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# Maldives Framework Zero Carbon Building Guidance

by The Carbon Advisory Service Ltd., December 2009

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# Maldives Framework Zero Carbon Building Guidance

## 1. Introduction [1]

### 1.1 Context

This Draft Framework Guidance constitutes a first step towards the development of a revised Building Code for the Maldives by raising a number of issues and examples aimed at the development of such a Code. At this stage, it is not intended to be prescriptive. It has been developed towards the creation of a Code which provides an integrating approach to embedding sustainability within buildings in the Maldives, in relation to their conceptualisation, design, construction and operation. The Code will be intended to assist stakeholders in achieving a zero carbon strategy by 2020. It is hoped that the Code will also incorporate solutions to other environmental sustainability issues that can arise, in the interest of providing co-benefits to those actors that are implementing the Code. Ideally, the Code should apply to all new and refurbished buildings from a reasonable period of its introduction in 2010 onwards.

### 1.2 Legislative Provisions

This Framework Guidance is designed to interface with and support amendments to the Republic of Maldives National Building Code 2008 and the Maldives Strategy for Sustainable Development 2009. It provides examples of both prescriptive and performance standards, upon which further detailed guidance documents and project examples would be addressed in the context of amendments to these two Government documents. As such, in relation to carbon reduction and sustainability issues it is submitted that the amended Code would contain similar provisions for **Objective**, **Functional Requirement** and **Performance** criteria, as well as **Acceptable Solutions** and **Verification Methods** for compliance purposes as is referenced in the current Maldives National Building Code.

[1] This Framework Guidance is drawn from selected existing experience in implementing AngloAmerican and European building codes and in their interpretation and adaptation to conditions in the Maldives including experience with practical implementation in developing states including the Maldives. The Guidance relies upon the source references found at the end of this document. At this stage this document only constitutes a Framework approach which will be developed towards the creation of an Amended Building Code taking account of zero carbon and sustainability considerations. It is hoped that a draft of the Amended Building Code will be completed and introduced for a full stakeholder consultation process in the second quarter of 2010.

## 1.3 Definitions

**Zero Carbon** activities are those with zero net carbon emissions. In the context of buildings we mean a fully minimised carbon intensity figure for a particular building project or sector.[2]

**Resort** Sector Building Projects are defined as a planned or existing building (project) for tourism purposes which are privately funded.

**Public Building** Projects are defined as a planned or existing public building (project) which are publically funded by the Maldives Government and align with the categories of 'Institutional and Community' and 'Utility and Municipal' used by the Maldives Ministry of Housing and Urban Development.

**Residential Low Cost** Building Projects are defined as a planned or existing building (project) for residential purposes which are publically funded by the Maldives Government. These align with the category of a 'residential' planning zone used by the Maldives Ministry of Housing and Urban Development.

**Residential Medium and High Cost** Building Projects are defined as a planned or existing building (project) for residential purposes which are privately funded. These align with the category of a 'residential' planning zone used by the Maldives Ministry of Housing and Urban Development.

**Commercial** Building Projects are defined as a planned or existing building (project) for commercial purposes which are privately funded. These align with the categories of a 'commercial' planning zone used by the Maldives Ministry of Housing and Urban Development.

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[2] It is recognised that an actual carbon intensity of zero is inherently unrealistic, and so this Guidance seeks to fully minimise the carbon emissions during construction, energy provision and building use and then provides guidance on further techniques to reduce the carbon intensity of a project or sector to zero overall.

**Industrial** Building Projects are defined as a planned or existing building (project) for commercial purposes which are privately funded. These align with the category of an 'industrial' planning zone used by the Maldives Ministry of Housing and Urban Development.

## 2. Building Guidance

Different applications are best suited to different approaches and therefore different Guidance. The precise nature of this Guidance will need to be discussed and agreed with stakeholders. As a minimum these would include government ministries, but it is important to consult with principal industries and community leaders as well.

Although the commitment is to reduce greenhouse gases, which might be expressed in terms of $CO_2$ equivalent, this might not be the appropriate syntax for the Building Guidance. This cannot be decided until more is known about any nationwide energy strategy. For instance, if a carbon-free national grid is to be instigated, then the purpose of these regulations will be to reduce energy consumption for the purpose of minimising the infrastructure cost, the $CO_2$ having already been avoided.

For now, energy-efficiency shall be used although its meaning ultimately is the avoidance of greenhouse gas emissions from the Maldives as a whole.

At this preliminary stage, the following applications have been identified with some initial ideas on suitable approaches.

*Refurbishments (excluding resort islands)*

With the possible exception of island resorts, most existing buildings are likely to still be occupied in 2020; however the vast majority of these will undergo a refurbishment before this time. This provides an opportunity to mandate an upgrade.

For each refurbishment, minimum standards should be introduced that are attuned to any nationwide energy strategy. Suggestions to be explored are:

- Apply restrictions to the choice of energy-consuming equipment and its control
- Stipulate minimum requirements of building-integrated renewables
- Stipulate minimum requirements of solar treatment at windows

- Stipulate minimum air permeability standards
- Zone for partial and out-of-hours occupancy
- Require that the building is connected to district energy loops
- Others, to be developed

*New-builds (excluding resort islands)*

New-builds offer significantly more scope than refurbishments. There are fundamentally three approaches: elemental, "trade-offs" and energy-based.

The elemental method places limitations on energy-consuming equipment. Some types of equipment might be banned and other types compulsory; equipment may have to meet minimum standards of efficiency or not contain harmful greenhouse gases; building elements such as windows might have to meet minimum solar-control standards or be shaded or not exceed a certain proportion of the external facade.

The advantage with this approach is that it is completely prescriptive and therefore easily applied. The disadvantage is that it limits design flexibility and stifles creativity and innovation.

"Trade-offs" allow more flexibility around the elemental method. For instance, formulae could be written to allow more glazing, but only if it is especially well shaded or that the cooling equipment is especially efficient.

The advantage with trade-offs is that they provide a very prescriptive and formulaic way of increasing design flexibility. Their disadvantage is that the flexibility is limited to the available formulae.

Energy-based methods are not concerned with which technologies are used, provided that the required effect is achieved. For instance, if a building is able to generate all of its cooling using carbon-free solar power, then it might not be necessary to mandate solar shading to windows.

The disadvantage with energy-based methods is in demonstrating that a building will achieve the required standard. To do this it is normal to use energy modelling software for which there are a variety of proprietary packages on the market, but each gives slightly different answers. More significant than differences between the software packages are the differences between assumptions made by modellers – especially where the modeller has a specific point to prove.

Validation of the modelling output requires an independent assessor, ideally equipped and conversant with the same software.

To overcome these problems, other countries, such as EU countries, have introduced standardised modelling tools and methods. But this is a substantial undertaking.

*Resort islands*

Resort islands could use the elemental and trade-off methods, but neither is likely to be sufficiently flexible for their needs. The energy-based method would better suit their requirements, but this obliges the Maldivian Government to develop a complicated national assessment approach.

The alternative is to simply require resort islands to demonstrate, to the Authorities, that they have achieved zero-carbon. The Authorities may, at their discretion, appoint independent external consultants to check the resorts' claims.

Existing resorts would be obliged to submit, to the Authority, their strategy for achieving zero-carbon by 2020. Again, the Authority may employ external consultants to review these strategies.

The Authority shall levy a fee for the review of resorts' applications sufficient to cover administrative expenses and consultants' fees.

## 3. Guiding Sustainability Principles

### 3.1 Social Sustainability

Capacity Building would be undertaken where possible. The education of local labour and management would occur where possible. Embedded costs of labour or management import should be included in the calculations of resource use. Buildings should where possible be in keeping with local cultural norms.

## 3.2 Environmental Sustainability

'Zero Carbon' should be achieved by maximising energy efficiency and taking other measures to reduce GHGs to the maximum extent possible taking account of internationally leading best available technologies. Local materials should be used wherever possible. This should not conflict with other guiding principles.

## 3.3 Economic Sustainability

Local Labour and management should be used where possible. The cost of design should be appropriate to the intended use.

# 4. Preliminary Assessment of GHG Emissions in the Maldives

## 4.1 Introduction

The Maldives was ranked 160th worldwide by volume of carbon dioxide emissions in 2006, contributing 869,000 metric tonnes of annual $CO_2$-equivalent (less than 0.1% of the world's total emissions). The *National Communication* and *Emission summary* document for the Maldives submitted to the UNFCCC suggests that the vast majority of the GHG emissions in the Maldives are in the energy sector (84.32%, 129 Gg $CO_2$ equivalent in 1994), with the remaining emissions pertaining primarily to the waste sector (15,68%, or 24Gg in 1994). According to the first national communication of Maldives to the UNFCCC, emissions from land use, land use changes and agriculture were considered insignificant 'as the islands of the Maldives are sparsely vegetated' and there was no attempt to estimate the role of carbon sinks to offset the total emissions.

The GHG inventory for the Maldives – a requirement under the UNFCCC even for non Annex I countries - was developed using 1994 as the base year. The IPCC *Reference Approach* was applied in the GHG inventory, estimating $CO_2$ emissions from the energy sector and the $CH_4$ emitted by solid waste. Although the tourism sector is responsible for a large proportion of fuel consumption in the Maldives, no attempt was made in the report to estimate the percentage contribution of the tourism sector.

As with other States, the *Emission Summary* or the *National Communication* for the Maldives submitted to the UNFCCC does not present concrete estimations of the percentage contribution of each subsector of the energy and waste sectors to the overall greenhouse emissions. Yet, more comprehensive estimates on the global emissions by sector have been carried out by the International Energy Agency. Although the figures on global emissions are not necessarily representative of the situation in the Maldives, they indicate a pattern of how emissions tend to be distributed by sector. Electricity and heat generation contributed to 41% of the global emissions, followed by contributions from the transport (23%), industry (20%) and residential (6%) sectors.

The *National Communication* for the Maldives highlighted many uncertainties in emissions estimates: including limitations in the statistical data of fuel imports, consumption and energy balances. To develop an initial GHG inventory for the Maldives, the estimated amount of $CO_2$ emitted was validated using an inter-country comparison methodology, which is based on a comparison with $CO_2$ emitted from the small island countries in the Pacific. The methodology takes account of the fact that emission of GHGs depends on the population and type of activities carried out in a given country. So the assumption is that small island countries share similar values and hence emission patterns.

In light of insufficient data on the emissions patterns by sector in the Maldives, this analysis aims to provide preliminary estimations of the levels of greenhouse gas emissions in the Maldives using a cross-country comparative methodology. This is only done to create context for this Building Guidance with a full assessment of sectoral greenhouse gas emissions to be completed in 2010.

In comparative validation terms, a total of five countries were selected in order for the estimations to be drawn upon, all of which are island states in the Indian and Pacific Oceans. The countries were selected on the basis of their geographical, cultural and/or economic proximity to the Maldives. Moreover, only countries that have submitted a more complete breakdown of GHG emissions by sector to the UNFCCC were selected in this preliminary analysis. Hence, although the Maldives shares many similarities with some small island states in the Pacific, only the Cook Islands has been chosen due to the unavailability of data for other countries.

## 4.2 Cross-Country GHG Comparative Analysis

On 6 October 2009 the International Energy Agency (IEA) released a new data set for 2007 emissions that listed about 140 countries.

**Table 1 Country Statistics and Emissions Data**

| Country | GDP (2008) US$ | Population (2008) | Per capita income (2008) US$ | Overall CO2 emissions (in 000's metric tonnes) (2006) | Per capita CO2 emissions (2005) (without LUC) |
|---|---|---|---|---|---|
| **Maldives** | $1.716 billion | 300,000 (2008) (plus expatriates) | $4,400 | 869 | 2.4 |
| **Seychelles** | $779 million | 87,476 | $17,000 | 744 | 7.0 |
| **Sri Lanka** | $40.7 billion | 20.2 million | | 11,876 | 0.7 |
| **Cook Islands** | $183.2 million | 18,027 | $9,100 | 66 | 2.9 |
| **Mauritius** | $8.128 billion | 1,284,264 | $2,100 | 3,850 | 2.7 |

**Source: Figures are from the US State Department (2008) and the IEA (2009)**

As can be seen from Table 1, relative to its GDP and population size the greenhouse gas emissions for the Maldives is closer to those of Mauritius and the Cook Islands, although its total emissions is more similar to the Seychelles. The GDP of Seychelles is about half of that of the Maldives, but its GDP per capita is more than three times higher than for the Maldives. These differences reflect the fact that the Seychelles population is less than a third of that of the Maldives. The differences in GDP, population size and total GHG emissions between the Maldives and Sri Lanka are even more striking. Moreover, as seen in Table 2 there are major differences in the share of GDP per sector in the five countries:

**Table 2 Share of GDP by Sector**

| | Trans-port | Industries (manu-facturing) | Services (incl. Tourism) | Govern-ment | Agricul-ture and fisheries | Others |
|---|---|---|---|---|---|---|
| **Mald-ives** | 20% | 7%; | 33.1% (tourism) | 16% | Agr (2,8%) and fisheries (7%;) | Real State (6%) construction (6%) others |
| **Seyche-lles** | - | Mining (2.5%) Manufacturing (19.7%) | Services (50.4%) | - | Agr (20.5%) | Construction (6.9%) |
| **Sri Lanka** | | 29.4% | Services (60% of GDP): *Major types*-- tourism, wholesale and retail trade, transport, telecom, financial services.<br><br>57,3% | | 13.4% | |
| **Cook Islands** | - | 9.6 % | Financial services (8.2 percent) Other 75.3% | - | 15.1% | |
| **Maur-itius** | - | 19.4% | 8.7% (tourism) Financial services (10.9%) | - | - | - |

Services account for the highest share of GDP for most of the five countries, although in the case of the Maldives a very large share (one-third) of the GDP is specifically attributed to the tourism sector. The share of GDP in the agricultural sector is lower in the Maldives than in most of the other countries, which could explain why the emissions in the sector were considered insignificant in the national inventory for the Maldives.

The differences highlighted above suggest that GHG figures from no single country alone could be sufficient for proper estimations of sectoral GHG emissions in the Maldives to be detailed, calling for a cross-country comparative methodology to be developed.

### 4.3 Emissions by Sector

**Table 3 Emissions by Sector (percentages)**

| | **Energy (total)** | **Energy sector (1): Electricity (power and heat generation)** | **Energy sector (2): Transport** | **Energy Sector (3): Industrial Processes** | **Agriculture** | **Waste** | **Other** |
|---|---|---|---|---|---|---|---|
| **Global ($CO_2$)** | 84% | 41% | 23% | 20% | | | 10% |
| **Maldives** | **84,32% 129Gg** | ***Est. 50,32%** | ***Est. 33%** | **Est >1%** | **0%** | **15,68%** | |
| **Seychelles** | 70,03% | 69,15% (of energy total) | 30,95% (of energy total) | 0% | 10,72% | 19,25% | |
| **Sri Lanka** | 23,25% | 12% | 11% | 0,94% | 39,35% | 36,46% | |
| **Cook Islands** | 98% | 50% | 50% | - | >1% | >1% | |
| **Mauritius** | 85.48% | Total: 45,33%<br><br>37,46% (energy industries)<br><br>8.86% (Other energy sectors) | 36.77% | 4.28% (man made industries and construction) | 6.76% | 3.37% | 0,58% |

Table 3 presents the emissions from the five sectors as required by the COP guidelines, as applied for the five countries under analysis and globally. The energy sector is the highest contribution to the overall emissions globally as well as for all countries surveyed other than Sri Lanka, for which the contribution of the agricultural sector to overall GHG emissions is the highest.

The energy sector is broken down in the table into power generation, transport and industrial processes, in line with the COP guidelines. The present preliminary analysis estimates GHG emissions in the Maldives from industrial processes approximately at less than 1% (in line with Sri Lanka's, in which the sector is also underdeveloped) and transport sector at around 33% (in line with the Seychelles).

This implies that the remaining emissions in the energy sector, i.e. from power generation, would be at around 46.32% - which is in line with the emissions estimated in the sector for the Cook Islands and Mauritius. This is also in line with recent estimates that have put the electricity generation sector at around 50% of the fuel consumption in the Maldives, including 18.31% used for public electricity (or around 270.000MWh), 18.31 % used for private electricity (or around 270.000MWh), 9,15% for desalination (or 108,000 MWh) and other uses (9.15%). Hence the electricity generation sector is the largest consumer of fuel in the Maldives, and is also one of the fastest growing ones, reflecting increased electrification in the islands and the growth in the tourist resorts.

### 4.4 Energy Consumption by Sector

Another more detailed analysis could be developed taking account of the energy use in different economic activities present in the Maldives. Although this detailed analysis is not a requirement under the UNFCCC, breaking down emissions by sector would be useful in the development of a national mitigation plan for the Maldives. At least one of the countries surveyed in this analysis (The Seychelles) has attempted to break down the emissions by different economic sectors.

Table 4 Emissions by economic activities

| | Dome-stic Transport | Ene-rgy Indus-try | Commer-ce | Tou-rism | Man made indust-ries and Constr-uction | Resi dent-ial | Gove-rnm-ent | Agric-ulture and fisher-ies | Oth-ers |
|---|---|---|---|---|---|---|---|---|---|
| Mald-ives | 33% | 10% | 3% | 30% | - | 15% | 3% | Agr (3%) | 3% |
| Seyche-lles | 56% | 8% | 5% | 5% | (3.08%) | 18% | 3% | 2% | 3% |
| Sri Lanka | 59% | 15% | 1% | 5% | | 12% | 2% | 3% | 3% |
| Cook Islands | 50% | 50% | - | - | | - | - | >1% | |
| Maur-itius | 36.77 % | 37,46 % | - | - | 4.28% | - | - | 6.76% | 0,58 % |

Although data for the percentage emissions in some sectors is missing for some countries, this preliminary analysis estimates the emissions in the transport sector in the Maldives to be at around 33%, which is approximately 10 percentage points higher than the global average (23%.) As for energy industries (10%) and commerce (3%), the estimation broadly averages out the emissions in those sectors in Sri Lanka and the Seychelles.

In line with the Maldives' National Communication to the UNFCCC which estimates that one-third of total GHG emissions directly attributed to the tourism sector - which corresponds to the share of GDP in that sector - it has been estimated that approximately 30% of the total GHG emissions in the Maldives could be attributed to the tourism sector. The contributions of the residential sector to GHG emissions in the Maldives is estimated at around 15%, which is fivefold to estimated contributions in government (3%), agriculture (3%) and 'other' (3%) activities.

It is also noticeable that, unlike the National Communication of the Maldives which underlines the analysis in section 2.1., there is an attempt in Table 4 to estimate the emissions in the agriculture sector (3%), which corresponds to the share of GDP in the sector.

### 4.5 GHG Emissions by Sector

In light of the preliminary analysis carried out in Sections 2.1, and taking the IEA's estimates of CO2 equivalent emissions in the Maldives for 2006, we have estimated the following GHG emission levels by sector in the Maldives:

**Table 5 GHG emissions by sector in Maldives (in thousands of metric tonnes of CO2 equivalent)**

| Energy (total) | Energy sector (1): Electricity (power and heat generation) | Energy sector (2): Transport | Energy Sector (3): Industrial Processes | Agriculture | Waste | Other |
|---|---|---|---|---|---|---|
| 732.74 | (Est.) 445.97 | (Est.) 286.77 | (-) | - | $CH_4$ 24 Gg (1994) | |

**Table 6 GHG emissions by sector in Maldives (in thousands of metric tonnes of CO4 equivalent)**

| | Domestic Transport | Energy Industries | Commerce | Tourism | Residential | Government | Agriculture and fisheries | Others |
|---|---|---|---|---|---|---|---|---|
| Maldives | 286,77 | 86.9 | 26.07 | 260.7 | 130.35 | 26.07 | 26.07 | 26.07 |

### 4.6 GHG Emissions by Fuel Type

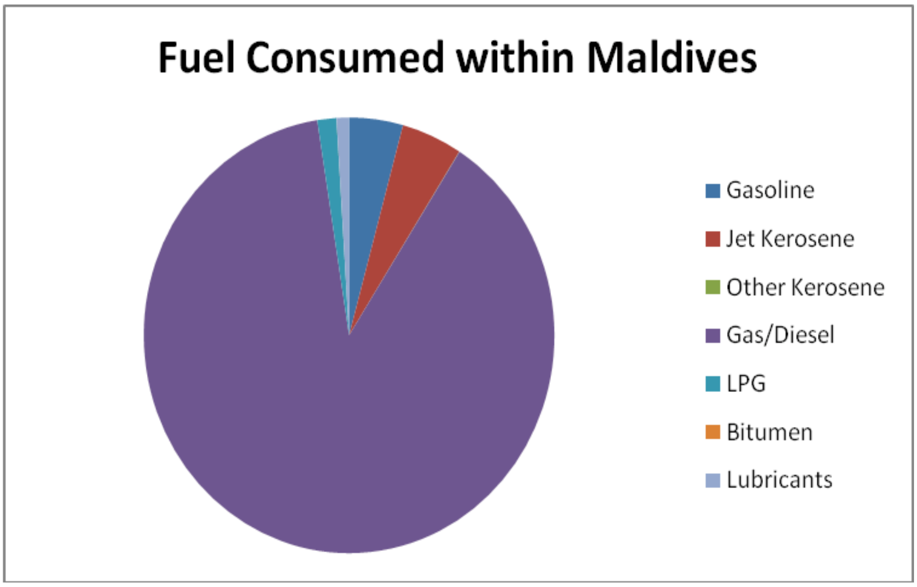
**Table 7 GHG emissions by fuels types**

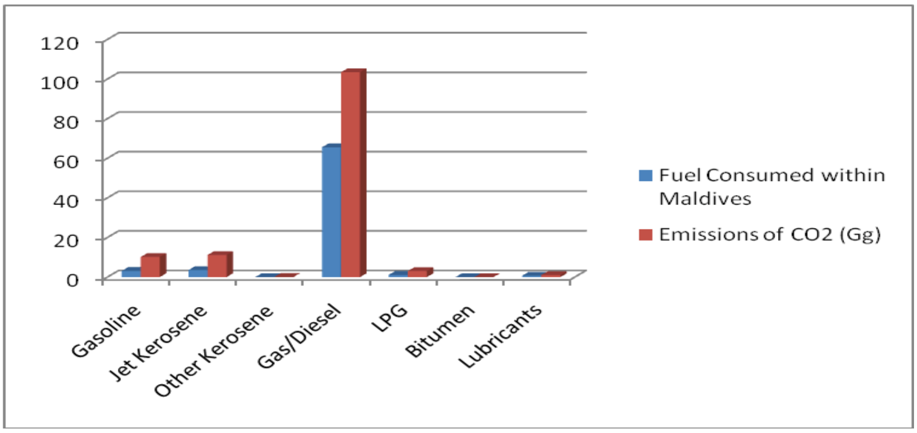
| Fuel Type | Fuel Consumed within Maldives | Emissions of CO2 (Gg) |
|---|---|---|
| Gasoline | 3.127 | 10.182 |

| | | |
|---|---|---|
| Jet Kerosene | 3.541 | 11.175 |
| Other Kerosene | 0.013 | 0.043 |
| Gas/Diesel | 65.556 | 103.465 |
| LPG | 1.107 | 3.033 |
| Bitumen | 0.006 | 0.009 |
| Lubricants | 0.719 | 1.048 |
| Total | **115.246** | **128.995** |

Source: First National Communication of Maldives to the UNFCCC (2000)

Figures 1-4 Fuels consumed in the Maldives



| Fuel Type | $CO_2$ (%) |
|---|---|
| Gasoline | 7.90 |
| Jet Kerosene | 8.67 |
| Other Kerosene | 0.03 |
| Gas/Diesel | 80.23 |
| LPG | 2.35 |
| Bitumen | 0.01 |
| Lubricants | 0.81 |

According to the Maldives' Ministry of Communication Science and Technology Master Plan, fuel consumption increased in Maldives from 1.20 million gallons in 1989 to 3.96 million in 1998. For 1998, electricity utilisation increased from 52.07 million kilowatt hours to 59.33, a one-year increase of almost 14%. The improving energy success is shown by the fact that the percentage of the national population with access to electricity has gone from two-thirds with access to over 90% with access in less than a decade. It has been suggested that electricity generation consumes 2,000 barrels per day (3,000 if you include desalination for freshwater and other components), while cars and small boats (490 barrels) cooking (200 barrels, kerosene) domestic flights (200 barrels) and international aviation (1,600 barrels) contribute to the remaining emissions.

The Maldives' National Communication has estimated the fuel consumption in the country by using a cross-country methodology which takes account of the fuel consumption in a number of Pacific Island states. It is suggested that diesel is the main fuel type consumed to meet the energy demand in the Maldives. Diesel is primarily used to generate electricity and for marine vessels and gasoline is used to power vehicles and speed boats. Although a large quantity of jet kerosene is imported, only 10% of the fuel is used within the country. 90% of the imported jet kerosene is used in intentional aviation bunkering. The large quantity of aviation fuel is internationally bunkered because a large number of tourists travel to and from the Maldives by air.

As seen in figure 1 above, the consumption of gasoline/diesel emits most of the $CO_2$ from the Maldives. This can again be linked to the importance of tourism to the Maldives and its reliance on aviation. The resorts of the Maldives are self-contained and all the facilities, like the generation of electricity and production of freshwater from desalination, depends on burning of diesel. In 1994, 73 tourist resort islands were in operation but this has largely increased since then. Each of these resorts would consume large amounts of diesel to provide the necessary services for the tourists in the resort islands. From the Maldives National Strategy for Sustainable Development 2009, assuming average use of 3,807 litres of diesel per bed and 18,298 beds, the diesel consumption of tourist resorts for electricity generation is estimated to be 70 million litres.

In a Review of the National Inventory for the Maldives, a study suggested that the main concerns arising from the Maldives' Inventory relate to the absence of any data related to the IPCC category of "gasoline", the failure to specify the units for the activity data, the resulting inability to verify if the conversion factors (i.e. the net calorific values, reported in TJ/unit) are correct, and the need to verify the amount of international bunkering.

### 4.8 Conclusion

The objective of this preliminary analysis was to provide context and background for this Zero Carbon Building Guidance. For this narrow purpose, we have also estimated the emissions by sector in the Maldives where inventory data was missing. The numbers will be subject to constant review as the development of this Guidance gathers further information and following a refinement of the cross-country methodology applied. It provides a useful preliminary analysis of the breaking down the emissions by sector in the Maldives until such time as the Government releases its second Communication to the UNFCCC. Following subsequent reviews and methodology refinement this preliminary analysis could provide valuable guidance to the Maldives' mitigation action plan.

## 5. Review of existing, medium-term and long-term nationwide energy supply strategy

Nationwide energy supply strategy is not part of this scope, however the optimum Building Codes cannot be developed in isolation from it as it is essential to know the nature and characteristics of the energy being supplied in order to know best how to use and conserve it.

Similarly decisions regarding the nationwide energy supply strategy should be informed by a clear understanding of available demand-side opportunities, so that supply and demand can be a symbiotic as possible. Moving forward, the energy supply strategy and Building Codes (part of demand strategy) shall be developed in parallel to ensure complete harmonisation and optimum utilisation.

Currently electricity is produced from diesel-powered generators. In the medium-term, by 2030, there are currently plans for a 75 MW (peak) wind farm and 50 MW liquefied natural gas power station. In order to achieve zero-carbon, these supply strategies might be augmented over time. Timelines for updating the supply strategies and Building Guidance will be synchronised.

## 6. Calculation of $CO_2$ building project emissions performance

$CO_2$-equivalent emissions are to be calculated using overall coefficients of (BEF, 2009):

Coal 0.320 kg per kWh of delivered energy;
Wood 0.050 kg/kWh;
Natural gas 0.195 kg/kWh;
LPG 0.235 kg/kWh;
Light heating oil 0.260 kg/kWh;
Electricity from the national grid 0.55 kg/kWh[3]

### Table 8 - E.g. Commercial Sector (Office)

| Energy Standard (Units kWh/m2yr) | | Existing Stock | Qualifying Examples<br><br>Level 1 | Level 2 | Level 3 |
|---|---|---|---|---|---|
| **Delivered Energy** | **Gas or Oil** | 151 | 30 | 18 | 16 |
| | **Electricity** | 85 | 26 | 20 | 20 |
| | **Total** | 236 | 56 | 38 | 36 |
| | **Index** | 100% | 24% | 16% | 15% |
| **Primary Energy** | **Gas or Oil** | 161 | 32 | 19 | 17 |
| | **Electricity** | 236 | 72 | 56 | 56 |
| | **Total** | 397 | 104 | 75 | 73 |
| | **Index** | 100% | 26% | 19% | 18% |
| **CO2 Emissions** | **Gas or Oil** | 29 | 6 | 4 | 3 |
| | **Electricity** | 47 | 14 | 11 | 0 |
| | **Total** | 76 | 20 | 15 | 3 |
| | **Index** | 100% | 26% | 19% | 4% |

[3] This assumes a movement away from diesel-powered electricity.

### 6.1 Further Reductions

As we shall see, further reductions can be achieved by using space external to the building (including landscaping) to introduce carbon negative technologies and techniques to reduce the building's emissions profile further. This may be done on a project–by-project basis but also a sectoral basis by overarching government schemes. Examples of this are use of biochar and reclamation and remediation of Greenfield land, as well as use of PV arrays and solar-thermal technology.

## 7. Building Project Guidance (Prescriptive & Performance)

At this point, the Guidance below seeks to cover both prescriptive and performance options for compliance with either new building projects or existing building retrofits.

<table>
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**7.1 Site**

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**Objective**

1. To reduce pollution from construction activities by controlling soil erosion, waterway sedimentation and airborne dust generation.

2. To avoid the development of inappropriate sites and reduce the environmental impact from the location of a building on a site.

3. To rehabilitate damaged sites where development is complicated by environmental contamination and to reduce pressure on undeveloped land.

4. To reduce pollution and land development impacts from vehicle use.

5. To conserve existing natural areas and restore damaged areas to provide habitat and promote biodiversity.

6. To limit disruption of natural hydrology by reducing impervious cover, increasing on-site infiltration, reducing or eliminating pollution from storm water runoff and eliminating contaminants.

7. To reduce heat islands to minimize impacts on microclimates and human and wildlife habitats.

8. To reduce development impact from lighting on nocturnal environments.

**Functional Requirements**

1. Create and implement an erosion and sedimentation control plan for all construction activities associated with the project. The plan should conform to local or government standards and codes. The plan would describe the measures implemented to accomplish the following objectives:

To prevent loss of soil during construction by storm water runoff and/or wind erosion, including protecting topsoil by stockpiling for reuse.

- To prevent sedimentation of storm sewers or receiving streams.

- To prevent pollution of the air with dust and particulate matter.

2. To ensure that buildings, landscape, roads or parking areas are not developed on portions of sites that are either greenfield sites or on previously undeveloped land that is within 15 metres of the sea.

3. To preferentially develop on a site documented as contaminated or brownfield by a local or government agency. Preference would also

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| | be given to redevelopment of a previously occupied or abandoned site.<br><br>4. To ensure the site located within easy walking distance of local amenities, reducing the requirement for further transport infrastructure.<br><br>5. To restore or protect a minimum of 50% of the site (excluding the building footprint) or 20% of the total site area (including building footprint), whichever is greater, with native or adapted vegetation.<br><br>6. To implement a storm water management plan that prevents the post-development peak discharge rate and quantity from exceeding the predevelopment peak discharge rate and quantity for the 1- and 2-year 24-hour design storms. The plan should reduce impervious cover, promote infiltration and capture and treat the storm water runoff from 90% of the average annual rainfall using acceptable best management practices.<br><br>7. To use a combination of the following strategies to reduce heat islands.<br>- Provide shade from the existing tree canopy or within five years of landscape installation. Landscaping (trees) should be in place at the time of occupancy.<br>- Provide shade using structures covered by solar panels that produce energy used to offset non-renewable resource use.<br>- Place parking spaces (there is a need for this on some islands) under covers. Any roof used to shade or cover parking should be a vegetated green roof or be covered by solar panels that produce energy used to offset non-renewable resource use.<br><br>8. To reduce interior lighting impact by reducing the input power (by automatic device) of all nonemergency interior lights with a direct line of sight to any openings in the building envelope.[4]<br><br>To reduce exterior lighting impact, design exterior lighting so that all site and building-mounted lighting produce a specified maximum initial illuminance value.<br><br>**Acceptable Solution Technologies & Strategies to achieve Performance** |

[4] For an example of greater detail that would be found in an amended Building Code, the glazing areas should be optimised with regard to daylight and solar gains. Lighting within 3m of a window or roof light should be on one photocell control zone, lighting between 3m and 6m from a window or roof light should be on another photosensitive control zone, and lighting further than 6m from a window or roof light should not be on photocell control. Further specifications would be put in place in respect of switching thresholds and dimming options. Photocell-controls on emergency lights may also be specified.

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| | 1. Create an erosion and sedimentation control plan during the design phase of the project. Consider employing strategies such as temporary and permanent seeding, mulching, and sediment traps and basins.<br><br>2. During the site selection process, give preference to sites that do not include sensitive elements. Select a suitable building location and design the building with a minimal footprint to minimize disruption of environmentally sensitive areas.<br><br>3. During the site selection process, give preference to brownfield sites (i.e., sites with previous contaminating uses so that these may be remediated in the interest of land conservation). Identify incentives and property cost savings. Coordinate site development plans with remediation activity, as appropriate.<br><br>4. Provide transportation amenities such as bike racks/showers and/or alternative-fuel refuelling stations/parking. Consider sharing the costs and benefits of refuelling stations with neighbours. Minimize parking lot/garage size. Consider sharing parking facilities with adjacent buildings. Consider alternatives that will limit the use of single occupancy vehicles.<br><br>5. Survey greenfield sites to identify site elements and adopt a master plan for developing the project site. Carefully site the building to minimize disruption to existing ecosystems and design the building to minimize its footprint. Strategies include tuck-under parking and sharing parking facilities with neighbours.<br>- Establish clearly-marked construction boundaries to minimize disturbance of the existing site and restore previously degraded areas to their natural state. For previously developed sites, use local and governmental agencies and native plant societies as resources for the selection of appropriate native or adapted plants.<br>- Prohibit plants listed as invasive or noxious weed species.<br>- Once established, native/adapted plants require minimal or no irrigation; do not require active maintenance such as mowing or chemical inputs such as fertilizers, pesticides or herbicides; and provide habitat value and promote biodiversity through avoidance of monoculture plantings.<br><br>6. Design the project site to maintain natural storm water flows by promoting infiltration. Specify vegetated roofs, permeable paving and other measures to minimize impervious surfaces. Reuse storm water for non-potable uses such as landscape irrigation, toilet and urinal flushing, and custodial uses.<br>- Use non-structural techniques (e.g., rain gardens, rainwater recycling) to reduce imperviousness and promote infiltration and thereby reduce pollutant loadings. Create integrated natural and mechanical treatment systems such as constructed wetlands, vegetated filters and open channels to treat storm water runoff. |

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| | 7. Employ strategies, materials and landscaping techniques that reduce the heat absorption of exterior materials. Use shade from native or adapted trees and large shrubs, vegetated trellises or other exterior structures supporting vegetation.<br>- Consider using new coatings and integral colorants for asphalt. Position photovoltaic cells to shade impervious surfaces.<br>- Consider replacing constructed surfaces (e.g., roof, roads, etc.) with vegetated surfaces such as vegetated roofs and open grid paving or specify materials, such as concrete, to reduce heat absorption.<br><br>8. Adopt site lighting criteria to maintain safe light levels while avoiding off-site lighting and night sky pollution. Minimize site lighting where possible, and use computer software to model the site lighting. Implement technologies to reduce light pollution including full cut-off lights, low-reflectance surfaces and low-angle spotlights. |

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| **7.2 Water** | **Objective**<br><br>1. To increase water efficiency within buildings to reduce the burden on municipal water supply and wastewater systems.<br><br>2. To limit or eliminate the use of potable water or other natural surface or subsurface water resources available on or near the project site for landscape irrigation.<br><br>3. To reduce wastewater generation and potable water demand.<br><br>**Functional Requirements**<br><br>1&2: To ensure no potable water is used. (Option 1). If this is not possible:<br>To employ strategies that in aggregate maximise water-use reduction compared to the water-use baseline calculated for the building. (Option 2).<br><br>Option 1. Use captured rainwater, recycled wastewater, recycled grey water or water treated and conveyed by a<br>Public agency specifically for non potable uses for irrigation. Install landscaping that does not require an irrigation system.<br><br>Option 2. Ensure use reductions are attributed to any combination of the above-mentioned technologies.<br><br>3. To Reduce potable water use for building sewage conveyance by 50% through the use of water-conserving fixtures and/or to: Treat 50% of wastewater on-site to tertiary standards. Treated water should be infiltrated or used on-site.<br><br>**Acceptable Solution Technologies & Strategies to achieve Performance**<br><br>1. Use high-efficiency fixtures (e.g. toilets and urinals) and dry fixtures, such as toilets attached to composting systems, to reduce potable water demand. Consider using alternative on-site sources of water (e.g., rainwater, storm water, and air conditioning condensate) and grey water for non-potable applications such as custodial uses and toilet and urinal flushing. The quality of any alternative source of water used should be taken into consideration based on its application or use.<br><br>2. Perform a soil/climate analysis to determine appropriate plant material and design the landscape with native or adapted plants to reduce or eliminate irrigation requirements. Where irrigation is required, use high-efficiency equipment and/or climate-based controllers. |

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| | 3. Specify high-efficiency fixtures and dry fixtures (e.g., composting toilet systems, non-water-using urinals) to reduce wastewater volumes. Consider reusing storm water or grey water for sewage conveyance or on-site mechanical and/ or natural wastewater treatment systems. Options for on-site wastewater treatment include packaged biological nutrient removal systems, constructed wetlands and high-efficiency filtration systems.<br><br>4. Rainwater harvesting systems should be installed to minimise dependence on municipal water supply. Drought resistant landscaping is mandatory. |

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**7.3 Energy and Emissions**

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**Objective & Prerequisites**

1. To verify that the project's energy-related systems are installed, and calibrated to perform according to the owner's project requirements, basis of design and construction documents.

Benefits of commissioning include reduced energy use, lower operating costs, fewer contractor call-backs, better building documentation, improved occupant productivity and verification that the systems perform in accordance with the owner's project requirements.

2. Consider the use of elemental method, trade-offs and energy-based methods in addressing low carbon energy issues for the proposed building including systems to reduce environmental and economic impacts associated with excessive energy use.

3. Consider using the same methods mentioned in 2 (above) to achieve increasing levels of energy performance beyond the prerequisite standard to reduce environmental and economic impacts associated with excessive energy use.

4. Consider the same methods mentioned in 2 taking account of the need to encourage and recognize increasing levels of on-site renewable energy self-supply to reduce environmental and economic impacts associated with fossil fuel energy use.

5. Consider planning for the ongoing accountability of building energy consumption overtime. Mandatory energy sub-metering and building energy certification along the lines of the European Union's Building Energy Performance legislation (i.e. Energy Performance Certificates at Construction, Sale or Lease) could be considered.

6. In making decisions related to the above, consider the objective of encouraging the development and use of grid-source, renewable energy technologies on a net zero pollution basis.

7. For resorts, in particular, though elemental and trade-off methods may be used, they may lack the inherent flexibility so consider the energy-based method, noting that the Government of the Maldives may well develop a national assessment approach.

8. For resorts, take it as an objective to achieve zero-carbon by self-initiated means leaving it to Government authorities to verify this claim, perhaps with the assistance of external experts.

**Functional Requirements**

The following functional requirements provide an example by way of a specific method that could be applied in building code regulation by

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| | way of an amendment of the current Building Code.<br><br>1. The following commissioning process activities should be completed by the project team: Complete a summary commissioning report.<br>Commissioning process activities should be considered for the following energy-related systems, at a minimum, as applicable:<br>- Heating, ventilating, air conditioning and refrigeration (HVAC&R) systems (mechanical and passive) and associated controls<br>- Lighting and day-lighting controls<br>- Domestic hot water systems<br>- Renewable energy systems (e.g., ocean water cooling, photovoltaic, concentrated solar)<br><br>2. Undertake a carbon and energy intensity study (for process and non-process energy) based on planned installations and individual building use. For the purpose of this study, examples of such process and non-process energy might include, but are not limited to, office and general miscellaneous equipment, computers, elevators and escalators, kitchen cooking and refrigeration, laundry washing and drying, and lighting.<br><br>Examples of regulated (non-process) energy might include but not be limited to lighting (for the interior, parking garage, façade, or building grounds, etc. except as noted above), heating, ventilation and air conditioning (HVAC) (for space heating, space cooling, fans, pumps, toilet exhaust, parking garage ventilation, kitchen hood exhaust, etc.), and service water heating for domestic or space heating purposes.<br><br>3. To achieve this aim, the proposed design could meet the following criteria:<br><br>Documentation of process load energy savings could include a list of the assumptions made for both the base and proposed design, and theoretical or empirical information supporting these assumptions.<br><br>4. To use on-site renewable energy systems to offset building energy costs.<br><br>5. To develop and implement a measurement and verification plan. The plan period could cover at least one year of post-construction occupancy and provide a process for corrective action if the results of the plan indicate that energy savings are not being achieved.<br><br>6. If regulated for, engage in a renewable energy contract to provide a proportion of the building's electricity from renewable sources, using observed or estimated consumption data. |

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| | **Acceptable Solution Technologies & Strategies to achieve Performance**<br><br>1. Systems for energy, water and building envelope must be included in the commissioning plan The building envelope is an important component of a facility that impacts energy consumption, occupant comfort and indoor air quality. While this prerequisite does not require building envelope commissioning, an owner can achieve significant financial savings and reduce risk of poor indoor air quality by including it in the commissioning process.<br><br>2&3: Consider an "elemental" method in designing the building envelope and systems to meet baseline requirements. In the alternative, consider using a computer simulation model to assess the energy performance and identify the most cost-effective energy efficiency measures.<br><br>4. Assess the project for non-polluting and renewable energy potential including solar, wind, biomass, biogas and biochar strategies.<br><br>5. Consider developing a plan to evaluate building and/or energy system performance. Characterize the building and/or energy systems through energy simulation or engineering analysis. Install the necessary metering equipment to measure energy use. Track performance by comparing predicted performance to actual performance, broken down by component or system as appropriate. Evaluate energy efficiency by comparing actual performance to baseline performance.<br>- Measurement & verification activities might not necessarily be confined to energy systems where energy management or energy conservation strategies have been implemented. These strategies could be used in conjunction with monitoring and trend logging of significant energy systems to provide for the ongoing accountability of building energy performance.<br>- For the corrective action process, consider installing diagnostics within the control system to alert the staff when equipment is not being optimally operated. Conditions that might warrant alarms to alert staff could include:<br>Leaking valves in the coils within air handling units;<br>Software and manual overrides allowing equipment to operate 24 hours a day/7 days a week; Equipment operation during unusual circumstances and many others<br><br>6. Determine the energy needs of the building and investigate opportunities to engage in a green power contract if this cannot be produced onsite. |

| 7.4 Materials | **Objective & Prerequisites**<br><br>1. To facilitate the reduction of waste generated by building occupants that is transported to and disposed of in landfills.<br><br>2. To extend the lifecycle of existing building stock, conserve resources, retain cultural resources, reduce waste and reduce environmental impacts of new buildings as they relate to materials manufacturing and transport.<br><br>3. To divert construction and demolition debris from disposal in landfills and incineration facilities. Redirect recyclable recovered resources back to the manufacturing process and reusable materials to appropriate sites.<br><br>4. To reuse building materials and products to reduce demand for virgin materials and reduce waste, thereby lessening impacts associated with the extraction and processing of virgin resources.<br><br>5. To increase demand for building materials and products that are extracted and manufactured within the region, thereby supporting the use of indigenous resources and reducing the environmental impacts resulting from transportation.<br><br>6. To reduce the use and depletion of finite raw materials and long-cycle renewable materials by replacing them with rapidly renewable materials.<br><br>**Functional Requirements**<br><br>1. To provide an easily-accessible dedicated area or areas for the collection and storage of materials for recycling for the entire building. Materials should include, at a minimum: paper, corrugated cardboard, glass, plastics and metals.<br><br>2. As a general rule, to maintain the existing building structure (including structural floor and roof decking) and envelope (the exterior skin and framing, excluding window assemblies and non-structural roofing material) where sustainability considerations suggest that it is sensible to do so. Ultimately, this decision is at the discretion of the project funder noting that demolition and new build is more common for certain uses.[5]<br>- To use existing interior non-structural elements (e.g., interior walls, doors, floor coverings and ceiling systems) in as much of the completed building as possible, including additions.<br><br>3. To recycle and/or salvage nonhazardous construction and |
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[5] It is noted that, in the resort sector, it is not uncommon to demolish guest facilities and then build new ones in less than a ten year time span even where adverse weather is not a factor.

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| | demolition debris. Develop and implement a construction waste management plan that, at a minimum, identifies the materials to be diverted from disposal and whether the materials will be sorted on-site or co-stored.<br><br>4. To use salvaged, refurbished or reused materials in the project as far as possible.<br><br>5. To use building materials or products that have been extracted, harvested or recovered, as well as manufactured, within 500 miles of the project site for as much as possible of the site design unless it can be shown that materials from further afield are more sustainable.<br><br>6. Consider using rapidly renewable building materials and products for as much of the total value of all building materials and products used in the project as possible. Rapidly renewable building materials and products are made from plants that are typically harvested within a 10-year or shorter cycle. Where non-biodegradable products are recyclable then this option could also be considered. Whatever option is selected, first analysing the low carbon and sustainability parameters is a sensible step.<br><br>**Acceptable Solution Technologies & Strategies to achieve Performance**<br><br>1. Designate an area for recyclable collection and storage that is appropriately sized and located in a convenient area.<br>- Identify local waste handlers and buyers for glass, plastic, metals, office paper, newspaper, cardboard and organic wastes.<br>- Instruct occupants on recycling procedures.<br>- Consider employing cardboard balers, aluminium can crushers, recycling chutes and other waste management strategies to further enhance the recycling program.<br><br>2. Consider reusing existing, previously-occupied building structures, envelopes and elements. Remove elements that pose a contamination risk to building occupants and upgrade components that would improve energy and water efficiency such as windows, mechanical systems and plumbing fixtures. Quantify the extent of building reuse.<br><br>3. Establish goals for diversion from disposal in landfills and incineration facilities and adopt a construction waste management plan to achieve these goals. Consider recycling cardboard, metal, brick, mineral fibre panel, concrete, plastic, clean wood, glass, wallboard, carpet fluorescent lamps and insulation. Construction debris processed into a recycled content commodity that has an open market value (e.g., wood derived fuel [WDF] etc.) may be applied to the construction waste calculation. Designate a specific area(s) on |

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| | the construction site for segregated or co-stored collection of recyclable materials, and track recycling efforts throughout the construction process. Identify construction haulers and recyclers to handle the designated materials. Note that diversion may include donation of materials to charitable organizations and salvage of materials on-site.<br><br>4. Identify opportunities to incorporate salvaged materials into the building design, and research potential material suppliers. Consider salvaged materials such as beams and posts, flooring, panelling, doors and frames, cabinetry and furniture, brick, and decorative items.<br><br>5. Establish a project goal for locally sourced materials, and identify materials and material suppliers that can achieve this goal. During construction, ensure that the specified local materials are installed, and quantify the total percentage of local materials installed. Consider a range of environmental, economic and performance attributes when selecting products and materials.<br><br>6. Establish a project goal for rapidly renewable materials, and identify products and suppliers that can support achievement of this goal. Consider materials such as bamboo, wool, cotton insulation, agrifibre, linoleum, wheatboard, strawboard and cork. During construction, ensure that the specified renewable materials are installed. |

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| **7.5 Environmental Quality** | **Objective**<br><br>1. Provide environments which are suitably lit, ventilated and temperature-controlled to suit the needs of the occupants and their anticipated task requirements.<br><br>2. Provide local control of lighting, ventilation and air-conditioning without introducing the potential for control system conflicts.<br>**Functional Requirements**<br><br>1. For larger buildings, or as appropriate to the relevant building, consider installing permanent monitoring systems to ensure that ventilation systems maintain design minimum requirements. Configure all monitoring equipment generate an alarm when airflow values or $CO_2$ vary by 10% or more from the design values via either a building automation system alarm to the building operator or a visual or audible alert to the building occupants<br><br>2. It is important to plan for maximum distances from work stations to an associated light switch. It would be useful to consider providing individual lighting controls for a majority of building occupants to enable adjustments to suit individual task needs and preferences. As well, it is worth considering the provision of lighting system controls for all shared multi-occupant spaces to enable adjustments that meet group needs and preferences. At a minimum, there should be provision for local light switching.<br><br>**Acceptable Solution Technologies & Strategies to achieve Performance**<br><br>1. In relation to large scale buildings it is worth considering the installation of $CO_2$ and air flow measurement equipment and feed the information to the heating, ventilating and air conditioning (HVAC) system and/or building automation system (BAS) to trigger corrective action, as applicable to individual circumstances. If such automatic controls are not feasible with the said large scale building systems then consider using the measurement equipment to trigger alarms that inform building operators or occupants of a possible deficiency in outdoor air delivery.<br><br>2. Design the building with occupant controls for lighting. Strategies to consider include lighting controls and task lighting. Integrate lighting systems controllability into the overall lighting design, providing ambient and task lighting while managing the overall energy use of the building. |

## 7.6 Specific Sectoral Provisions and Priority Low Carbon Technologies

This table details a hierarchy of achievement for each technology and related uses. These levels are then attributed to the following timeline and sectoral aims table.

**Table 9 – Technology Use and Building Guidance Level Requirements**

| Technology/Use & Level Requirements | Solar (Water Heating, Laundry, Cooking) | Space Heating / Cooling | Lighting & Energy Provision |
|---|---|---|---|
| **Level 1** | Design:<br><br>Basic passive solar design - design all buildings so that daylighting can be optimised to displace substantial amounts of electric light. Set aside an area of wall or roof to retrofit solar thermal or photovoltaic panels where possible. Provide space to retrofit solar tank.<br><br>Cooking:<br><br>Solar/bio-gas integrated cookers to be installed where possible, otherwise clean-burning biomass - liquids or gases only. | Cooling<br><br>Thermally-driven cooling such as absorption chillers or desiccant dehumidification, to be used where appropriate. | Lighting:<br><br>Use only lamps with a luminous efficacy in excess of 50 lumens per watt, i.e. compact and linear fluorescent, metal halide, LED, low and high pressure sodium, etc.<br><br>Onsite Energy Provision:<br><br>N/A |

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| **Level 2** | Cooking:<br><br>Solar/bio-gas integrated cookers to be installed.<br><br>Water Heating:<br><br>As Level 2 but solar water heating would also be installed. | Heating:<br><br>Include hot water coil(s) in ventilation ductwork.<br><br>Cooling<br><br>Thermally-driven cooling (as above) or equivalent to be mandatory | Lighting:<br><br>Use only lamps with a luminous efficacy of 70 lumens per watt.[6]<br><br>Onsite Energy Provision:<br><br>N/A |
| **Level 3** | Cooking:<br><br>As Level 2.<br><br>Water Heating:<br><br>As Level 2 but solar energy (i.e., photovoltaic) system(s) would be installed. | Heating:<br><br>As Level 2<br><br>Cooling:<br><br>As Level 2 | Lighting:<br><br>As Level 2<br><br>Onsite Energy Provision:<br><br>Enough to offset the building's $CO_2$ emissions due to its electricity use for HVAC pumps, fans & controls, lighting and most electrical appliances / equipment. |

The following table details sectoral performance aims and timelines for each sector and the level of attainment required by the timeline specified.

**Table 10 – Sectoral Performance Aims & Timeline**

| **Sector / Technology Level Required** | **Solar (Water Heating, Laundry, Cooking)** | **Space Heating / Cooling** | **Lighting** |
|---|---|---|---|
| **Resort** | Level 3 by 20xx[7] for new build<br><br>Level 3 by 20xx for retrofit | Heating:<br><br>Level 3<br><br>Cooling: | Level 3 |

[6] It is noted that LEDs are not yet the most efficient lamp type. For example, linear fluorescent lighting can be twice as efficient.

[7] Where "20xx" is indicated in this table, it is sensible to arrive at such deadlines by consultation and in accordance with amended Building Code implementation time lines (which are not known at this point in time).

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| | | Level 3 +<br><br>Consider deep ocean cooling where possible though evaporative coolers may be appropriate | |
| **Public Buildings** | Level 2 by 20xx for new build | Level 2 | Level 2 |
| **Residential Low Cost** | Level 1 by 20xx for new build | Level 1 | Level 1 |
| **Residential Medium/High Cost** | Level 2 | Level 2 | Level 2 |
| **Commercial** | Level 2 | Level 2 | Level 2 |
| **Industrial** | Level 2 | Level 2 | Level 2 |

**Sector Measures**

### 7.6.1 Low cost residential

Low cost residential communities may have unique building needs and circumstances. This has been considered in relation to the points made in this section.

#### 7.6.1.1 Building materials and construction – Compressed bricks

Consistent with an appropriately scoped life cycle analysis (LCA) or in relying upon existing LCA analyses at the time that decisions are made about material use, materials should aim to be:

- Locally sourced;
- Contain embodied carbon of no greater than x g/kg; and,
- Be designed to be integrated with an x[8] year building lifetime in mind.[9]

For example, compressed bricks could be used as these are non-fired, low emission alternatives to traditional bricks. As well, Aeonian bricks could be considered due to high suitability to the Maldivian climate (they are hurricane resistant and do not encourage mould or

[8] The "x" should be decided through a larger consultation process appropriate to local circumstances.
[9] Ideally, such a full life cycle analysis should examine such issues as: embodied carbon; longevity; recyclability; and, energy-in-use.

mildew). Locally manufactured compressed bricks would be optimal. Hurricane proof sealed concrete roofing is also preferable to corrugated steel sheets, due to its longevity.

#### 7.6.1.2 Energy provision and efficiency – Solar water heaters

Solar water heaters should be installed as standard in low-cost homes due to their ease of maintenance and long lifespan and reduction of emissions through lower energy usage.
Basic home solar systems should be considered which provide electricity for low energy lighting (over 50 lumens per watt) and running a few appliances. This would reduce the usage of and dependence on the mains electricity supply.

Homes could be built with regard to the prevailing winds, allowing through flow ventilation thereby potentially reducing the need for cooling systems.

Houses could be connected to a gas grid that provides biogas from municipal facilities where this becomes possible.

#### 7.6.1.3 Building use and operation

Housing should be integrated into the municipal sewer system to enhance local hygiene while also providing valuable substrate for a centralised biogas facility.

Vertical gardens should be integrated into the building designs to promote self-sustainability, reduce the local dependence on air-imported foods, and provide and promote a 'greening' of the area in question.

Basic waste compressors should be installed to encourage the municipal disposal of waste and discourage localised incineration.

### 7.6.2 Resorts

#### 7.6.2.1 General

The resort sector has continued to be the fastest growing part of the national economy. Therefore, it is given selective and more detailed treatment in this Guidance as an example of sectoral considerations.

As with other sectors of this document, resort owners and investors may choose to follow their own path in relation to technology and method selection towards a zero carbon strategy. However, the proposals found herein may form a useful starting point noting that each resort will want to tailor its zero carbon strategy to its own needs in terms of build. As well, the technologies, techniques and measures suggested in this section may well be considered for other sectors in this Guidance.

In relation to existing and future resorts, the assumption being made is that the investment time horizon and investment capacity are more fortuitous than for State-funded zero carbon initiatives covered by this document. However, there is a point of private and public sector convergence around detailed electricity provision both now and for the future of the Maldives. At present, it is imperative that a full understanding of electricity provision and use is required and that a detailed electrical survey nationwide will be important in determining the boundaries of parameters for resorts to consider in adopting individual zero carbon strategies. What is more, such an activity will assist in fully understanding where electricity is being used (and for what purpose) so that energy efficiency measures can be adopted and other more carbon-intensive fuels (including biofuels) can be phased out.

#### 7.6.2.2 Tri-generation

In the Maldives the most common way that electricity is generated is with electrical alternators driven by diesel-fired internal combustion engines.

The use of Combined Heat and Power (CHP) for co- and/or tri-generation should be considered in a resort context.

Electrical generators produce waste heat which can be reclaimed and used to heat water (co-generation) and provide cooling through an absorption chiller or desiccant system (tri-generation)

To water-cool the chillers using seawater, the seawater needs to be no warmer than about 31 °C. Fortunately the actual seawater temperature peaks at around 19 °C (depending upon depth). According to energy modelling efforts, cooling can represent approximately 25% of total electricity demand, of which about 85 percent can reduced by the adoption of a trigeneration system. Further, at times when the cooling load is low, the generators will be able to divert their waste heat to replenish domestic hot water calorifiers, thereby reducing energy consumption further. These figures suggest that trigeneration is a significant carbon reduction measure.

#### 7.6.2.3 Biodiesel

To achieve the desired 'zero-carbon' status, it will be necessary for resorts not to rely on diesel fuel for electricity generation. A 'green-powered' CHP plant (combined heat and power) will generate not only electricity, but also valuable waste heat which will operate the cooling systems at a resort. This generator plant can be fuelled using a readily available and sustainable ethically resourced biofuel (e.g., biodiesel) noting that biodiesel is already market-competitive and prices are generally falling.

There are companies in India producing and exporting biofuels using socially responsible, sustainable methods and grown on marginal lands which are unfit to sustain food crops. Using biodiesel from a socially responsible and sustainable supplier will not only lower the carbon footprint of a resort, but it will help Indian farmers and communities out of poverty.

*Storage of Biodiesel*

The standard storage and handling procedures used for petroleum-based diesel fuel apply to biodiesel. Compared to petroleum-based diesel, biodiesel fuel has lower oxidation stability, and there are greater concerns for water contamination within the storage tank and microbial growth. Biodiesel should be stored in a clean, dry, dark environment. Acceptable storage tank materials include aluminium, steel, fluorinated polyethylene, fluorinated polypropylene or Teflon®. Storage containers which contain copper, brass, lead, tin or zinc should not be used. Every effort should be taken to make sure that the Biodiesel product is used within six months of the date of manufacture.

#### 7.6.2.4 Photovoltaics

The use of photovoltaics should be considered but the actual energy-efficiency savings for particular uses when measured against investment and upkeep costs requires careful consideration in cost terms before an investment decision can be made. As photovoltaic technologies are becoming more cost effective, the timing of investment decisions will be important in going forward noting that photovoltaics will be approximately 25 % cheaper than current photovoltaic technologies by 2011.

#### 7.6.2.5 Solar thermal domestic hot water (DHW)

Solar-thermal hot water is an extremely cost-effective and practical solution for the Maldives. Seldom should it be necessary to generate hot water from hydro-carbon fuels or worse, electricity.

#### 7.6.2.6 Anaerobic digestion

Anaerobic digestion occurs when bacteria breakdown organic material into gas and a solid residual. If for example a resort were to produce approximately half a tonne per day of dry "leafy" biomass and about half a tonne per day of dry food waste. Feeding these into a well-run anaerobic digester would yield approximately 1,667 kWh of biogas per day.

The exact composition of the biogas will depend upon the nature of the organic matter, but would typically be between 50 and 75 percent methane, occupy a volume of between 150 and 300 cubic metres (if stored) and have a mass of between circa 100 and 200 kg.

There are two further advantages with anaerobic digestion: the first is that any gas captured and burnt is preventing methane entering the atmosphere, which is about 23 times more potent as a greenhouse gas than $CO_2$. The other is that it reduces the associated waste streams to an inert compact residue.

- The biogas, being as it is mostly methane, is toxic and highly combustible and should be used directly rather than stored. Although capture and storage technology does exist, the maintenance and supervision requirements are not well-suited to holiday islands such as those that we find in the Maldives. It would be useful to consider better ways of using the gas as it is produced, for which there are a number of options and combinations

#### 7.6.2.7 Lighting

Though there has already been discussion about issues pertaining to minimum luminous efficacy and switching and dimming considerations as well as lighting technologies, aesthetics also merit attention. For instance, fluorescent lighting may not be favoured in guest areas because they it does not create the right mood, fluorescent lighting cannot be dimmed, it flickers, etc. As well, it contains small doses of mercury which pollutes the water table if not properly disposed of – which is currently not possible to do in the Maldives.

On the other hand, human beings universally like tungsten lights – there is something about their "incandescence" that seems to relax us, much like an open fire would. This is not a modern adaptation but something innate; for instance the colour spectrum of tungsten lamps is so far skewed towards the red end of the visible spectrum that they should give everything a red tint. However, our eyes have adapted to this to the extent that we can differentiate between colours as effectively under tungsten lighting as we can under daylight. In fact, tungsten is the reference against which the colour-rendering properties of all other lamps are judged.

Most fluorescent lamps have a colour spectrum that is towards the blue end of the spectrum which appears "cool", invigorating, energetic and ideal for an office or a shop, but not for a romantic villa or restaurant.

Most of the problems of fluorescents can be resolved: they can have a warmer light similar to tungsten and light fittings can be provided with high-frequency control gear that allows fluorescents to be dimmed whilst eliminating low-frequency mains flickering. However, high frequency control gear is bulky and might be difficult to retro-fit, and there's still the problem of the mercury.

In the short term resorts may also consider the point at which LED lighting has matured to the extent that it has the same, or higher, light output per watt as compact fluorescent lamps.

By way of advantages, LEDs can be warming (similar to tungsten), they can be dimmed, they do not flicker and they contain no mercury.

Finally, though this may appear to be common sense, individual rooms and villas should have a master switch in an obvious location by the front door that will interrupt the lighting circuit(s) at the distribution boards. This is a simple solution which can realise not inconsiderable energy savings.

#### 7.6.2.8 Wind power

Wind power can be a cost-effective solution where the average annual wind speed is over about 6 metres per second. A 75 MW (peak) farm has already been commissioned. Additional wind farms might be considered where suitable wind conditions prevail.

In the first instance, any adverse effects on the tourist industry would have to be assessed.

#### 7.6.2.9 Desalinated water

While reverse osmosis process technologies to purify seawater into drinking water can be implemented on cost-effective terms it is also quite energy intensive. To purify one cubic metre of water requires circa 5.62 kWh of electricity. The low energy alternative is solar desalinisation. The solar desalination process is based on evaporation of salt water and the subsequent condensation of the generated steam using only solar power. The produced steam is virtually clear and does not carry any solvents.

Following condensation, salt-free fresh water is collected. In the process, sea water is heated by the sun or by use of waste heat, supplied via heat exchangers. The heated salty water enters an evaporation chamber from where it evaporates from antibacterial fleece surfaces. The produced steam is transported to the condenser in a second step, without additional energy demand.

Solar desalination is a sensible option where there is sufficient space to install the plant.

#### 7.6.2.10 Biochar

Pyrolysis is the process of burning something in the absence of oxygen. There are two stages to the process. In stage one the biomass feedstock is placed in a container with a chimney but otherwise sealed. A fire is lit beneath the biomass, but because the biomass container is sealed, no oxygen can enter and so the biomass is being heated in the absence of oxygen. Stage one lasts about eight hours during which time mostly water vapour is driven off. In stage two toxins start to be driven off, such us methane which is a greenhouse gas (GHG) 23-times more potent than $CO_2$. Rather than allow these into the atmosphere, the chimney is blocked and a damper opened to the fire box. The toxins are thus burnt in the fire box, at which point the process becomes self-powering and the toxins are either bound within the biochar or released as less harmful gases, such as $CO_2$. Stage two lasts for about four hours.

Creating biochar prevents the biomass simply decomposing into $CO_2$ and methane by binding up half the GHGs into the biochar and converting the other half of methane into the less damaging $CO_2$. The biochar can then be mixed with organic waste to make an excellent fertiliser. Fish waste, which is abundant in the Maldives, is one of the best possible organic wastes to mix with the biochar, as is the digestate from the anaerobic digester process. The biochar fertiliser can either be used at the relevant resort or sold.

#### 7.6.2.11 Ocean Water Cooling

Ocean water cooling can be used to assist with air-conditiong and to reject heat from absorption chillers.

#### 7.6.2.12 Additional One-Off Measures

Beyond a more detailed option-based approach (elaborated above), the following measures are worth considering at a strategic level before detailed planning measures for a given resort (retrofit or new build) commence:

- Take steps to reduce energy consumption through simple energy-efficient measures, such as better light switching, efficient use of potable water, better energy metering and thorough energy auditing.

- Provide site-wide solar-thermal domestic hot water (DHW).

- Manufacture or purchase "ethical" biodiesel.

- Switch from electricity to solar-thermal DHW or biogas wherever possible in kitchens and laundries.

- As appropriate to certain islands, provide island-wide chilled water network with central absorption chillers powered from the waste heat off the new biodiesel CHP units and water-cooled using a refurbished seawater system.

- Biochar all branches and other "woody" biomass.

- Use organic digesters to gasify food waste and "leafy" biomass. The gas is then used to displace LPG and/or to reduce electrical loads through micro CHP – all dependent upon project-specific analysis and load profiles.

These various technologies are harmonised at different levels to realise the most efficient system at each location and achieve a Zero Carbon status.

## 8. Sectoral Monitoring and Compliance:

Monitoring should be undertaken by use of smart metering and one year of data would be obtained.

One year of post-build or post-retrofit data is required to ensure that the building conforms to the Guidance standards and confirms which level of compliance the building has achieved.

At this time an inspection is to be undertaken and signed off by the director of public works. Non-compliance results in the possibility of a non-compliance levy and a period of six months to become compliant.

| Sector | Specific Monitoring Requirements |
|---|---|
| Resorts | All buildings to have a smart meter integrated with building management system. |
| Public Buildings | All buildings to have a smart meter and energy management plan. |
| Residential | All residential buildings to be issued with a smart meter free of charge by the electricity provider. |
| Commercial | All commercial buildings to be fitted with a smart meter and develop an energy management plan. |
| Industrial | All industrial buildings to be fitted with a smart meter and develop an energy management plan. |

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