June

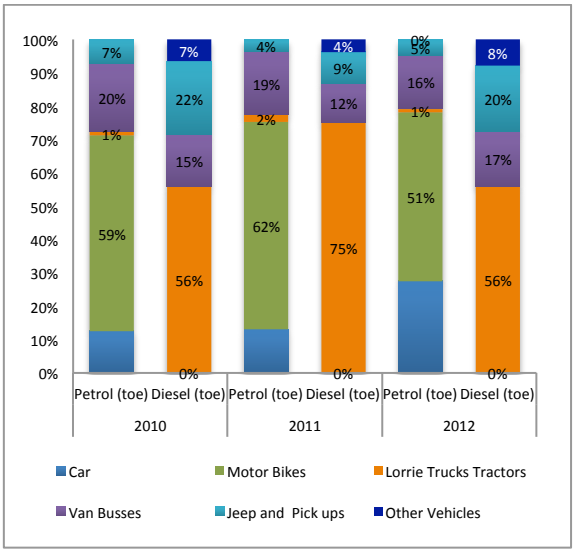
[122] Ministry of Environment and Energy (2014) *Maldives Low Carbon Development Strategy*, Joergen Fenhann from UNEP Risoe Centre (URC) and Marianne Ramlau consultant to URC, June

	Type of Vehicle	Car	Motor	Lorrie Trucks Tractors	Van Busses	Jeep and Pick ups	Other Vehicles
2012	Registered Vehicles	1038	10210	484	544	733	522
	Petrol	100%	100%	5%	75%	45%	0%
	Diesel			95%	25%	55%	100%
	Km/day	25	15	40	40	20	5
	Km/yr	9125	5475	14,600	14,600	7,300	1,825
	Petrol km/l	12	15	5	5	7	6
	Diesel km/l	14	20	8	8	10	8
	Petrol (toe)	1629.3	299 0.6	56.7	956.1	276.0	0.0
	Diesel (toe)	0.0	0.0	729.5	215.8	255.9	103.5

There is significant difference in terms of fuel used for transport between Greater Male' Region and other atolls. This can be attributed to the better standard of roads and saturated economic activities in the Greater Male' Region. However, it is noted that the rate at which transport increase in other atolls would continue to be at a higher rate than in Greater Male' Region as the scope of development in other atolls is much greater.

FIGURE 5.6

Energy usage by land transport for greater male region



Source[123]

[123] Analysis by Author. Data extracted from, Maldives Energy Authority (2014), Maldives Energy Balance 2010 to 2012.

The petrol energy consumption by cars at outer atolls jumped from 13% at 2010 and 2011 to 28% in 2012. As a result the percentage share of energy consumption by motor bikes in outer atolls have declined. As in the Greater Male' Region, the majority of Diesel energy is consumed by heavy vehicles such as lorries, trucks and tractors. See Figure 5.6.

The total energy consumption for transport sector is 99,821toe for 2012, which is a jump of 11% compared to the 2010 levels. The energy consumption in maritime and land transport has remain relatively constant from 2010 to 2012, however the increase in energy consumption in the aviation sector has substantially increased. See Table 5.7 and Figure 5.7.

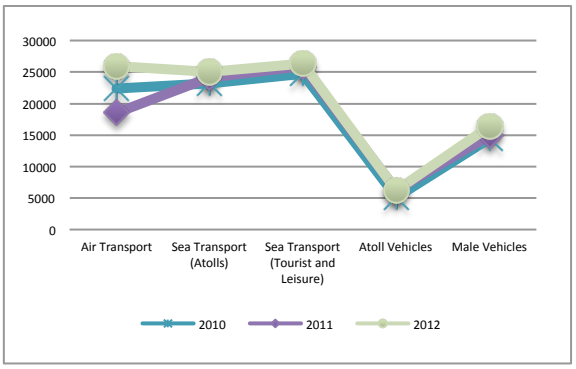
TABLE 5.7

Energy Consumption in the Transport Sector

	Toe	Air Transport	Sea Transport (Atolls)	Sea Transport (Tourist and Leisure)	Atoll Vehicles	Male Vehicles
2010	Diesel	660.0	20233.5	13187.5	1176.0	2104.8
	Petrol	69.0	3021.2	11593.4	3949.0	12312.2
	Jet A1	20009.8				
	Electrical	1515.0				
	Total	**22353.8**	**23254.7**	**24780.9**	**5125.0**	**14417.0**
2011	Diesel	660.0	20,939.8	13716.3	1661.4	2185.4
	Petrol	69.0	3197.6	12198.4	4601.4	12784.2
	Jet A1	16239.0				
	Electrical	1609.4				
	Total	**18577.4**	**24137.4**	**25914.8**	**6262.7**	**14969.6**
2012	Diesel	660.0	21658.8	13655.3	1304.8	2283.9
	Petrol	69.0	3328.0	12655.1	4913.0	14092.7
	Jet A1	23552.1				
	Electrical	1638.4				
	Total	**25919.5**	**24986.7**	**26,320.4**	**6217.8**	**16,376.6**

FIGURE 5.7

Energy Consumption in the Transport Sector



Source[124]

5.7 GHG EMISSIONS FROM TRANSPORT SECTOR

Taking this into account and countries obligations for international reporting, Maldives is a country striving for low carbon development.[125] The sector emitted 304,186tCO_2e in 2012, which is an increase of 10.7% by 29,596 tCO_2e compared to the 2010 levels.[126] Furthermore, the transport sector contributes to approximately 25% of the overall GHG emissions in the Maldives. This rate is more or less consistent with the business as usual scenarios of the Maldives Low Carbon Development Strategy (2014)[127] and the Maldives Carbon Audit of 2009.[128] See Table 5.8 and Figure 5.8.

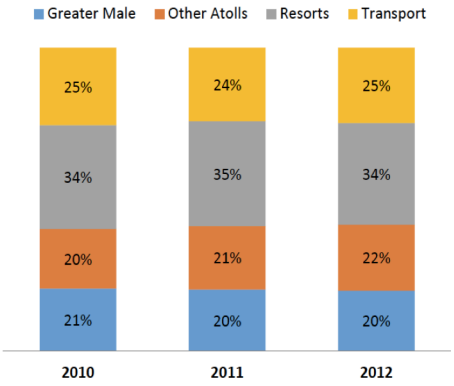
TABLE 5.8

GHG Emissions by Transport Sector

	tCO_2	Air Transport	Sea Transport (Atolls)	Sea Transport (Tourist and Leisure)	Atoll Vehicles	Male Vehicles
2010	Diesel	2016.9	61832.2	40300.1	3593.8	6432.1
	Petrol	195.7	8570.3	32886.8	11202.2	34926.0
	Jet A1	58436.2				
	Electrical	14198.6				
	Total	**74847.4**	**70402.5**	**73186.9**	**14796**	**41358.1**
2011	Diesel	2016.9	63990.6	41916.3	5077.0	6678.5
	Petrol	195.7	9070.6	34603.1	13053.7	36264.9
	Jet A1	47424.2				
	Electrical	14657.8				
	Total	**64294.6**	**73061.2**	**76519.4**	**18130.7**	**42943.4**
2012	Diesel	2016.9	66187.8	41729.7	3987.3	6979.4
	Petrol	195.7	9440.4	35926.8	13936.8	39976.7
	Jet A1	68781.3				
	Electrical	15027.6				
	Total	**86021.5**	**75628.2**	**77656.5**	**17924.1**	**46956.1**

FIGURE 5.8

Sector contribution to emission by energy consumption



Source[129]

The Asian Development Bank has estimated that the emissions from the transportation sector of the Maldives will reach nine hundred thousand tCO_2e by 2020, which will inflate by an additional 1 million tCO_2e to 1.9

[124] Analysis by Author. Data extracted from, Maldives Energy Authority (2014), Maldives Energy Balance 2010 to 2012.

[125] Maldives Energy Authority (2014), Maldives Energy Balance 2010 to 2012.

[126] Analysis by Author. Data extracted from, Maldives Energy Authority (2014), Maldives Energy Balance 2010 to 2012.

[127] Ministry of Environment and Energy (2014) *Maldives Low Carbon Development Strategy*, Joergen Fenhann from UNEP Risoe Centre (URC) and Marianne Ramlau consultant to URC, June.

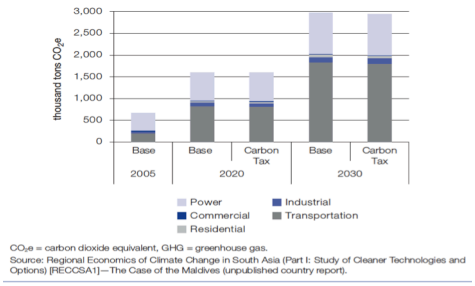
[128] The Maldives's 2009 Carbon Audit (2010) Ministry of Housing and Environment, November.; Ministry of Housing, Transport and Environment (2010) *Report on Energy Supply and Demand 2008-2009*, Technical assistance by UNDP and GEF, August.

[129] Analysis by Author. Data extracted from, Maldives Energy Authority (2014), Maldives Energy Balance 2010 to 2012.

million tCO_2e by 2030.[130] This is a 624.6% increment compared to the GHG emissions in 2012. See Figure 5.9.

FIGURE 5.9

Sectorial GHG emission in the Maldives



CO_2e = carbon dioxide equivalent, GHG = greenhouse gas.
Source: Regional Economics of Climate Change in South Asia (Part I: Study of Cleaner Technologies and Options) [RECCSA1]—The Case of the Maldives (unpublished country report).

Source[131]

The following sections provide the strategies for the mitigation of GHG emissions from the transport sector and the strategies for the adaptation to climate change by the transport sector.

[130] ADB (2012) *Economics of Reducing Greenhouse Gas Emissions in South Asia: Options and Costs*, Financed under ADB-Australia South Asia Development Partnership Facility.

[131] ADB (2012) *Economics of Reducing Greenhouse Gas Emissions in South Asia: Options and Costs*, Financed under ADB-Australia South Asia Development Partnership Facility.

6. STRATEGIES FOR GHG MITIGATION IN TRANSPORT SECTOR

This section provides The Low Carbon Strategies for GHG mitigation in the transport sector of Maldives. The fundamental objective of these strategies is to ensure that transport systems meeting society's economic, social and environmental needs whilst minimizing their undesirable impacts. The vision is to reduce the environmental impact by providing an efficient, safe and easy to use low carbon transport system which will stimulate economic growth by providing high quality transport choices. The Low Carbon Strategies outline a framework of actions which will contribute towards achieving this vision and reducing the carbon footprint of transport in Maldives. The successful delivery of the strategies will rely on both high impact actions and low cost interventions.[132]

TABLE 6.1

GHG Mitigation Strategies for the Transport Sector

MITIGATION STRATEGIES		REMARKS/DESCRIPTION/ JUSTIFICATION
1. Reduce the Need to Travel	**Timeline for Action:** Short Term **Actors:** Transport Authority, Ministry of Environment **Avenue for Further Research**: Yes	➢ **Increase Control on Transportation Demand Management** - Transportation demand management (TDM) focus on encouraging the use of less energy-intensive forms of transportation. These include promoting public transportation, encouraging people to drive less, and developing effective sustainable urban planning to minimize transportation needs. Demand-side management in the context of transport in cities (such as Male') includes such measurers as staggered working hours and staggered weekly offs, providing alternative means of transport, promoting safer and high-quality services to transport schoolchildren etc. In broader terms, demand-side management is all about analyzing what makes people travel in the first place instead of simply estimating travel requirements and then providing for them.[133] It is important to note that, demand reduction is challenging because of the economic and social opportunities that transport provides, even though reduced demand may provide other benefits (e.g. improved air quality).[134] ➢ **Reduce Transportation Activity-** Low carbon transportation strategies can be among the least costly ways to reduce GHG emissions when they are designed to reduce the need for

[132] For the purpose of this study adaptation is addressing the impacts of climate change and mitigation is addressing the causes of climate change. *See definition in* UK Climate Impacts Program (2009) *Local Transport: Adapting To Climate Change*, September

[133] Abdulla A.A. (2007) *In-Depth Technology Needs Assessment on Transport Sector*, Ministry Of Environment, Energy And Water, July

[134] Imperial College London (2010) *Road transport technology and climate change mitigation,* Grantham Institute for Climate Change, Briefing paper No 2, October.

		travel, to shift trips to often less expensive low carbon modes, and to improve system management by reducing congestion and inefficiency in the use of transport capacity. These approaches can also produce disproportionate social and economic benefits for low-income people who are more dependent on walking, cycling, and public transport.[135] Decreasing transportation activity generally implies a loss of mobility. In some cases, a reduction in travel can be accomplished without losing convenient access to people and places. For example, using more direct routes from origins to destinations, increasing vehicle occupancy rates, or designing more geographically efficient communities can result in less motorized transport without compromising accessibility.[136] Reducing demand for transport to Male' from outer islands shall be a priority.
2. Promote Eco-Driver Behavior	**Timeline for Action:** Short Term **Actors:** Transport Authority **Avenue for Further Research**: Yes	➢ **Increasing Awareness on Good Driving Behavior** – Encouraging good driving behavior minimizes carbon emissions.[137] With a view to halving road transport deaths as well as reducing the number of injured in road traffic, increasing road safety by promoting awareness campaigns with a view to change road user behavior and effective driving (including lessons and testing) will reduce GHG emissions from transport sector.[138] ➢ **Encourage eco-driving behavior** - Driving behavior measures such as 'eco-driving' can reduce fuel consumption by around 10-15% at low cost, but require ongoing training.[139]
3. Foster Greater Information Gathering, Management and Sharing	**Timeline for Action:** Short Term **Actors:** Transport	➢ **Gathering, Management and Sharing information on Roads, Traffic and Travel Data -** Many applications rely on an accurate knowledge of the road network and of traffic regulations like one-way streets and speed limits. Whilst in the past the bulk of this knowledge was provided by the authorities, today commercial sources are becoming increasingly important. Relevant information is necessary for all players for the orderly

[135] ADB (2010), Reducing Carbon Emissions from Transport Projects: Evaluation Report, July; See also Newman P and Kenworthy J. (2011) *Evaluating the Transport Sector's Contribution to Greenhouse Gas Emissions and Energy Consumption*, in Technologies for Climate Change Mitigation for Transport Sector, UNEP and GEF.; see also US Department of Transport (2010) *Transportation's Role in Reducing US Greenhouse Gas Emissions*, Volume 1: Synthesis Report, Report to Congress, April.
[136] Abdulla A.A. (2007) *In-Depth Technology Needs Assessment on Transport Sector*, Ministry Of Environment, Energy And Water, July
[137] Birmingham Low Carbon Transport Strategy (2012) Birmingham City Council.
[138] National Assessment Report of Maldives (2010) Department Of Climate Change And Energy, Ministry Of Housing, Transport And Environment.
[139] Imperial College London (2010) *Road transport technology and climate change mitigation,* Grantham Institute for Climate Change, Briefing paper No 2, October.

	Authority, National Bureau of Statistics, Ministry of Environment, Transport Service Providers	management of traffic. Furthermore, optimal use of data will facilitate multimodal journey planning.[140] ➢ **Establish Mechanisms for Collection of Statistics**- An effective mechanism needs to be in place to maintain the statistics of vehicles/vessels as this would provide valuable information in planning.[141]
4. Promote Low Carbon Vehicle Technology	**Timeline for Action:** Short to Medium Term **Actors:** Transport Authority **Avenue for Further Research**: Yes	➢ **Introduction of Smaller and Smarter Vehicles Technologies**- Significant CO_2 reductions of 30% on average could be achieved at relatively low cost with established technologies such as engine downsizing, light weighting and selection of smaller vehicles.[142] Many new vehicle technologies contribute to improvements in GHG emissions, which are: • *reducing vehicle weight and aerodynamic drag with new structure design and materials,* • *smaller engines,* • *light-duty hybrids,* • *low rolling-resistance tires,* • *low friction lubricants,* • *idle-stop features; and* • *advanced air conditioning technology.* ➢ **Promote Hybrid Vehicles -** Use of more efficient motors in transport vehicles/vessels is a government priority.[143] A hybrid-electric vehicle (HEV) combines an electric drive with a down-sized internal combustion engine. HEVs consume less energy by regenerating energy while braking, using smaller engines, allowing the engine to run at its optimal efficiency through computer control, and allowing the engine to be turned off during

[140] European Commission (2011), *Intelligent Transport Systems in Action*, Action Plan and Legal Framework for the Deployment of Intelligent Transport Systems (Its) In Europe.; Traffic management information technology – electronic congestion and toll collection system. See Ministry of Housing and Environment (2010), *National Economic Environment Development Studies (NEEDS),* June.

[141] Ministry of Environment and Energy (2014) *Maldives Low Carbon Development Strategy*, Joergen Fenhann from UNEP Risoe Centre (URC) and Marianne Ramlau consultant to URC, June

[142] Imperial College London (2010) *Road transport technology and climate change mitigation,* Grantham Institute for Climate Change, Briefing paper No 2, October; *See also* Birmingham Low Carbon Transport Strategy (2012) Birmingham City Council.

[143] Ministry of Environment and Energy (2014) *Maldives Low Carbon Development Strategy*, Joergen Fenhann from UNEP Risoe Centre (URC) and Marianne Ramlau consultant to URC, June

		stops, braking, and coasting. Depending on driving conditions and specifics of hybrid technologies, HEVs can achieve fuel efficiency gains of 25% or higher than comparable, gasoline-powered vehicles. Subsidies or tax exemptions for hybrid vehicles/vessels encourage wide spread use that leads to overall fuel savings.[144] ➢ **Promoting Electro-mobility –** Use of electric and other low emission vehicles minimize impact of road transport.[145] Electric-drive vehicles including pure battery BEVs, and Fuel Cell Vehicles (FCVs) use electricity as a transportation energy source. Therefore, emissions per kilometer travelled are related only to the emissions produced at electricity generating power plants. Electric vehicles tend to have lower overall primary energy requirements per kilometer than gasoline cars of the same size, depending on primary energy sources.[146] Purely electric vehicle are generally only suitable for travelling short distances due to limitations on energy storage (battery) capacity, which is ideal for Male'. Promote electric vehicles including electrical bicycles and their charging stations is a priority for the Government.[147] ➢ **Use of Catalyst Converters -** Catalytic converters are devices, fitted near the exhaust pipes of cars that neutralize three major pollutants, namely carbon monoxide, hydrocarbons, oxide of nitrogen, by converting them to harmless gasses. Devices that trap the pollutants have also been developed for diesel powered vehicles and vessels.[148] ➢ **Use of Alternative Engines Technologies-** The amount of pollutants emitted by an engine depends not only on the quality of fuel but also on how efficiently that the fuel is burnt. Lean burn engines, for example, achieve better combustions by ensuring that air and fuel are mixed in the right proportion in the combustions chamber of an engine. The amount of pollutants emitted by an engine depends not only on the quality of fuel but also on how efficiently that the fuel is burnt. Lean burn engines, for example, achieve better

[144] Abdulla A.A. (2007) *In-Depth Technology Needs Assessment on Transport Sector*, Ministry Of Environment, Energy And Water, July
[145] Birmingham Low Carbon Transport Strategy (2012) Birmingham City Council.
[146] Abdulla A.A. (2007) *In-Depth Technology Needs Assessment on Transport Sector*, Ministry Of Environment, Energy And Water, July
[147] Ministry of Environment and Energy (2014) *Maldives Low Carbon Development Strategy*, Joergen Fenhann from UNEP Risoe Centre (URC) and Marianne Ramlau consultant to URC, June
[148] Catalyst Converters have their drawbacks. Converters begin to work only when the exhausts warm, which happens only after the engine has been running for a while – at the point of start, when emissions are maximum, the converters are ineffective. Cars fitted converters cannot run on petrol that contains lead because it "poisons" the catalyst. Devices that trap the pollutants emanating from diesel-powered vehicles, especially buses and lorries are known as after "treatment" devices. Most of them can work on ultra-low-sulphur diesel (o.005% sulphur). *See* Abdulla A.A. (2007) *In-Depth Technology Needs Assessment on Transport Sector*, Ministry Of Environment, Energy And Water, July

		combustions by ensuring that air and fuel are mixed in the right proportion in the combustions chamber of an engine. Type of alternative engines are:[149] • *Gasoline Direct Injection;* • *Advanced Diesel Engines;* • *Sequential Spark Ignition;* • *Variable Valve Timing and Lift;* • *Cylinder Deactivation;* • *Variable Displacement;* • *Variable Compression Ratios;* • *Idle Stop;* • *Advanced Transmissions;* • *Supercharging and Turbocharging; and* • *Diesel Vehicles Direct-injection Lean-burn Diesel Engines.*[150] ➢ **Regulate Vehicle Inspections and Air Quality Emissions Testing –** The current regulation on the testing for road worthiness needs to be revisited and the measures for non-compliance needs to be strengthened to ensure less emission by vehicles.[151] Implementation of air quality emissions testing and vehicle inspection mechanisms are identified mitigation strategies by the National Assessment on Climate Change report of the Maldives.[152]
5. Promote Low Carbon Vessel Technology	**Timeline for Action:** Short to Medium Term	➢ **Promote Technology for Maritime Transport** - the growth in the maritime transportation sector will also increase the use of energy for its operations.[153] By using a range of business-as-usual rapid ton-mile growth scenarios, a 2009 International Maritime Organization (IMO) study projects that by 2050 the baseline world international maritime

[149] See Abdulla A.A. (2007) *In-Depth Technology Needs Assessment on Transport Sector*, Ministry Of Environment, Energy And Water, July

[150] Such engines generally offer an approximate 20-25% efficiency gain when compared to a similar gasoline engine. However, diesel engines are inherently more polluting that petrol engines. See Abdulla A.A. (2007) *In-Depth Technology Needs Assessment on Transport Sector*, Ministry Of Environment, Energy And Water, July.

[151] Ministry of Environment and Energy (2014) *Maldives Low Carbon Development Strategy*, Joergen Fenhann from UNEP Risoe Centre (URC) and Marianne Ramlau consultant to URC, June

[152] National Assessment Report of Maldives (2010) Department Of Climate Change And Energy, Ministry Of Housing, Transport And Environment.

[153] The marine mode alone consumed 1.22 quadrillion Btu of energy in 2009. *See* The International Council of Clean Transportation (2011) *Reducing Greenhouse Gas Emissions from Ships*, Cost Effectiveness of Available Options, July.

	Actors: Transport Authority **Avenue for Further Research**: Yes	CO_2 growth will range from 220–310%, with a 265% average. Without technology improvements, the high end estimate is a 723% CO_2 increase, providing a major incentive for improvement. Studies evaluated options to improve international marine energy intensity through better ship design, engine and driveline efficiency waste heat recovery, and operational changes. These studies also examined wind and solar options to improve energy efficiency. The projected range of energy intensity reduction is 25%-75% by 2050. Also evaluated were several reports on inland waterway transport that projected a potential for 15% improvement in energy intensity by 2030 and 30% by 2050. [154] To achieve this, various methods for GHG reduction technology has been recommended, such as: • *Water injection and water emulsion;* • *HAM, Humid Air Motor;* • *Selective Catalytic Reduction, SCR;* • *Control technology for the control of ship;* • *Control Technology Developments;* • *Approaches to Reducing Shipping Emissions;* • *Lower Sulphur Content in Fuel; and* • *NOx Reduction Measures.*[155] ➢ **Development of Hybrid Vessels -** According to the National Assessment Report on Climate Change of the Maldives (2010), development of hybrid vessels is a priority. [156] ➢ **Promote the Use of Solar Power on Vessels -** Vessels use diesel to run the engine and diesel gen sets for electricity demands including for desalination. Mitigation options include solar panels and waste heat from the engine used for hot water. In addition solar power vessels could be used for short recreational trips. This has been tried out in Maldives with a diving boat. In many countries vessels have small PV or wind turbine installed to deliver power to electrical applications on the boats. [157]

[154] US Department of Energy (2013) Transportation Energy Futures Series: Potential For Energy Efficiency Improvement Beyond The Light-Duty-Vehicle Sector, February
[155] Abdulla A.A. (2007) *In-Depth Technology Needs Assessment on Transport Sector*, Ministry Of Environment, Energy And Water, July
[156] National Assessment Report of Maldives (2010) Department Of Climate Change And Energy, Ministry Of Housing, Transport And Environment.
[157] Ministry of Environment and Energy (2014) *Maldives Low Carbon Development Strategy*, Joergen Fenhann from UNEP Risoe Centre (URC) and Marianne Ramlau consultant to URC, June

6. Promote Low Carbon Aircraft Technology	**Timeline for Action:** Short to Medium Term **Actors:** Civil Aviation Authority **Avenue for Further Research**: Yes	➢ **Promote Technology for Aviation -** Historically, technology enhancement in airframe and engine design, air traffic control, and airport operation, etc. has improved fuel efficiency in the air transport sector over the years. Trends in improving efficiency levels have shown that aircraft entering today's fleet are around 80 percent more fuel-efficient than they were in the 1960s. These efficiency levels have been achieved with step changes in design—such as the introduction of turbofan engines with increasingly high bypass ratios—coupled with year-on-year "incremental" improvements to engine design and operation. Technology has by far the best prospects for reducing aviation emissions. The industry is making great advances in technology such as: revolutionary new aircraft designs; new composite lightweight materials; radical new engine advances; and the development of sustainable alternative jet fuels that could reduce CO_2 emissions by 80 percent, on a full carbon life-cycle basis.[158] ➢ **Improve Operations -** Improved operational practices, including reduced auxiliary power unit usage as well as more efficient flight procedures and weight reduction measures have the potential of reducing CO2 emissions. [159]
7. Encourage Low Carbon Modes of Transport	**Timeline for Action:** Short to Medium Term **Actors:** Transport Authority, Ministry of Environment, Housing Development Corporation **Avenue for Further Research**: Yes	➢ **Promote Smarter Choices of Transport** – Promote low carbon transport modes as "Smart Choices" in order to influence people's behavior towards more sustainable modes. Changing travel behavior can reduce transport carbon emissions, improving quality of life and reducing congestion. These choices often include interventions which are easy, do not restrict choice and work with human behavioral tendencies to encourage "good" choices. ➢ **Maximizing the Potential and Attractiveness of Low Carbon Transport**- Maximizing the potential and attractiveness of the Smart Choices in transport. ➢ **Designate Lanes for Bicycles and Push bikes -** More incentives needs to be in place to promote bicycle lanes giving preference to push bikers. As Hulhumale' is one of the recently designed islands, the use of push bikes needs to be promoted on the island.[160]

[158] World Bank (2012) *Air Transport and Energy Efficiency*, Transport Papers TP-38, February
[159] World Bank (2012) *Air Transport and Energy Efficiency*, Transport Papers TP-38, February
[160] Ministry of Environment and Energy (2014) *Maldives Low Carbon Development Strategy*, Joergen Fenhann from UNEP Risoe Centre (URC) and Marianne Ramlau consultant to URC, June

8. Develop Transport Sector through Urban Planning	**Timeline for Action:** Short to Medium Term **Actors:** Transport Authority, Ministry of Housing and Infrastructure, City/Island Councils **Avenue for Further Research**: Yes	➢ **Develop Transport Sector through Urban Planning** - Transportation planning can integrate transportation and land use planning to reduce travel distances, promote low carbon alternatives, and improve the operating efficiency of the multimodal transportation network.[161] It is necessary that all levels of government engage in adaptation planning to deal with the consequences of climate change. [162] In urban planning, councils should develop and implement urban transport plans and road side tree planting to make roads pleasant for pedestrians. Urban transport planning initiatives shall reducing dependency and use of the private car as well as promote School Travel Plans (STPs) to encourage greater use of cycling, walking and public transport for trips to/from schools. STPs will typically include promotional and education activities, cycle proficiency training for children (e.g. Bikeability), road safety training, local infrastructure improvements (e.g. cycle parking) and transition training (support for young people's move from primary to secondary school). Furthermore, urban transport planning shall promote Workplace Travel Plans (WTPs) to reduce the reliance of commuters on cars and to promote travel to/from work by cycling, walking and public transport.[163] ➢ **Transport Time Management** - Synchronizing working hours with school study hours, relocating large offices, and streamlining civic administration to reduce number of visits people are required for routine tasks (i.e. paying electricity, water bills for instance) through information technology (such as internet and mobile phones) are measures that can reduce travel demand.[164] ➢ **Improve Road Safety and Security through Urban Transport Planning**- Ensuring the safety and security of the transport sector is an identified priority in the National Assessment on Climate Change report of the Maldives.[165] The security of transport systems must be taken into account without jeopardizing efficient and effective transport operations. Technology based road safety and security applications have proved their effectiveness in ensuring the safety of vulnerable road users such as the elderly.[166] In fact, evidence suggests that vehicular

[161] US Department of Transport (2010) *Transportation's Role in Reducing US Greenhouse Gas Emissions*, Volume 1: Synthesis Report, Report to Congress, April.
[162] Oregon Department of Transport (2012) *ODOT's Climate Change Adaptation Strategy Report*, April
[163] Urban Transport Planning is defined as - Considering more comprehensively how the authority's transport and planning services are delivered in a sustainable way, from inception through to implementation, and how wider partnerships can help to reduce carbon impacts. *See* Birmingham Low Carbon Transport Strategy (2012) Birmingham City Council.
[164] Abdulla A.A. (2007) *In-Depth Technology Needs Assessment on Transport Sector*, Ministry Of Environment, Energy And Water, July
[165] National Assessment Report of Maldives (2010) Department Of Climate Change And Energy, Ministry Of Housing, Transport And Environment.
[166] European Commission (2011), *Intelligent Transport Systems in Action*, Action Plan and Legal Framework for the Deployment of Intelligent Transport Systems (Its) In Europe.

		traffic in Male' is due to parents' fear of traffic accidents and public transport might not arrive on time. Therefore, children will be ferried around in cars and motorcycles in Male'.[167] Safer roads will encourage low carbon modes of transport. ➢ **Population Consolidation in Urban Planning** - Harbors have been established on several islands at huge financial cost even though these facilities cannot be utilized due to the lack of any effective inter island transportation. Populations of the nation are scattered into small island with limited people. Hence traffic alone on any route may not be initially sufficient to make the whole transportation network feasible unless the transportation service providers have been given opportunities to operate ferry terminals and generate revenues. Population consolidation will make these transport infrastructure commercially viable. Furthermore, equitable development between population groups through recognition of the unique nature of each of the atolls, diversity of needs and access to opportunities, services, goods and privileges, is an identified priority.[168] ➢ **Introduce Parking Spaces and Parking Management through Urban Planning** - 66% of available road space is utilized by 4 wheeled (or larger) vehicles. This includes space for both circulation and parking. The net contribution to the transport effort by these vehicles is around 25%. The absence of a policy on parking has resulted in 1/4th of vehicles taking up 2/3rd of available road space. Over 70% of household do not have own parking for vehicles.[169]
9. Enhance Traffic Management	**Timeline for Action:** Short to Medium Term **Actors:** Transport Authority, Traffic Police,	➢ **Traffic Management to Relieve Congestion at Male'** - Traffic management and speed optimization can cut CO_2 emissions.[170] Traffic management encourages the use of public transport and reduce car dependency. Such measures should reduce the number of vehicles entering urban areas, leading to an overall reduction in vehicle emissions.[171] Most of the road transport emissions come from petrol fuelled vehicles like motor bikes and cars which accounts for about 80% of the emissions in Male'. In 2012, for every 3.5 persons living in Male' there was one motor bike and one car for every 50 persons.

[167] Abdulla A.A. (2007) *In-Depth Technology Needs Assessment on Transport Sector*, Ministry Of Environment, Energy And Water, July
[168] Maldives Climate Change Policy Framework, Ministry of Environment and Energy
[169] Abdulla A.A. (2007) *In-Depth Technology Needs Assessment on Transport Sector*, Ministry Of Environment, Energy And Water, July
[170] ADB (2010), Reducing Carbon Emissions
from Transport Projects: Evaluation Report, July.
[171] Abdulla A.A. (2007) *In-Depth Technology Needs Assessment on Transport Sector*, Ministry Of Environment, Energy And Water, July

	City/Island Councils **Avenue for Further Research**: Yes	Congestion control of transport in Male' through electronic toll collection system is a convenient technology that may be feasible in spite of the high initial costs with implementing this technology.[172] ➢ **Promote Vehicle Free Days and Islands –** it is a means of effective traffic management.[173]
10. Establish Public Land Transport Network	**Timeline for Action:** Short to Medium Term **Actors:** Transport Authority, City/Island Councils, Transport Service Providers **Avenue for Further Research**: Yes	➢ **Establishment of an Efficient Land Transport Network** - A well organized and systematic land transport network is not present (both in Malé and outer atolls).[174] As a result usage of privately owned cars and motorbikes, demand for fuel, cost of transport, air pollution and traffic congestions has increased drastically over the years. The Government recognizes transport and connectivity as pivotal in fostering economic growth and social cohesion.[175] Such a network will reduce congestion by taking cars, taxis, motor cycles and even pedestrians off the road.[176] The government has declared to commence an integrated public Mini Bus services for Male', Hulhumale', Addu Atoll, Laamu Atoll, Fuahmulah and Kulhudhufushi road networks with 16 to 20 seater high roof mini buses, based on a careful root planning.[177]

[172] Ministry of Housing and Environment (2010), *National Economic Environment Development Studies (NEEDS),* June

[173] Ministry of Environment and Energy (2014) *Maldives Low Carbon Development Strategy*, Joergen Fenhann from UNEP Risoe Centre (URC) and Marianne Ramlau consultant to URC, June

[174] In fact, maintaining a successful and sustainable transport network will be one of the vital components in growing and strengthening the economy without losing sight of our environmental responsibilities. See Birmingham Low Carbon Transport Strategy (2012) Birmingham City Council.

[175] National Assessment Report of Maldives (2010) Department Of Climate Change And Energy, Ministry Of Housing, Transport And Environment.

[176] Abdulla A.A. (2007) *In-Depth Technology Needs Assessment on Transport Sector*, Ministry Of Environment, Energy And Water, July; The most cost-effective urban mobility improvements are typically improvements in bus operations, replacing inefficiently run small buses in mixed traffic with high capacity buses operated on rights-of-way that give priority to these vehicles, bus stations, and improving conditions for walking and cycling in public transport corridors. See ADB (2010), Reducing Carbon Emissions from Transport Projects: Evaluation Report, July.

[177] Ministry of Housing and Environment (2010), *National Economic Environment Development Studies (NEEDS),* June

11. Establish Public Maritime Transport Network	**Timeline for Action:** Short to Medium Term **Actors:** Transport Authority, City/Island Councils, Transport Service Providers **Avenue for Further Research**: Yes	➢ **Develop an Integrated Maritime Transport Network** - The integrated ferry transport system for Male' Urban Region must replace the existing spoke and hub system, where all ferries must always transit Male' as the hub,[178] as well as reduce idle time at the terminals or harbors.[179] A number of ferries are operated by island communities, private parties or the Maldives Transport and Contracting company. However, the scheduled ferry services network in the Maldives is still very limited.[180] Developing integrated ferry services in the atolls as well as between atolls to reduce the ad hoc movement of boats would reduce GHG emissions. The network must be carefully designed with more direct (short) routes for ferries.[181] ➢ **Develop Freight Network for Tourist Resorts** - Establish ferry links for freight logistics for tourist resorts.[182]
12. Improve Public Air Transport Network	**Timeline for Action:** Short to Medium Term **Actors:** Transport Authority, City/Island	➢ **Increase Number of Passengers per Flight** - In terms of mitigation, there is not much available for the aviation sector. The development of energy efficient and fuel flexible engines are mostly concentrated on large scale commercial airlines. The only options would likely be to increase efficiency in operation and maintenance including through improvement of capacity utilization (number of passengers per flight). [183] ➢ **Improve design of Airport** - Careful planning and design of regional airport hubs could be done so as to reduce the number of flights, [184] thus reducing GHG emissions.

[178] Ministry of Housing and Environment (2010), *National Economic Environment Development Studies (NEEDS),* June

[179] Ministry of Environment and Energy (2014) *Maldives Low Carbon Development Strategy*, Joergen Fenhann from UNEP Risoe Centre (URC) and Marianne Ramlau consultant to URC, June

[180] National Assessment Report of Maldives (2010) Department Of Climate Change And Energy, Ministry Of Housing, Transport And Environment.

[181] Ministry of Environment and Energy (2014) *Maldives Low Carbon Development Strategy*, Joergen Fenhann from UNEP Risoe Centre (URC) and Marianne Ramlau consultant to URC, June; Connect services, markets, people and harbors through and integrated transport system which will ensure equal access to affordable transportation for all citizens.

[182] National Assessment Report of Maldives (2010) Department Of Climate Change And Energy, Ministry Of Housing, Transport And Environment; Improving the efficiency of the movement of freight minimize the carbon impact. Birmingham Low Carbon Transport Strategy (2012) Birmingham City Council.

[183] Ministry of Environment and Energy (2014) *Maldives Low Carbon Development Strategy*, Joergen Fenhann from UNEP Risoe Centre (URC) and Marianne Ramlau consultant to URC, June

[184] Ministry of Environment and Energy (2014) *Maldives Low Carbon Development Strategy*, Joergen Fenhann from UNEP Risoe Centre (URC) and Marianne Ramlau consultant to URC, June

	Councils, Transport Service Providers **Avenue for Further Research**: Yes	
13. Promote the Use of Low Carbon Fuel Technology and Alternatives to Fossil Fuels	**Timeline for Action:** Medium Term **Actors:** Transport Authority, Ministry of Environment **Avenue for Further Research**: Yes	➢ **Promote the Use of Low Carbon Alternative Fuels** - The transport sector accounts for 22% of global energy use.[185] World transport energy use and emissions are projected to increase by more than 50% by 2030 and will more than double by 2050 in a business-as-usual scenario. Virtually all (>95%) of transport energy comes from oil-based fuels, predominantly diesel and gasoline.[186] In 2012, an assessment of the increase in CO_2 emissions from global economic growth (in GDP) points to a shift towards less fossil-fuel intensive activities and to the more use of alternative fuels for increased energy savings.[187] Rising oil prices and concerns over limited resources incentivize the introduction of alternative fuels and vehicles, e.g. plug-in hybrids and electric vehicles.[188] The primary source of energy supplied in Maldives is from imported oil products. Maldives do not have other forms of energy supply coming from nuclear, hydro, biomass or any other sources to mention a few. The only indigenous source of energy used is the solar energy.[189]

[185] Newman P and Kenworthy J. (2011) *Evaluating the Transport Sector's Contribution to Greenhouse Gas Emissions and Energy Consumption*, in Technologies for Climate Change Mitigation for Transport Sector, UNEP and GEF

[186] Creutzig, F., Flachsland, C., McGlynn, E., Minx, J., Brunner, S., Edenhofer, O. (2010). CITIES: Car industry, road transport and an international emission trading scheme – policy options.

[187] Trends in Global CO2 Emissions (2013) *Background Study Report 2013*, PBL Netherlands Environment Assessment Agency, Joint Research Center of European Commission.

[188] Creutzig, F., Flachsland, C., McGlynn, E., Minx, J., Brunner, S., Edenhofer, O. (2010). CITIES: Car industry, road transport and an international emission trading scheme – policy options; Land transport will remain a key sector in climate change mitigation during the next decades. *See* Uherek E. et al (2010) *Transport impacts on atmosphere and climate: Land transport*, Atmospheric Environment 44, p.4772 – 4816; Currently available are vehicles designed to run on propane, electricity, compressed or liquefied natural gas, and battery-electric power, which run on, Ethanol, Bio diesel, Compressed Natural Gas, Propane, Electricity, Hydrogen, Methanol, P-Series Fuel and Energy from Fuel Cells. See Abdulla A.A. (2007) *In-Depth Technology Needs Assessment on Transport Sector*, Ministry Of Environment, Energy And Water, July; See also Institute Of Transportation Studies At University Of California (2011) *Sustainable Transportation Energy Pathways*, A Research Summary For Decision Makers.

[189] Maldives Energy Authority (2014), Maldives Energy Balance 2010 to 2012.

		➢ **Introduction of Fuel Cells** - Fuel cells are a pollution-free power source for automobiles.[190] ➢ **Use of bioFuels** - Transport sector offers mitigation opportunities by switching to biodiesel. Biofuels could make a potentially significant contribution for all types of road transport, including hybrid and plug-in hybrid vehicles. Given likely supply limitations, their optimal transport use in the long term might be for long haul trucks/ buses and aviation, where alternatives to liquid fuels are not presently viable.[191] In the short term, use of biofuels in transport, such as petrol-ethanol blends, could be introduced for vehicles. It was estimated that about 15% ethanol can be blended and used without having to modify the vehicles. The goal of attaining 10% biofuels of transport fuels by 2015 and increase it to 20% by 2020 is a challenge considering also the prices of biofuels versus fossil fuels. However, technically 20% blends of biodiesel and 15% blends of bio ethanol are reachable with little or no capital investment in the sector. A policy directive to the main fuel importer to import 10% or 20% blends of biofuels would allow the transport sector to utilize this fuel and to reduce emissions of GHG. It would also help reduce other major pollutants like particulate matter, hydrocarbons, sulphur oxides and carbon monoxide. A more aggressive target might need to be set for the share of biofuels in transport sector for example by using exclusively biofuels in marine transport. Obviously, this comes at extra costs as it requires some modifications to the existing motors used in transport. Thus, such a target might be ideally set for a longer term of next 10 to 15 years. These options would help reduce GHG-emissions from the transport sector by 19%. In order to become carbon neutral in 2020, there would remain GHG-emissions of about 450 ktCO2e from the transport sector that would require offsets.[192] ➢ **Use of Hydrogen** - Hydrogen offers the potential of a high energy density synthetic chemical fuel that can be flexibly produced from a variety of sources and consumed in fuel cells.[193]

[190] Abdulla A.A. (2007) *In-Depth Technology Needs Assessment on Transport Sector*, Ministry Of Environment, Energy And Water, July
[191] Imperial College London (2010) *Road transport technology and climate change mitigation,* Grantham Institute for Climate Change, Briefing paper No 2, October.
[192] Ministry of Environment and Energy (2014) *Maldives Low Carbon Development Strategy*, Joergen Fenhann from UNEP Risoe Centre (URC) and Marianne Ramlau consultant to URC, June
[193] Imperial College London (2010) *Road transport technology and climate change mitigation,* Grantham Institute for Climate Change, Briefing paper No 2, October.

		➢ **Establishment of Fuel Quality Testing Mechanisms** - to ensure higher grade of petrol and diesel imported to Maldives.[194] ➢ **Reduce Government Expenditure on Fossil Fuels** - The total CIF value of imported petroleum products stood at US$486 million in 2012, which is a figure equivalent to around 23% of the GDP.[195] This dependency will increase in the future under a business as usual scenario. This will make the Maldives more energy insecure, economically vulnerable and burden the society.[196] ➢ **Investment in Low Carbon Fuel Research -** Investment in low carbon fuel research and vehicle technology will encourage the use of low carbon and electric vehicles, which will in turn minimize the carbon impact on the environment.[197]
14. Increase Fuel Economy and Energy Efficiency	**Timeline for Action:** Medium Term **Actors:** Transport Authority, Ministry of Environment **Avenue for Further Research**: Yes	➢ **Increase Fuel Economy** - Mitigation through improved fuel economy can reach a savings amounts to US$10 million annually. The fuel economy of motor bikes was estimated to be 15km/l on average whereas the fuel economy for these vehicles estimated by manufacturer ranges from 35-55km/l. The road congestion further aggravates the inefficiencies. Assuming that fuel economy can improve from 15 km/l to 25 km/l through better maintenance, demand for petrol by 2020 could decrease with 8.4 ktoe and emissions could drop with 24 $ktCO_2e$.[198] Achieve energy efficiency by adopting: • *More direct(short) routes for ferries;* • *Careful design of an efficient ferry network within and among the atolls;* • *Building boats with efficient hulls and improve the boat building code to incorporate efficient designs and technology;* • *Reduce idle time at the terminals or harbor;* • *Use of more efficient motors;*

[194] Abdulla A.A. (2007) *In-Depth Technology Needs Assessment on Transport Sector*, Ministry Of Environment, Energy And Water, July

[195] Tourism sector is the single most significant economic sector in terms of energy consumption. It accounts for 1/3 of the total energy consumption in Maldives. Maldives Energy Authority (2014), Maldives Energy Balance 2010 to 2012.

[196] Maldives Economic Diversification strategy (2013) Ministry of Economic Development Maldives.

[197] Birmingham Low Carbon Transport Strategy (2012) Birmingham City Council.

[198] Ministry of Environment and Energy (2014) *Maldives Low Carbon Development Strategy*, Joergen Fenhann from UNEP Risoe Centre (URC) and Marianne Ramlau consultant to URC, June.

		• *Sizing the boat to optimize passenger/ load per liter of fossil fuel consumed; and* • *Incorporate renewables to supplement the motors to reduce consumption.*[199] ➢ **Achieve Fuel Economy through Lower Carbon Intensive Modes -** DASH 8 flights consumes less fuel per passenger than twin Otters Sea Planes, namely 4.3 liters per passenger to travel 100 km for DASH 8 versus 7.5 liters per passenger to travel 100 km for twin Otters Sea Planes.[200]
15. Introduce limits on the Importation and Use of Vehicles and Vessels	**Timeline for Action:** Medium to Long Term **Actors:** Transport Authority	➢ **Limitation of Vehicles and Vessels** - The growth in cars is faster in developing countries where growing per capita incomes are boosting car ownership.[201] The rapid growth of road transport has affected health and environment through congestion, car crashes, air pollution and noise.[202] The total registered vehicles have increased more than 295% from 22,303 in 2007 to 65,932 in 2014. In 2012, for every 3.5 persons living in Male' there was one motor bike, and one car for every 50 persons. Most of these vehicles are old and inefficient.[203] Furthermore, the total number of vessels registered has also increased from 7,016 in 2005 to 11,913 in 2014 by approximately 70%.[204] It is imperative to introduce limits on the importation and use of the vehicles as well as vessels by regulating a maximum limit per island.[205]

[199] Ministry of Environment and Energy (2014) *Maldives Low Carbon Development Strategy*, Joergen Fenhann from UNEP Risoe Centre (URC) and Marianne Ramlau consultant to URC, June

[200] 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, as tourists are increasingly switching to larger land based DASH 8 flights rather than going by sea plane. See Ministry of Environment and Energy (2014) *Maldives Low Carbon Development Strategy*, Joergen Fenhann from UNEP Risoe Centre (URC) and Marianne Ramlau consultant to URC, June.

[201] Newman P and Kenworthy J. (2011) *Evaluating the Transport Sector's Contribution to Greenhouse Gas Emissions and Energy Consumption*, in Technologies for Climate Change Mitigation for Transport Sector, UNEP and GEF

[202] WHO (2014) *Developing national action plans on transport, health and environment: A step-by-step manual for policy-makers and planners*, Regional Office for Europe.

[203] Ministry of Environment and Energy (2014) *Maldives Low Carbon Development Strategy*, Joergen Fenhann from UNEP Risoe Centre (URC) and Marianne Ramlau consultant to URC, June; In fact, the vehicle stock is projected to triple between now and 2030 in non-OECD countries. As a result, some developing countries will observe exponential growth in transport fuel consumption. Creutzig, F., Flachsland, C., McGlynn, E., Minx, J., Brunner, S., Edenhofer, O. (2010). CITIES: Car industry, road transport and an international emission trading scheme – policy options.

[204] Abdulla A.A. (2007) *In-Depth Technology Needs Assessment on Transport Sector*, Ministry Of Environment, Energy And Water, July

[205] Ministry of Environment and Energy (2014) *Maldives Low Carbon Development Strategy*, Joergen Fenhann from UNEP Risoe Centre (URC) and Marianne Ramlau consultant to URC, June

16. Develop an Environmentally-Friendly Vehicle (EFV) Rating system	**Timeline for Action:** Medium Term **Actors:** Transport Authority **Avenue for Further Research**: Yes	➢ **Develop an Environmentally-Friendly Vehicle Rating System** - Such systems are designed to measure the total environmental impact of various vehicle models and give an overall "Green Score" to each vehicle model based on its tailpipe pollutant emissions and weight. The system is designed to give manufacturers, consumers, and policy-makers a metric by which to measure the total environmental impact of different vehicle models. The scoring system shall become the base of future policies such as criteria for green procurement of Government vehicles and the application of subsidies or tax-breaks.
17. Re-engineer Roads for Low Carbon Transport	**Timeline for Action:** Medium to Long Term **Actors:** Transport Authority, Ministry of Housing and Infrastructure, City/Island Councils **Avenue for Further Research**: Yes	➢ **Re-engineer roads:** • *For safer pedestrian activity, especially for children and elderly who cannot use motor vehicles;* • *To design streets as a place of community social interactions;* • *To give priority to a modes of public transport and eco-friendly vehicles;* • *Move parking to multi-story garages and limit street parking only where it is required;* • *To eliminate congestion by introducing traffic management; and* • *Introduce physical designs to control vehicle speed.* ➢ **Pedestrian Friendly Routes–** Even though there is considerable pedestrian activity in Male', facilities for pedestrians is grossly under provided. This has resulted in loss of quality of social interaction especially for children and the elderly in Male'. This also encourages unnecessary motorized travel and parking requirements. ➢ **Designation of Cycling and Bus Routes –** it reduces both CO_2 and local pollution.[206] Promoting the use of cycling and bus routes to complement targeted travel planning initiatives.[207]

[206] ADB (2010), Reducing Carbon Emissions from Transport Projects: Evaluation Report, July.
[207] Birmingham Low Carbon Transport Strategy (2012) Birmingham City Council.

18. Establish Energy Efficient Infrastructure	**Timeline for Action:** Long Term **Actors:** Transport Authority, Ministry of Environment, Ministry of Housing and Infrastructure **Avenue for Further Research**: Yes	➢ **Develop Smart Infrastructure -** Decarbonized smart electric grids and electric charging infrastructure are critical to the realization of low-carbon transport goals.[208] Providing the suitable infrastructure (such as lighting, surfaces, way finding and crossings) to support the smarter choices of walking and cycling will enhance the quality of pedestrian and cyclist environments. ➢ **Integration of Vehicle into the Transport Infrastructure -** The streamlining and integration of smart applications within a coherent, open-system design could improve efficiency and usability, reduce costs and enable the 'plug-and-play' integration of new or upgraded applications. Furthermore, cooperative systems (based on exchange of information and communication between vehicles and with the infrastructure) are developing rapidly.[209] ➢ **Develop Fuelling Infrastructure -** Although liquid biofuels could use the same distribution and fuelling infrastructure as fossil fuels, however Hydrogen requires a completely new supply infrastructure and refueling system. [210] ➢ **Installing LED Lighting Technology** - This will reduce the carbon impact of lighting used at transport infrastructure.

[208] Imperial College London (2010) *Road transport technology and climate change mitigation,* Grantham Institute for Climate Change, Briefing paper No 2, October.; A transport system can be considered as smart if it is capable of dealing with new situations (such as concerning safety, traffic congestion, obstacles or modal integration) by linking all sources of data to produce valuable information for transport users and operators. *See* European Commission (2011), *Intelligent Transport Systems in Action*, Action Plan and Legal Framework for the Deployment of Intelligent Transport Systems (Its) In Europe.

[209] European Commission (2011), *Intelligent Transport Systems in Action*, Action Plan and Legal Framework for the Deployment of Intelligent Transport Systems (Its) In Europe.

[210] Imperial College London (2010) *Road transport technology and climate change mitigation,* Grantham Institute for Climate Change, Briefing paper No 2, October.

7. CLIMATE CHANGE ADAPTATION STRATEGIES IN TRANSPORT SECTOR

Climate change will affect a wide array of systems, in a variety of ways; some impacts will occur quickly, while other impacts will occur more gradually over time. Due to this variability, adaptation strategies will vary greatly, from policy changes to technological fixes to adaptive resource management.[211] Adaptation measures (both feasible and implementable) can substantially reduce the potential for damage, while increasing the likelihood that some regions, communities, or individual entities may even be able to take advantage of opportunities created by climate change.[212] Since many transport services strongly depend on weather conditions, it is important to understand if and how these services should be adapted to current and predicted future climate change.[213]

TABLE 7.1

GHG Adaptation Strategies for Transport Sector

ADAPTATION STRATEGIES		REMARKS/DESCRIPTION/ JUSTIFICATION
1. Establish Stringent Laws, Regulations, standards and plans to regulate low carbon transport	**Timeline for Action:** Short Term **Actors:** Transport Authority, Parliament	➢ **Formulate Laws and Regulations for Transport Management** - A low-carbon development path needs it own set of supporting laws including regulations, rules and standards.[214] Formulate Laws and Regulations mandating: • *Continuous transport planning;* • *Data collection;* • *Determining quality and capacity of vehicles that can be sustained in each island;* • *Control on taxes for importations;*

[211] Adaptation strategies are actions by individuals or systems to avoid, withstand, or take advantage of current and projected climate changes and impacts. See Oregon Department of Transport (2012) *ODOT's Climate Change Adaptation Strategy Report*, April

[212] Abdulla A.A. (2007) *In-Depth Technology Needs Assessment on Transport Sector*, Ministry Of Environment, Energy And Water, July

[213] Potsdam Institute for Climate Impact Research PIK (2011) *Adaptation to Climate Change in the Transport Sector: A Review*, No.122.

[214] United Nations (2010) *Low-carbon Development Path for Asia and the Pacific: Challenges and Opportunities for the Energy Sector*, Energy Resources Development Series 41, December; Laws will play a major role in the green development of the Maldives. See The Maldives's 2009 Carbon Audit (2010) Ministry of Housing and Environment, November.

		• *Parking space requirement and parking fees; and* • *Development of alternative fuels and eco-friendly taxi, bus, ferry and air services.*[215] ➢ **Formulation of Transport System Efficiency Strategies** – Such strategies reduce the energy use and GHG emissions of travel by optimizing the design, construction, operation, and use of transportation networks.[216] ➢ **Formulate Laws and Regulations on Emission Standards for the Transport Sector** – Stringent laws and regulations play a role to promote low carbon adaptation.[217]The Asian Development Bank has estimated that the emissions from the transportation sector of the Maldives will reach nine hundred thousand tCO_2e by 2020, which will inflate further by an additional one million tCO_2e to 1.9 million tCO_2e by 2030.[218] This is a 624.6% increment compared to the GHG emissions in 2012. A significant portion of global CO_2 emissions is a byproduct of fossil fuel combustion from human activity. Most such combustion occurs in the production of energy, and about a third of this involves transportation.[219] These assumptions are more or less consistent with the business as usual scenarios of the Maldives Low Carbon Development Strategy (2014)[220] and the Maldives Carbon Audit of 2009.[221] Regulations, such as fuel economy standards, can be used to increase the efficiency of energy use or to change the properties of transportation fuels.[222] Formulation of laws and regulations on emission standards for the transport sector is a priority for the government.[223]

[215] Abdulla A.A. (2007) *In-Depth Technology Needs Assessment on Transport Sector*, Ministry Of Environment, Energy And Water, July
[216] US Department of Transport (2010) *Transportation's Role in Reducing US Greenhouse Gas Emissions*, Volume 1: Synthesis Report, Report to Congress, April.
[217] Aparicio Á. (2013) *Support to transport and environment assessments Adaptation to Climate Change in the Transport Sector*, ETC/CCA Technical Paper 03/2013, 30 September.
[218] ADB (2012) *Economics of Reducing Greenhouse Gas Emissions in South Asia: Options and Costs*, Financed under ADB-Australia South Asia Development Partnership Facility.
[219] Hartgen D.T et al (2011) Impacts of Transportation Policies on Greenhouse Gas Emissions in U.S. Regions, Policy Study 387, November
[220] Ministry of Environment and Energy (2014) *Maldives Low Carbon Development Strategy*, Joergen Fenhann from UNEP Risoe Centre (URC) and Marianne Ramlau consultant to URC, June
[221] The Maldives's 2009 Carbon Audit (2010) Ministry of Housing and Environment, November.; Ministry of Housing, Transport and Environment (2010) *Report on Energy Supply and Demand 2008-2009*, Technical assistance by UNDP and GEF, August.
[222] Abdulla A.A. (2007) *In-Depth Technology Needs Assessment on Transport Sector*, Ministry Of Environment, Energy And Water, July
[223] Ministry of Environment and Energy (2014) *Maldives Low Carbon Development Strategy*, Joergen Fenhann from UNEP Risoe Centre (URC) and Marianne Ramlau consultant to URC, June

		➢ **Formulation of Low Carbon Fuel Strategy for the Transport Sector -** Development of a long term and coherent fuel strategy for transport is an identified priority for the Maldives.[224] A low carbon fuel standard, mandates a specific overall decrease in the average carbon intensity of all fuels and, it accounts for the carbon emissions of each individual fuel including non-conventional fossil fuels.[225] ➢ **Formulate Low Carbon Intensive Standards for Boat Building** - Building boats with efficient hulls and improved boat designs and technology, through effective boat building standards, will increase fuel economy.[226] ➢ **Formulation of Low Carbon Master Plan for Transport Sector** - The sector lacks a development master plans much less a sector specific policy document which address the emissions issues in the sector. A national transport master plan was drafted in 2003 and second document named 'Domestic Maritime Transport Master Plan' was compiled in 2009. None of these plans as well as laws and regulations applicable to transport in the Maldives stipulate specific measures to mitigate GHG emissions to curb climate change. ➢ **Formulation of Standards for Resorts -** energy use in the transport for tourism sector and for their leisure activities, are the fastest growing emissions sectors in Maldives. ➢ **Formulation of Standard for Live-aboard Safari Vessels -** According to the draft 4th Tourism Master Plan, the most significant regulatory reforms required for the tourism sector in the environmental arena at present includes new environmental regulations for live-aboard vessels.[227] ➢ **Formulation of Regulations for Buildings** – Many office buildings and commercial establishments are putting up building without a fraction of the required parking. Every new vehicle that is imported will need approximately two new parking spaces apart from

[224] National Assessment Report of Maldives (2010) Department Of Climate Change And Energy, Ministry Of Housing, Transport And Environment.; Ministry of Environment and Energy (2014), *Environment and Social Management Framework for the proposed Solar PV Projects,* March.
[225] Creutzig, F., Flachsland, C., McGlynn, E., Minx, J., Brunner, S., Edenhofer, O. (2010). CITIES: Car
industry, road transport and an international emission trading scheme – policy options.
[226] Ministry of Environment and Energy (2014) *Maldives Low Carbon Development Strategy*, Joergen Fenhann from UNEP Risoe Centre (URC) and Marianne Ramlau consultant to URC, June
[227] Ministry of Environment and Energy (2014) *Maldives Low Carbon Development Strategy*, Joergen Fenhann from UNEP Risoe Centre (URC) and Marianne Ramlau consultant to URC, June

		space for circulation. The regulations will ensure that every new building in the country complies with the requirements of parking and energy mitigation.[228] ➢ **Formulation of Regulation for Transport Sector at Outer Atolls** - Road transport in the atolls is considerably small in terms of energy consumptions and emissions. However, the decentralized development in the recent past has increased GHG-emissions from road transport in atolls. The emissions increased from 1.85ktCO_2e in 2003 to estimated 20ktCO_2e in 2012 in the outer atolls (i.e. at a much faster rate than in Malé). So far the road transport in atolls does not face the issues that Malé is facing at the moment, but there is possibility of the same issues being replicated in some of the islands if the sector is not regulated.[229] The petrol energy consumption by cars at outer atolls jumped from 13% at 2010 and 2011 to 28% in 2012. ➢ **Formulate Policies to Foster Public-Private Partnership** - Make transport more environmentally sustainable by seeking public private partnerships in adopting low carbon technology, alternative fueling, public awareness and research. ➢ **Formulate Policies to Incentivize the Purchase of Eco-friendly Products in Transport Sector**- Evidence suggests that purchase of environmentally preferred products leads to reduction of negative impacts to the environment.[230]
2. Designation of Realistic Targets	**Timeline for Action:** Short Term **Actors:** Transport Authority, Ministry of Environment	➢ **Designation of Realistic Targets -** The Government has announced its target to become carbon natural by 2020. The aim on carbon neutrality is essentially an emissions target capping eligible greenhouse gas emissions in 2020 at zero. To complement the broader policy of becoming carbon neutral by 2020, the specific policy targets assigned to the sectors are to: • *Establish an integrated public passenger transport service by 2015;*[231]

[228] The Maldives's 2009 Carbon Audit (2010) Ministry of Housing and Environment, November

[229] Ministry of Environment and Energy (2014) *Maldives Low Carbon Development Strategy*, Joergen Fenhann from UNEP Risoe Centre (URC) and Marianne Ramlau consultant to URC, June

[230] Department of Ecology of Washington State (2010) Pathway to GHG Emissions Reduction in Washington State Government: A look at the progress of Washington State agencies working to reduce their greenhouse gas emissions, December

[231] The target to establish an integrated public passenger transport service by 2010 in the National Assessment Report of Maldives (2010) was not achieved. Furthermore, the target to establish an integrated, energy efficient public passenger transport service by 2009 in the Third National Environment Action Plan (2009) as not achieved. See National Assessment Report of Maldives (2010) Department Of Climate Change And Energy, Ministry Of Housing, Transport And Environment.; and Third National Environment Action Plan (2009) Ministry of Housing, Transport And Environment Government Of The Maldives

		• *Reduce CO_2 emissions from light vehicles – the average car fleet should achieve CO_2 emissions of 140g/km by 2015; and* • *By 2015 not less than 10% of transport fuel should consist of biofuels and 20% by 2020.* [232]
3. Conduct Public Awareness Programs on Low Carbon Transport	**Timeline for Action:** Short Term **Actors:** Transport Authority, Ministry of Environment	➢ **Promote Public Awareness on Low Carbon Transport -** Public information and education programs can help markets function more effectively and may lead to significant voluntary efforts to curb emissions and adopt technology to make vehicles and vessels more fuel efficient. Public education and information are powerful and important tools to sway the vehicle/vessel markets by creating mental connections between environmental externalities and particular sizes, kinds, or models of vehicle/vessel.[233] It is imperative to increase awareness of the benefits of sustainable modes or "Smarter Choices" by using a coordinated marketing and communications campaign. [234] ➢ **Awareness Programs to Reduce Negative Public Pressure** - The low-carbon development path should be supported by a number of political constituencies and able to build a broad political consensus. To be politically feasible, policies and measures that attempt to address climate change and energy security must build this political consensus.[235] It may be politically sensitive to impose new regulations limiting traffic by cars, motor bikes and vessels as well as to enforce regulations on parking/vessel berthing.[236] Dissemination of information on the impacts to climate change from the transport sector through awareness programs shall reduce negative public and political pressure.
4. Build Human Capacity at relevant Government Agencies	**Timeline for Action:** Short Term **Actors:** Transport Authority,	➢ **Build Human Capacity at Relevant Government Agencies -** Climate change is expected to have a significant impact on local transport, however the Maldives is yet to place effective regulatory duties on the Transport Authority to have regard to government policies and guidelines on climate change mitigation and adaptation. The difficulty seems to rest with lack of capacity of the authorities regulating the sector. Capacity building, particularly in the government is important in implementing the low-carbon development

[232] National Assessment Report of Maldives (2010) Department Of Climate Change And Energy, Ministry Of Housing, Transport And Environment.
[233] Abdulla A.A. (2007) *In-Depth Technology Needs Assessment on Transport Sector*, Ministry Of Environment, Energy And Water, July
[234] Birmingham Low Carbon Transport Strategy (2012) Birmingham City Council.
[235] United Nations (2010) *Low-carbon Development Path for Asia and the Pacific: Challenges and Opportunities for the Energy Sector*, Energy Resources Development Series 41, December
[236] Ministry of Environment and Energy (2014) *Maldives Low Carbon Development Strategy*, Joergen Fenhann from UNEP Risoe Centre (URC) and Marianne Ramlau consultant to URC, June

	Ministry of Environment	strategy. Capacity building could be facilitated through structured, regularly scheduled interactions among team members, government ministries, experts, and stakeholders, as well as through workshops and meetings centered on cross-sector discussions.[237] The gap analysis of capacity assessment illustrated that there are no or anecdotal evidence of existing capacity in relevant agencies.[238] Building human resources of this sector is an identified priority. [239]
5. Establish Financing Mechanisms for Low Carbon Technology	**Timeline for Action:** Medium Term **Actors:** Transport Authority, Ministry of Finance, Ministry of Environment **Avenue for Further Research**: Yes	➢ **Establish Sustainable Financing Mechanisms to Foster Low Carbon Transportation –** It has been noted that the dearth of investment capital is a major constraint on the low carbon development of the transport sector. It is very important to source finance to the interested private sector parties for the development of the terminals and capital investment of boats to enhance low carbon development.
6. Introduce Subsidies, Taxes and Tax breaks to incentivize low carbon transportation	**Timeline for Action:** Medium Term **Actors:** Transport Authority, Ministry of Finance, Maldives	➢ **Imposition of Taxes on Transport Services -** Vehicle and fuel taxes as well as road and parking pricing schemes, are an important way both to affect manufacturer and consumer behavior and to generate revenue to invest in transportation infrastructure.[240] With taxation, governments decide on a price for the emission of a greenhouse gas such as a tonne of carbon, whether from a power plant, a factory or an aero plane.[241] In stark contrast to policies in many developed countries, Maldives does not presently have a fuel tax to take into account the environmental externalities and energy security concerns of the consumption of oil. Fuel taxation is extremely effective at limiting vehicle use and

[237] United Nations (2010) *Low-carbon Development Path for Asia and the Pacific: Challenges and Opportunities for the Energy Sector*, Energy Resources Development Series 41, December
[238] Abdulla A.A (2007) *Systems' Capacity To Undertake Future Technology Needs Assessment on Climate Change*, Ministry of Environment Energy And Water, December
[239] National Assessment Report of Maldives (2010) Department Of Climate Change And Energy, Ministry Of Housing, Transport And Environment.
[240] Abdulla A.A. (2007) *In-Depth Technology Needs Assessment on Transport Sector*, Ministry Of Environment, Energy And Water, July
[241] Lazarowicz M. (2009) *Global Carbon Trading: A framework for reducing emissions*

	Inland Revenue Authority	encouraging the use of fuel-efficient vehicles, as it is the highest and most visible variable cost incurred during vehicle use. ➢ **Provision of Subsidies** - Financial incentives, in combination with sound information, incentivize the purchase of more energy efficient vehicles and so can accelerate the deployment of energy efficient technologies.[242] Where possible, the private sector should be left to finance new technologies for GHG mitigation. However, if market failures exist governments can use subsidies to support low carbon technologies (particularly in the early stages of development) and behaviors. This is a mechanism that governments already use to address environmental externalities.[243] ➢ **Imposition of Bans -** Banning the import of reconditioned vehicles is a priority.[244] In the past, Government has banned in December 2000, the import of reconditioned motorcycles which have an engine capacity of less than 150 cubic meters into the country. Similarly, a ban was introduced on the import of cars more than 5 years old into the country. [245] ➢ **Provide Tax Breaks for Low Carbon Technology -** The introduction of vehicles standards based of emissions and introduction of incentives in the form of reduced tax for efficient vehicles would increase the mitigation efforts. It would create an economically viable market for high end hybrid vehicles whose fuel efficiency is estimated to be about 2-3 times higher than current vehicles.[246]
7. Establish Carbon Trading	**Timeline for Action:** Medium Term **Actors:** Transport Authority,	➢ **Establish Carbon Trading -** Altogether, to reign in overall GHG emissions in the transport sector and to address the shift of responsibilities upstream of fuel supply chains, transport fuel inclusion to cap-and-trade, complemented by appropriate regulatory policies, such as tank-to-wheel based fuel efficiency metrics, is the most promising policy option for future climate policy regulation of transport sector. [247] Market forces can be harnessed through emission cap-and-trade programs or by using fiscal policies (taxes, subsidies, and

[242] International Energy Agency (2010) *Transport Energy Efficiency: Implementation Of IEA Recommendations Since 2009 And Next Steps*, September.
[243] Lazarowicz M. (2009) *Global Carbon Trading: A framework for reducing emissions*
[244] Ministry of Housing and Environment (2010), *National Economic Environment Development Studies (NEEDS),* June
[245] Abdulla A.A. (2007) *In-Depth Technology Needs Assessment on Transport Sector*, Ministry Of Environment, Energy And Water, July
[246] Ministry of Environment and Energy (2014) *Maldives Low Carbon Development Strategy*, Joergen Fenhann from UNEP Risoe Centre (URC) and Marianne Ramlau consultant to URC, June
[247] Creutzig, F., Flachsland, C., McGlynn, E., Minx, J., Brunner, S., Edenhofer, O. (2010). CITIES: Car industry, road transport and an international emission trading scheme – policy options.

	Ministry of Finance, Maldives Inland Revenue Authority **Avenue for Further Research**: Yes	incentives) to "internalize" the value of reducing carbon emissions. In particular, internalizing the externality of climate change through carbon cap-and-trade systems or direct pricing of the carbon content of motor fuels is an especially attractive option. An even greater impact can be achieved by redistributing certain fixed costs of motor vehicle travel so that they fall on carbon fuels. One example is collecting a portion of vehicle insurance fees as a surcharge on motor fuel.[248] Cap and trade is capable of delivering emissions reductions effectively, efficiently and equitably, and should play a central role in emissions reduction strategies. By putting a price on emissions, it can provide clear signals against which consumers, producers and investors can make decisions.[249] The Ministry of Housing and Environment has recognized that carbon credit point trading as a option to reduce GHG emissions. [250]
8. Invest in Research and Development	**Timeline for Action:** Medium Term **Actors:** Transport Authority, Ministry of Environment	➢ **Invest in Research and Development -** Research and development in new low carbon technologies is essential to tackle climate change. Government funding and investment can create innovative approaches to greenhouse gas abatement which would not necessarily be stimulated by a carbon price.[251]Consumers and businesses acting according to self-interest will not fully consider the need to reduce GHG emissions when they purchase vehicles and fuels and decide how much to travel. Economists call this a public good externality, because the costs and benefits of controlling it are external to market decision-making. If the market does not fully value reducing GHG emissions, firms will under-invest in research and development to create new, less polluting technologies. Without collective action to curb public good externalities, market economies will produce excessive amounts of environmental pollution. A wide variety of policies and measures are available to governments to correct this problem. Governments can directly invest in research and development or can partner with industry to accelerate technological progress. [252]

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8. CONCLUSION

Maldives is extremely vulnerable to the global problem of climate change. Transport sector in the Maldives is considered as one of the most energy consuming sectors and it is estimated that 25% of GHG emissions in the Maldives are accounted for the transport sector. Furthermore, GHG emissions in the transport sector is increasing rapidly, mainly due to increased economic development and continued increase in aviation, sea and land transportation. In fact, the total registered vehicles have jumped more than 295% from 2007 to 2014, and the vessel registrations have increased by approximately 70% during the period 2005 to 2014.

Maldives is committed to ensuring that sustainable transport, carbon awareness and smarter choice travel principles are at the heart of people's everyday lives. The Low Carbon Strategies proposed illustrate how the transport network will face the challenges while at the same time make significant improvements to the quality of life for all who live, work and travel in the Maldives.

The Low Carbon Strategies for Transport Sector consist of 18 GHG mitigation strategies as well as 8 adaptation strategies. Reducing the need to travel, promoting eco-driving behavior supported by an effective mechanism for the collection, management and sharing transport information have been identified as short term mitigation strategies. Promoting of low carbon technology for vehicles, vessels and aircrafts as well as encouraging low carbon modes (in other words "Smart Choices") of transport are mitigation strategies to be implemented in the short to medium term.

Development of transport sector through urban transport planning, traffic management and the establishment of integrated transport networks (for land, maritime and air) are mitigation strategies to be implemented in the short to medium term. Furthermore, promoting the use of low carbon fuel technology and alternatives to fossil fuels, along with increasing fuel economy and energy efficiency are proposed GHG mitigation strategies. Long term GHG mitigation strategies include the introduction of limits on the importation and use of vehicles and vessels, development of an eco-friendly vehicle rating system as well as the establishment of energy efficient infrastructure and re-engineering roads for low carbon transport.

The formulation of stringent laws, regulations, standards and plans to regulate low carbon transport, as well as the designation of realistic targets and the facilitation of public awareness programs on low carbon transport along with building human capacity at relevant government agencies are the adaptation strategies that are to be implemented as a matter or urgency in the short term. Establishment of a sustainable financing mechanism for low carbon technology, carbon trading and investment in research and development, as well as the introduction of subsidies, taxes and tax breaks to incentivize low carbon transportation are strategies to be implemented in the medium to long term.

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