UNDP and GEF

Technical Assistance for Development of Annual Energy Statistics

August 2010

MALDIVES

REPORT ON ENERGY SUPPLY & DEMAND 2008 - 2009

Prepared for

Ministry of Housing, Transport & Environment (MHTE)

by

riyan

Project

Report on Energy Supply and Demand - Maldives 2008 to 2009

Client

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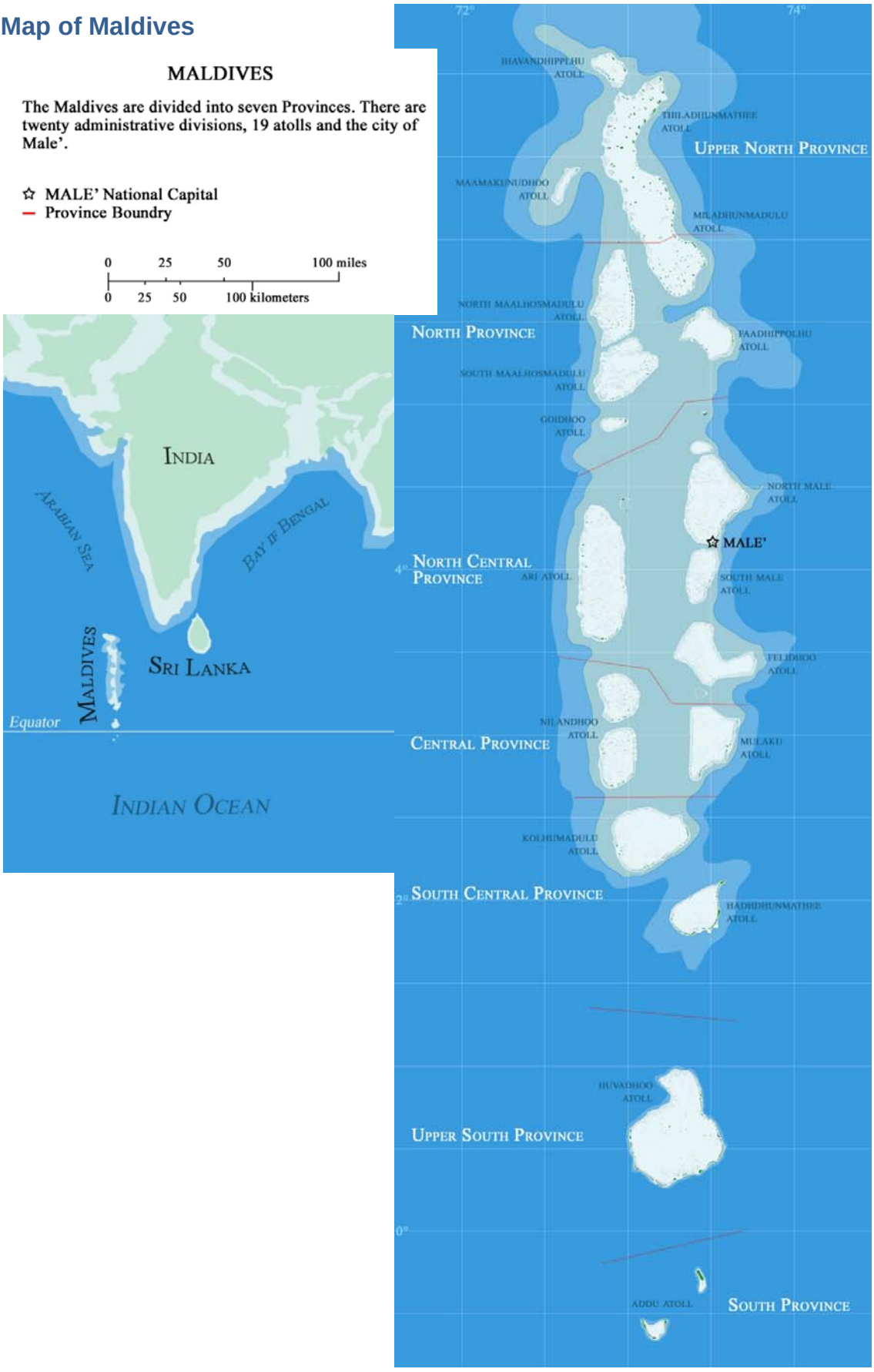
Map of Maldives



List of Abbreviations

CDM	Clean Development Mechanism
CEN	European Standardisation Body
CHP	Combined Heat and Power
CO2	Carbon Dioxide (type of “green house gases”)
COP	Conference of the Parties to the Framework Convention on Climate Change
DEA	Danish Energy Authority
DK	Denmark
ECN	Energy Consulting Network
elec	Electricity
EU	European Union
EUR	Euro
FCB	Fluidised Bed Combustion
GDP	Gross Domestic Product
GHG	Green house gas (principally CO2)
HFO	Heavy Fuel Oil
IPP	Independent Power Producer
JI	Joint Implementation
Mt	Million ton
Mtoe	Million ton oil equivalents
MHTE	Ministry of Housing, Transport and Environment
MoHA	Ministry of Home Affaires
MFT	Ministry of Finance and Treasury
DNP	Department of National Planning
NCM	Nordic Council of Ministers
NGO	Non-governmental organization
PIN	Project Identification Note
PPP	Public Private Partnership
PDD	Project Development Document
PSC	Project Steering Committee
QA	Quality Assurance
R&D	Research and Development
RES	Renewable Energy Sources
STO	State Trade Organisation
STELCO	State Electric Company Ltd.
ToR	Terms of Reference
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
UNOPS	United Nations Office for Projects Services
UNDP	United Nation Development Programme
VAT	Value Added Tax

Units

Given the variety and general in-consequence regarding the use of energy units when referring to energy resources and utilisation of resources found in the available literature, we have chosen to use the following units, which in relation to the physical units are based on the SI-system.

Measure	Unit	Conversion
Energy contents	Joule (J)	1 PJ = 10^{15} J = 0.278 TWh = 0.239 million Gcal 1 TWh = 10^{9} kWh = 0.860 million Gcal = 3.6 PJ 1 PJ = 23,900 tonnes oil equivalent (toe)
Capacity	Watt (W)	
Temperature	Celsius (°C)	
Currency	Euro (EUR or €)	

Prefix

The following prefixes have been used to indicate powers of 10:

Number	Prefix	Abbreviations
10^{15}	Peta	P
10^{12}	Tera	T
10^{9}	Giga	G
10^{6}	Mega	M
10^{3}	Kilo	k

Energy carrier characteristics / Assumptions

Energy carrier	Density (ton/m^3)	Heat value (GJ/ton)	Toe conversion factors (toe/ton)
Diesel oil / gas oil	0.84	42.7	1.035
Petrol/motor gasoline	0.75	43.8	1.070
Jet petrol (JP 1)	0.80	43.5	1.070
Aviation gasoline	0.71	43.8	1.070
Kerosene	0.80	43.5	1.045
LPG	0.54	46.0	1.130

Source: toe conversion factors from IEA, Density and heat value from Maldives Energy Balance 2005

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1 Introduction

The Energy Balance Report is prepared for the Ministry of Housing, Transport and Environment (MHTE) supported by United Nations Office for Projects Service (UNOPS), Global Environment Facility (GEF), as part of the United Nations Development Programme (UNDP) for Maldives. This report gives an update to the existing Energy Demand and Supply prepared for Maldives in the year 2005.

The information collected shall contribute to the assessment and development of the energy sector in the Maldives. The work in the documentation includes the use of conventional energy sources as well as a potential for renewable energy use in the country.

The result of the project will be used in the planning of future energy sector of the Maldives.

This report is prepared as a result of energy supply and demand survey, which was conducted in March to May 2010.

Riyan Pvt. Ltd. would like to take this opportunity to thank everyone who has provided assistance, information and ideas for the work process involved in producing this report.

Male', September 30th 2010

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Project manager

2 Why supply and demand analysis?

The energy sector is a significant factor to the national balance of trade and national economic budget. A steady and secure supply of energy is a basic need for the development and operation of any nation.

Supply and demand analyses are essential in order to understand the characteristics of the national energy balance and the energy market dynamics.

By establishing realistic and operational supply and demand analyses a national energy balance can be developed. A reliable energy balance is the fundamental requirement for establishing reliable modelling of the potential energy market development, and the effects of any given market intervention.

In essence, an energy balance is necessary to provide an understanding of the complexity of the energy sector and to assess the social, legal, technological, financial and economic effects of any measure of intervention into the energy sector.

Different types of national energy modelling tools have been used for decades in Europe. The use of energy statistics and balances provides for development of powerful energy and national policy assessment tools, such as:

- Modelling and impact analyses in relation to strategy development, and action planning
- Benchmarking (regional, sector and technology comparison, international comparison)
- Development of policy indicators (energy intensity, price elasticity, etc)

The energy balance report of Maldives 2003 and 2005 has contributed to the national energy planning of the country. The same magnitude of contribution is expected from this study.

3 Energy balance methodology

3.1 Principle of balance

An energy balance can assume many forms and shapes, but the most commonly used format and methodology refers to the model set-up, which is used by e.g. IEA and OECD.

The basic principle is that the balance is divided into three parts:

1. Primary energy - imported and indigenous energy (in raw forms)
2. Conversion of primary energy into electricity (and thermal energy)
3. Final energy demand at the point of end use.

3.2 Unit of energy – tons oil equivalent (toe)

The calculations made are in internationally accepted, commonly used standards of measure, which are “ton oil equivalent”, or toe. One toe is equivalent to the energy of standard crude oil, and is defined as 11,630 kWh.

All energy forms in the balance are re-calculated into this format. This ensures:

- National comparability between energy carriers, fuels, and energy types
- International comparison and benchmarking

The basic characteristics and toe conversion factors are shown in the table below.

Energy carrier	Density (ton/m^3)	Heat value (GJ/ton)	Toe conversion factors (toe/ton)
Diesel oil / gas oil	0.84	42.7	1.035
Petrol/motor gasoline	0.75	43.8	1.070
Jet petrol (JP 1)	0.80	43.5	1.070
Aviation gasoline	0.71	43.8	1.070
Kerosene	0.80	43.5	1.045
LPG	0.54	46.0	1.130

4 Data availability and sources

4.1 Customs Services

The Maldives Customs Service (MCS) has accurate and comprehensive data on imports of fossil fuels (Oil, LPG, Kerosene, Petrol, Aviation gas and Aviation Jet kerosene, etc.).

4.2 State Trade Organisation

The State Trade Organisation (STO) has information on bunkering and stock levels of Oil, LPG and other oil products.

4.3 STELCO

The State Electricity Company (STELCO) has over the years developed an informative statistics covering the islands that they supply with power.

4.4 Ministry of Housing, Transport and Environment

The Ministry of Housing, Transportation and Environment (MHTE) has been helpful with providing information regarding the transport sector. Full-scale transport studies have not yet been conducted, as a master plan for the transport sector is yet to be established, therefore, the level of available details has been scarce.

4.5 Survey questionnaire

For energy demand information on local, inhabited islands, a survey has been prepared and circulated. This questionnaire was designed to find the end–use of energy and available biomass resources. A separate set of energy review questions was sent to the resort islands to find end-use energy and available biomass resources.

Male has not been included in the questionnaire, as this area is covered in official statistics and other previously developed survey, reports and datasheets from STELCO.

4.6 Conclusion

There are reliable sources of information, which are able to provide solid data. In order to accommodate the collection of the necessary information required to establish an annual energy balance, initiatives are necessary, including:

- Establishment of regular collection/reporting routines of standardised information from all islands
- Establishment of regular collection/reporting routines of standardised information from all resorts
- Establishment of regular reporting of statistics from MCS, STO, etc.
- Establishment of a permanent working group in the MHTE to review analyse and adapt information and prepare energy balance.

5 Energy Balance

5.1 Resource

The information collected on the primary fuel usage in the Maldives has largely been obtained directly from official sources (such as STO) and through registered data from the Maldives Custom Service (MCS). The well documented data suggests a solidity and reliability to the "input" of the national energy balance presented in the following sub-chapters.

5.1.1 Diesel

Diesel is the foremost imported energy carrier. Major holder is State Trade Organisation (STO) with 60 to 70%; the remaining percentages are private importers.

The total diesel imported to the Maldives has increased significantly in recent years. The amount of diesel imported and re-exported in 2008 and 2009 are shown in table 5.1.1.1:

Table 5.1.1.1: The amount of diesel imported and re-exported in toe, 2008 and 2009

Fuel	2008	2009
Imported	276,534	290,066
Re-Exported	11,047	8,066

The net use of diesel oil in 2009 can be calculated as the imports adjusted for the changes in stock and bunkering:

Table 5.1.1.2: The gross domestic consumption for Diesel,- 2009

	Diesel oil toe
Import	290,066
- Bunkered	- 9,320
Gross domestic consumption	**280,746**

5.1.2 Petrol

Petrol is the second largest energy carrier brought in to the Maldives, according to MCS.

The import of petrol in 2009 is given in the table 5.1.2.1. In addition to the import the balance consists of net storage of petrol. According to STO and other petrol importers the stock level was 2,576toe. The net use of Petrol in 2009 can be calculated as the imports adjusted for the changes in stock:

Table 5.1.2.1: The gross domestic consumption for Petrol, 2009

	Petrol toe
Import	30,305
- Net stored	-2,576
Gross domestic consumption	**27,729**

5.1.3 LPG

LPG is bottled in the Maldives. The import of LPG in 2009 is given in table 5.1.3.1.
In addition to the import the balance consist of net storage of LPG. According to STO, the stock level was 500toe, therefore the net use of LPG in 2009 can be calculated as the imports adjusted for the changes in stock.

Table 5.1.3.1: The gross domestic consumption for LPG, 2009

	LPG toe
Import	13,038
- Net stored	500
Gross domestic consumption	**12,538**

5.1.4 Kerosene

Lamp oil is included in the kerosene figure, as the both products are similar. Lamp oil imports are in litres, the import of kerosene is calculated in metric tonnes. Adding the two together, the equivalent energy content, as shown in table 5.1.4.1, is 1,922toe:

Table 5.1.4.1: The gross domestic consumption for Lamp Oil & Kerosene, 2009

	Kerosene toe
Gross domestic consumption	**1,922**

5.1.5 Jet A1

Jet A1 is imported as "aviation gas" and "kerosene. Data is collected from MCS and additional information on stock levels is obtained from Maldives Airport Company.

The import cleared through customs services (MCS) for domestic flights is in metric tonnes. In addition to the import the balance consist of net storage of aviation gas. According to STO, and other kerosene importers, the stock level was:

Table 5.1.5.1: The gross domestic consumption for JetA1, 2009

	Aviation toe
Import	27,280
- Net stored	- 10,200
Gross domestic consumption	**17,080**

5.1.6 Biomass

Available biomass resources were collected by circulating questionnaire and by series of site visits to small communities on different islands.

Table 5.1.6.1: The resource overview for Biomass, 2009

Resource overview	*Amount*	*Energy contents*	*Comment*
	ton/year	**toe/year**	
Inhabited Islands			
Solid agro waste	42,098	7,964	Easily accessible
Animal waste	15,000	193	Easily accessible
Household waste	4,563	588	Easily accessible/sorting required
Male Villingili			
Solid agro waste	2,735	517	Easily accessible/requires sorting
Organic waste	29,149	3,760	Easily accessible/requires sorting
Landfill gas		900	Being tested (400-1,380)
Un-inhabited islands			
Solid agro waste	29,373	5,556	Difficult to access
Organic waste	0	0	
Total		**~ 19,500**	

The use of biomass on the Maldives differs from island to island, but fuel wood is generally the main consumer of biomass for energy; fuel for cooking and for the smoking of fish.

5.1.7 Solar heat

The present use of solar heating technology is primarily used in resorts for the warming of water in guest rooms. Based on the questionnaires, a qualified estimation is made with the following assumptions:

Table 5.1.7.1: Assumptions for the survey, with information gathered from resorts directly, 2009

Assumptions	
Number of resorts	96
Bed capacity	20,435
of which with solar hot water	60%
of which with solar hot water	12,261
Bed Capacity Utilization Rate (%) (2008)	78.03%
Total number of bed nights	5,451,164
Number of solar m^2 per bed	0.5
Number of m^2 solar collector in use	3120
Average daily heat produced by solar, per bed	0.9 kWh
Average yearly production by solar, per bed	329 kWh
Solar heat utilised /year	2,775 MWh
Solar heat utilised /year	239 toe
Volume of water heated 22 C, /day/ bed	35.1 Litre
Estimated demand for hot water per bed night	60.0 Litre
Volume of water heated per year	108,121
Yearly demand for hot water	303,983
Covered by solar heating	36%

The use of solar heating in 2009 expresses the net utilised energy on the user side, i.e. in the showers.

Table 5.1.7.2: The gross domestic consumption for Solar Heat, 2009

	Solar heat toe
Gross domestic consumption	239

5.1.8 Electricity

Electricity from Solar and Wind is produced as pilot projects on inhabited islands by the telecommunication company Dhiraagu (including PV panels to supply their masts with power for stand-alone operation in remote locations). The production of electricity is currently not performed on any scale of significance in regard to the collection of information for the energy survey balance.

5.2 Conversion

At present, most of the energy conversions are a process of converting oil products to electricity. In future, there could be potential for conversion between renewable energy sources and electricity.

Some of the conversion factors, especially information collected from STELCO (diesel to electricity in STELCO operated areas), are well documented. Data sources from local inhabited and resort islands (outside STELCO supplied region) are difficult to assess. These areas are covered by the surveys. The results have been extrapolated to a national scale.

5.2.1 Diesel to electricity

All the electricity production is based on diesel generators except for a negligible amount. The electricity production is decentralised, and based on production units of various size.

STELCO supplied area

The State owned Electricity Company STELCO provides electricity to the island of north central province, including the capital city Male'. STELCO has standard quality data material providing details on each of their network for production of electricity and consumption of diesel.

Production

Electricity production data is provided in the data annex. The annex evidently indicates the production as almost constant over the year (from month to month). Production for Male/ Vilingili/ Hulhumale/ Thilafushi islands represents approximately 95% of the total STELCO production.

The use of diesel oil for electricity production is available from official statistics (see also data annex). Combining the information with the production data and the electricity utilisation data, it is possible to analyse and calculate the conversion efficiency for all STELCO served area, including the distribution loss for Male'. The conversion efficiency varies between 26 and 28% depending on the size and operation of the installation:

Distribution

Distribution loss Male:	7.39%
Distribution loss on Vilingili:	5.42%
Distribution loss on Hulhumale:	9.09%
Distribution loss on Thilafushi:	5.10%

Private/Community supplied area

The remaining inhabited islands are served by respective utility companies, private and/or community owned electricity producers. Electricity and fuel consumption data information for these islands were collected by circulating questionnaires.

Sample island analysis

Table 5.2.1.1: Sample analysis for electricity consumption/year

Island Name	Population	kWh/year
Gdh. Thinadhoo	6,970	4,210,000
Ga. Kanduhulhudhoo	853	200,444
Ha. Thuraakunu	641	156,985
Hdh. Kulhudhuffushi	8,235	5,295,920
R. Angolhitheem	452	98,437
Lh. Naifaru	4,731	2,654,000
M. Raimandhoo	218	68,881
Dh. Kudahuvadhoo	2,333	1,548,015
Th. Veymandoo	1,089	285,547
L. Maavah	1,749	532,826
Gn. Fuvahmulah	10,870	5,853,000

Average specific electricity demand per capita of kWh/cap/year was calculated using the population on each island.

Distribution
From the data obtained through the survey, distribution loss varies from 5 - 24% depending on the quality of the distribution systems on each island. Elevated distribution losses are found at islands with poorly designed and low maintained distribution systems.

Production
By extrapolating the specific electricity demand to all non-STELCO supplied regions, using the amount of inhabitants on each island and compensating for the distribution loss, the total electricity production can be calculated.

Analyzed and incorporated into the survey is the conversion efficiency of the diesel gen-set, including the variation of size of production installation and general maintenance level.

Based on known conversion efficiency of a number of production units in the Maldives, it has been possible to establish a satisfactory relation between the expected production efficiency and the total production installation. The assumption that the efficiency is relative to the total electricity production is reasonable from the following point of view:

- An increasing production requires a larger production unit which increase efficiency
- An increasing production requires the existing unit run for more hours, increasing the efficiency

The conversion efficiency (y) has been modelled based on the analysis to be

$$y = 1.1269\ln(x) + 26.518,$$

where (x) is the electricity production, and the minimum efficiency is set at 26%.

This methodology provides a reasonable result, which can compensate for the difference in size of installations as the table below indicates:

Table 5.2.1.2: The efficiency of electricity production

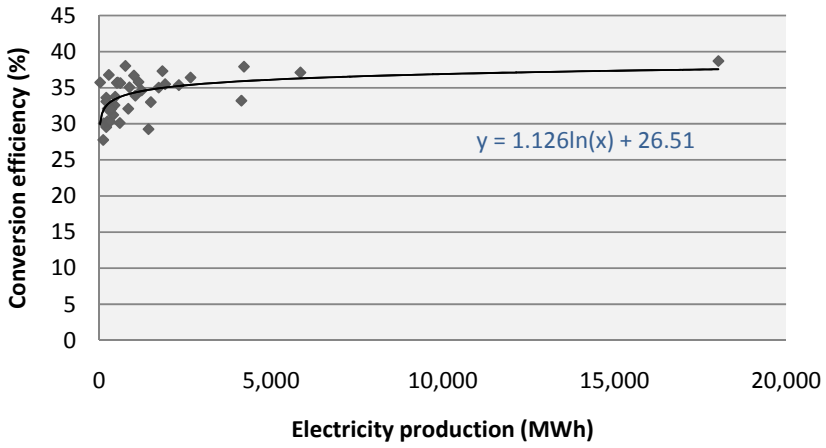

Table 5.2.1.3: Total electricity production outside STELCO supplied region

Atoll islands *(outside Stelco supply area)*	Pop. 2009	Specific elect utilization	Total elect. utilization	Elec. distrib. loss	Total electricity production	Fuel conver. efficiency	Oil input	Oil input
	Male / Female	**kWh/cap/y**	**kWh/y**	**%**	**kWh/y**	**%**	**kWh/y**	**toe/y**
Kolamaafushi	1,545	4,612	593,781	7%	635,346	30%	2,110,186	181
Vilingili	3,110	7,387	2,313,000	5%	2,428,650	35%	6,869,000	591
Maamendhoo	1,382	35,905	4,135,013	18%	4,879,315	33%	14,695,116	1264
Nilandhoo	973	2,456	199,180	5%	209,139	30%	707,843	61
Dhaandhoo	1,830	3,486	531,667	12%	595,467	36%	1,667,157	143
Dhevvadhoo	1084	3039	274,558	12%	307,505	37%	836,338	72
Dhiyadhoo	230	1134	21,726	12%	24,333	36%	68,124	66
Gemanafushi	1359	3878	439,236	12%	491,944	33%	1,510,612	130
Kanduhulhudhoo	853	2820	200,444	12%	224,497	34%	667,817	57
Kondey	502	20063	839,300	14%	956,802	32%	2,982,723	256
Gadhdhoo	1077	8764	1,046,000	5%	1,098,300	34%	3,241,000	279
Thinadhoo	6970	5927	4,210,000	5%	4,420,500	38%	11,661,000	1003
Fares-Maathoda	1763	7757	1,139,695	9%	1,242,268	36%	3,471,667	299
Fiyoree	1361	2120	240,409	14%	274,066	32%	854,363	73
Hoandehdhoo	1102	4033	125,120	24%	155,149	30%	516,294	44
Madaveli	1644	3349	458,865	9%	500,163	34%	1,482,474	127
Nadalla	1062	2620	231,872	14%	264,334	30%	871,571	75
Rathafandhoo	974	10774	874,495	14%	996,924	35%	2,844,094	245
Vaadhoo	1411	3436	404,052	18%	476,781	31%	1,526,764	131
Hithaadhoo	1194	3723	310,599	24%	385,143	30%	1,270,669	109
Kamandhoo	446	12346	200,012	18%	236,014	33%	713,532	61
Kendhoo	1107	3013	347,606	18%	410,175	32%	1,279,378	110
Kihaadhoo	420	9939	111,218	24%	137,910	28%	496,881	42
Ungoofaaru	1391	13695	1,497,583	9%	1,632,366	33%	4,946,641	425
Alifushi	2403	2777	506,105	7%	541,532	36%	1,518,115	131
Kurendhoo	1862	4190	607,585	12%	680,607	36%	1,909,720	164
Manadhoo	1661	12118	1,429,508	24%	1,772,590	29%	6,059,706	521
Holhudhoo	2066	5179	1,004,928	7%	1,075,273	37%	2,931,389	252
Velidhoo	2223	3674	1,229,000	5%	1,290,450	35%	3,728,000	321
Hulhudhuffaaru	1297	7407	756,000	14%	861,840	38%	2,267,000	195
Eydhafushi	2883	3712	1,836,000	5%	1,927,800	37%	5,169,000	444
Hinavaru	4455	3476	1,726,000	5%	1,812,300	35%	5,176,000	445
Naifaru	4731	5242	2,654,000	5%	2,786,700	36%	7,655,000	658
Fuvahmulah	10870	3545	5,853,000	5%	6,145,650	37%	16,562,000	1424
Hitadhoo (Central Power)	23910	5547	18,027,000	5%	18,928,350	39%	48,920,000	4206
Hudhudhoo-Meedhoo	6089	2290	1,915,000	5%	2,010,750	35%	5,666,000	487
Total (for all islands)					**130,321,209**			**31,191**

The main result for the islands supplied from regional utility companies, community/privately owned production units can be summarised as:

Table 5.2.1.4: Electricity Production in toe

Oil / Electricity		Total toe
Total oil consumption		31,191
Electricity production		**11,206**

Resorts

All resort islands have a private electricity production. Detailed data covering all of these islands is not available. A data questionnaire has been issued to produce a reliable basis for analysis of the resort consumption. A total of 96 resorts are registered in the Maldives, as of 2010.

Production

Based on an analysis of the replies, an average use of diesel for electricity production can be estimated at: 4.59toe/bed

Using “bed” as the unit of scaling, instead of “bed night”, is based on the electricity demand as a constant, since A/C systems and water pumps are operational in all rooms/guest facilities regardless of guest occupancy.

Table 5.2.1.5: Electricity production in resorts

Oil / Electricity	Unit	Comments	Total
Oil consumption for electricity	toe/bed		4.59
Total beds	beds	In 2009	19,860
Total oil consumption	toe		91,226
Electricity production	**toe**	**Conversion efficiency 28%**	**25,543**

The average conversion efficiency of 28% is assumed on information collected from selected resorts and site visit experience, with the level of maintenance and operation of the diesel generator sets.

Distribution

Because of the special nature of the end-use, the distribution loss is perceived as included in the end-use.

Industrial

The desalination company (Maldives Sewage and Water Company) serving in Male, Hulhumale and Vilingili have their own electricity production, which is utilised for desalination. All data from this production has been made available.

Table 5.2.1.6: Yearly electricity production and end-use

	Male	Hulhumale	Vilingili	Total
Yearly diesel consumption (toe)	3,461	250	142	3,853
Yearly electricity production and end-use (toe)				**1,453**

Source: MWSC

There are additional industrial activities in connection to freezing/cooling storage facilities for fish products. The demand for diesel oil for electricity and steam production at the three industrial plants is provided by MifCo.

Overview
The table below provides an overview of the produced electricity and use of diesel use.

Table 5.2.1.7: Total electricity demand in toe

Electricity to grid	Electricity Production toe	Diesel toe
STELCO		
STELCO, Greater Male region	19,530	51,269
STELCO, Islands	1,019	2,979
Utility, Community / Private (Islands)	33,563	115,220
Industry, manufacturing (MWSC)	1,453	3,853
Industry, cold stores and canning	1,745	6,233
Resorts	25,543	91,226
Distribution losses (excl resorts)	- 1438	
Total electricity demand	**84,291**	**270,780**

Other
No other forms of conversion of energy have been identified.

5.3 Demand
The following describes and analyzes the energy demand:

5.3.1 Household, Manufacturing and Public sector
The break down on households for Male, Hulhumale and Vilingili can be established from combining the electricity production, distribution losses (from STELCO) and population with information from the 2006 census on electrical appliances and utilisation in the household sector.

The break down for public and manufacturing in Male, Hulhumale and Vilingili can be established by combining the information regarding electricity production, distribution losses (from STELCO) and information from other official statistics on electrical utilisation.

The consumption pattern for electricity between Male' and local inhabited islands differs significantly. The dissimilarity between STELCO supplied areas and the utility, private/community-supplied area is ascribed as developed and stable supply in STELCO's district. A stable supply provides for larger consumption.

Table 5.3.1.1: Specific electricity demand kWh/capita/year

Area	Specific electricity demand kWh/capita/year
Male, Hulhumale & Vilingili	1,658.1
Islands (average)	729.6

Table 5.3.1.2: Energy consumption between the different types of end-uses in toe (Male Region)

Greater Male Region	**Population: 130850**				
toe	Electricity	Biomass	LPG	Kerosene	Total
Households	9,032	6	3,011	88	12,137
Lighting	2,181	0	0	1	
Appliances & AC	6,845	0	0	0	
Cooking and smoking	6	6	3,011	87	
Public	322	0	0	0	322
Manufacturing & Commerce	5,924	0	0	0	5,924
Government Buildings	3,377	0	0	0	3,377
Total	**18,665**	**6**	**3,011**	**88**	**21,759**

Table 5.3.1.3: Energy consumption between the different types of end-uses in toe (Atolls)

Atolls	**Population: 183140**				
toe	Electricity	Biomass	LPG	Kerosene	Total
Households	6,725	527	7,723	692	15,668
Lighting	3,268	0	0	235	3,503
Appliances & AC	3,207	0	0	0	3,207
Cooking and smoking	126	527	7,723	457	8,834
Others	124	0	0	0	124
Public	4,348	0	375	74	4,797
Lighting	2,643	0	0	0	2,643
Appliances & AC	1,705	0	0	56	1,761
Cooking and smoking	0	0	375	18	393
Others	0	0	0	0	0
Manufacturing & Commerce	399	0	20	141	560
Lighting	200	0	0	85	285
Appliances & AC	199	0	0	56	255
Cooking and smoking	0	0	20	18	38
Others	0	0	0	0	0
Total	**11,472**	**527**	**8,119**	**907**	**21,025**

Electricity, biomass, LPG and kerosene on households, public and manufacturing & commerce for the Islands are based on a demand surveys, sent to all inhabited islands. With the results, it has been possible to establish a realistic distribution of the energy consumption between the different types of end-uses.

The specific energy demand per capita (kWh/capita) is seen below for Male, Vilingili, Hulhumale and for local islands. The total energy demand per capita being close to 1.3 times higher in Male, Hulhumale & Vilingili than in the Islands.

Table 5.3.1.4: Specific Energy demand between the different types of end-uses in kWh/capita (Male Region)

Greater Male Region	**Population: 130850**				
kWh/capita	Electricity	Biomass	LPG	Kerosene	Total
Households	802.8	0.5	267.6	7.8	1,078.7
Lighting	193.0			0	193.0
Appliances & AC	608.4			0	608.4
Cooking and smoking	0.5	0.5	267.6	7.8	276.4
Public	28.6	0		0	28.6
Manufacturing & Commerce	526.5	0		0	526.5
Government Buildings	300.1	0		0	300.1
Total	**1658.0**	**0.5**	**267.6**	**7.8**	**1,933.3**

Table 5.3.1.5: Specific Energy demand between the different types of end-uses in kWh/capita (Atolls)

Atolls	**Population: 183140**				
kWh/capita	Electricity	Biomass	LPG	Kerosene	Total
Households	427.0	33.5	490.5	44.0	995.0
Lighting	207.5	0	0	15.0	222.5
Appliances & AC	203.7	0	0	0	203.7
Cooking and smoking	8.0	33.5	490.5	29.0	561.0
Others	7.9	0	0	0	7.9
Public	276.1	0.0	23.8	4.7	304.6
Lighting	167.8	0	0	0	167.9
Appliances & AC	108.3	0	0	3.6	111.9
Cooking and smoking	0	0	23.8	1.2	25.0
Others	0	0	0	0	0.0
Manufacturing & Commerce	25.3	0.0	1.3	8.9	36.6
Lighting	12.7	0	0	5.4	18.1
Appliances & AC	12.6	0	0	3.6	16.2
Cooking and smoking	0	0	1.3	0	1.3
Others	0	0	0	0	0.0
Total	**728.5**	**33.5**	**515.6**	**57.6**	**1,335.2**

Cooking
The 'Population and housing Census, 2006' provides a large amount of information.

Assumptions:
The assumptions made include:

- Utilised energy for cooking (supplied to the pan/pot/oven) is 3.50[1] kWh/day/household

- Efficiency in utilisation of fuels

Changes in use of fuel type
It is assumed that Male and neighbouring islands does not use fuel wood/biomass.

Table 5.3.1.6: Energy sources for cooking

Fuel	Efficiency[1]
Firewood	20%
Kerosene oil	50%
LPG	50%
Electricity	95%
Other (not defined – probably biomass)	20%

[1] This is equivalent of average cooking places (each 575 W) used for approx. 3 hours/day.

5.3.2 Water supply and desalination
The energy consumption related to water supply and desalination includes the public installations providing water and desalination for Male, Hulhumale and Vilingili, serviced by Male Water and Sewage Company (MWSC).

The electricity for the system is produced at diesel gen-sets at the MWSC premises.

Table 5.3.2.1: Diesel consumption: litres/year

	Unit	Male'	Vilingili	Hulhumale'
Water production per day	m3	10,000	450	375
Specific Energy consumption	kWh/m3	4.5	5.3	5
Daily Energy consumption	kWh	44,400	2,350	2,000
Yearly Electricity consumption	MWh	16,200	850	730
Efficiency in Electricity production	%	38	35	35
Diesel consumption	**Liters/year**	**3,969,000**	**163,000**	**287,000**

Source: MWSC

There are also desalination installations on the resorts; however, these have been included in the end-use analysis for resorts.

5.3.3 Resorts
Consumption of energy is significant in tourist resorts. To collect accurate information, a survey study was prepared. There are a total of 96 resorts registered in the Maldives as of 2010.

There is no official information available on the energy consumption in the resorts; therefore a survey covering a selection of 16 resorts has been conducted during April & May 2010, to establish the level of use of energy resources and consumption pattern.

Based on an analysis of the replies, the following assumptions can be established:

- Use of diesel for electricity production: 4.59toe/bed
- Use of LPG for cooking: 3.77 kg/bed night
- Use of fuel for transportation is dealt with elsewhere.

Using "bed" as the unit of scaling, instead of "bed night", is based on the electricity demand as a constant, since A/C systems and water pumps are operational in all rooms/guest facilities regardless of guest occupancy.

Table 5.3.3.1: Electricity production on resort/year in toe

Oil / Electricity	Unit	Comments	Total
Oil consumption for electricity	toe/bed		4.59
Total beds 2009	beds		19,860
Total oil consumption	**toe**		**91,226**
Electricity production	**toe**	**Conversion efficiency 28%**	**25,543**

The use of LPG for cooking is related to the amount of meals and therefore to the actual tourist bed nights.

Table 5.3.3.2: F consumption for cooking on resorts/year

LPG	Unit	Comments	Total
LPG consumption for cooking	kg/bed-night		3.77
Total bed-nights 2009	bed-night		5,451,164
Total LPG consumption	**toe**		**48**

5.3.4 Fishing

The analysis of the energy consumption for fishing is collected from statistical yearbook 2009, Table 9.20: "Fish Catch, Fishing Trips and Catch per Unit effort by Locality, 2008". This provides the amount of energy consumed in fishing vessels other than transport. The transport is covered under the Transport heading. The following table shows the necessary assumptions highlighted in blue:

Table 5.3.4.1: Kerosene and LPG consumption for fishing boats

Categories of Vessel		Kero-sene	LPG		Kerosene			LPG		
Mechanised fishing vessel	No. of Vessel	Lit/trip	Kg/trip	Trip/y	Toe/y Male	Toe/y Atoll	Toe/y	Toe/y Male	Toe/y Atoll	Toe/y
1 Fishing vessels: < 60 feet	3152	4	2	105,907	71	283	354	48	191	239
2 Fishing vessels: 60-80 feet	350	5	3	31,500	26	105	132	21	85	107
3 Fishing vessels: > 80 feet	140	6	6	11,760	4	55	59	5	75	80
4 Small collection vessels	444	5	7	31,968	8	126	134	15	238	253
5 Collection Mother vessels	10	5	25	720	0	3	3	1	19	20
Total	**4,096**				**109**	**573**	**681**	**90**	**609**	**699**

5.3.5 Travel person/freight related to Islands

The analysis of the energy consumption for travel and freight transport to and from Islands, and inside atolls is based on the statistical yearbook 2009. The table below shows vessels energy consumption categorized based on various purpose of the vessel

Table 5.3.5.1: Energy consumption of transport in toe

	Diesel TOTAL	Petrol TOTAL	of which Male		of which Atolls	
			Diesel	Petrol	Diesel	Petrol
Fishing	25,223	-	2,814	-	22,409	-
Transport – passengers and goods	49,588	-	9,918	-	39,670	-
Transport – tourists	11,388	10,435	1,588	2,087	9,800	8,348
Pleasure and others	383	668	134	192	249	476
TOTAL	**86,582**	**11,103**	**14,454**	**2,279**	**72,126**	**8,824**

Vehicles

The analysis of the energy consumption for land transport in vehicles is based on the Statistical yearbook 2009, Table 11.3: "Registered and Newly Registered Vehicles According to Type, 2008" and information directly from the Ministry of Transport.

Table 5.3.5.2: Fuel consumption for land transport in vehicles

	2008	Fuel			Avg. Dist.	Miles	Fuel econ. petrol	Fuel econ. diesel	Total petrol	Total diesel
Types of vehicles	**Register**	**Petrol**	**Diesel**	**Total**	**Km/d**	**Km/lit**	**Km/lit**	**Km/lit**	**Litre**	**Litre**
All types	19,914									
Motor Car	3,262	100%	0%	100%	20.00	7,300	12.0	14.0	1,975,333	7,758
Motor Cycle/ Auto Cycle	36,824	100%	0%	100%	20.00	7,300	20.0		13,440,760	
Lorries/ trucks/ Tractors	1,235	98%	2%	100%	40.00	14'600	6.0	8.0	2,952,444	39,542
Van/ Bus	1,047	28%	72%	100%	40.00	14'600	7.0	8.0	604,590	1,381,759
Jeep/Land rover/Pickup	2,007	25%	75%	100%	40.00	14'600	7.0	10.0	1,046,507	2,197,665
Other vehicles	953	90%	10%	100%	5.00	1'825	6.0	8.0	260,884	21,740
Total									**20,380,518**	**3,648,464**
								toe	**16,275**	**3,172**

In the table below the assumptions made regarding the distribution between petrol and diesel fuel is made (based on input from Ministry of Transport), and the average distance and fuel economy.

Table 5.3.5.3: Energy consumption on average distance and fuel economy

Type of vehicles	Petrol	Diesel	Avg. Distance (km/day)	Mileage (km/year)	Fuel economy petrol (km/l)	Fuel economy diesel (km/l)
Motor Car	100%	0%	15.00	5,475	12.0	14.0
Motor Cycle/Auto Cycle	100%	0%	15.00	5,475	20.0	25.0
Lorries/Trucks/Tractors	98%	2%	40.00	14,600	5.0	8.0
Van/Bus	28%	72%	30.00	10,950	5.0	8.0
Jeep/Pickup	25%	75%	10.00	3,650	7.0	10.0
Taxi (running in Male')	100%	0%	80.00	29,200	12.0	14.0
Other Vehicles	90%	10%	5.00	1,825	6.0	8.0

6 Energy balance overview

Table 6.0.0.1: Overview of the energy balance of the Maldives in toe, 2009

	Diesel	Petrol	Jet A1	LPG	Kero-sene	Bio	Elect-ricity	Solar Heat	Total
Resources	1	2	3	4	5	6	7	8	
Domestic Resources									
Biomass						533			533
Wind									-
Solar								263	263
Landfill gas									-
Imports									
Oil Products	290,066	30,305	27,280	13,038	1,922				362.611
Exports									
Oil Products	(9,320)		N/A						(9,320)
Stock									
Change in stock		(2,576)	(10,200)	(500)	(500)				(13,776)
Gross Domestic Consumption	**280.746**	**27,729**	**17,080**	**12,538**	**1,422**	**533**	**-**	**263**	**340,311**
Electricity (incl. Distribution loss)									
STELCO									
- Male, Hulhumale, Vilingili	(49,786)						18,820		(30,966)
- Atolls	(3,516)						1,227		(2,289)
Domestic Airports	(4,240)						1,615		(2,625)
Community/ Private (Atolls)	(31,191)						10,398		(20,793)
Desalination Industry	(3,874)						1,529		(2,345)
Industry, Cold-store, Canning	(6,233)						1,745		(4,488)
Resort (conversion, distribution)	(91,226)						25,543		(65,683)
Conversion Total	(190,066)	-	-	-	-	-	60,877	-	(129,189)
Energy Consumption	**90,680**	**27,729**	**17,080**	**12,538**	**1,422**	**553**	**60,877**	**263**	**211,122**
Household - Residential									
Male – Capital Region				3,011	88	6	9,032		12,137
Atolls				8,119	907	527	6,725		16,278
Manufacture, commerce, service									
Male & Vilingili									
- Public buildings, incl. Schools							322		322
- Industry, manuf., commercial							5,924		5,924
- Fishing (boats)	2,814			573	109				3,496
- Desalination Industry							1,529		1,529
- Waste (Thilafushi)									
- Government Buildings							3,377		3,377
Atolls									
- Public buildings, incl. Schools							4,348		4,348
- Manufacturing							399		399
- Cold stores & Canning							1,745		1,745
- Desalination Industry									
- Fishing (boats	22,409			609	90				23,108
Resorts (excluding transport)									
- Resorts etc.				110			25,543	263	25,916
Domestic Transport									
Hulhule Airport (operation)	924	96					1,615		2,636
Domestic air transport			17,080						17,080
Sea transport, Atolls	49,588								49,588
Sea transport, tourists & leisure	11,771	11,103							22,874
Vehicles	3,172	16,275							19,447
Energy Consumption Total	**90.679**	**27,474**	**17,080**	**12,421**	**1,195**	**533**	**60,559**	**263**	**210,204**
Balance	**1**	**255**	**-**	**117**	**227**	**-**	**318**	**-**	**918**

Primary Energy Consumption

Imported fossil fuels, primarily diesel, dominate primary energy consumption, as it constitutes of 79.61% of the total primary energy demand.

Indigenous renewable energy constitutes only approximately 0.2% of the primary energy use.

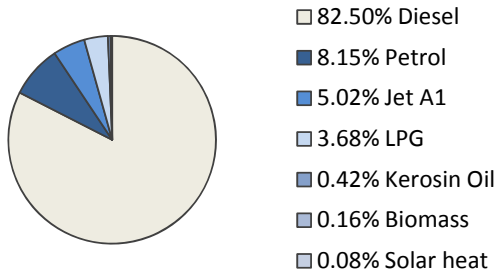

Table 6.0.0.a: Primary Energy Consumption

Conversion

Almost 42% of the diesel oil is used for production of electricity in resorts, 33% is used for electricity production by STELCO, and the remaining 25% is used in the local islands and for industrial purposes.

There is definitely a gap for improvement in the overall system efficiency.

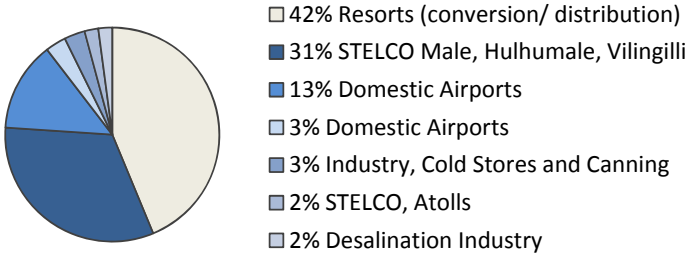

Table 6.0.0.b: Conversion

The conversion and distribution losses of the electricity sectors are high, especially in local islands, where the electricity production and distribution is organised by regional utility companies, private/community owned operators.

Final Energy Demand

The final energy consumption includes only 0.25% biomass.

The dominant final energy use is diesel, primarily for fishing and sea-based transport, to and from inhabited islands and resorts.

42% of the final electricity demand is primarily used at the resorts.

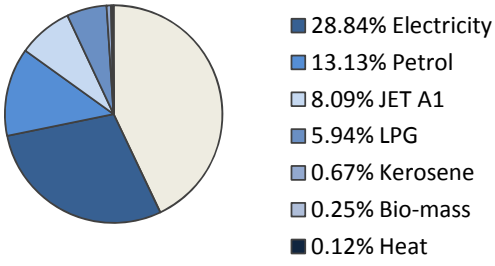

Table 6.0.0.c: Final energy demand/consumption

Emission

The total green house gas emission from the energy supply in the Maldives is concentrated on the emission from the imported fossil fuels. Emissions categorized by fuel type and usage are illustrated in the table below;

Table 6.0.0.2: Overview of the Emissions by energy use in tons of co^2 equivalent, 2009

	Diesel	Petrol	Jet A1	LPG	Kero-sene	Bio	Elect-ricity	Solar Heat	Total
Specific emission factors (ton/toe)	3.13	3.09	3.05	2.75	3.05	-	9.41	3.10	
Final Energy Consumption	1	2	3	4	5	6	7	8	
Household - Residential									
Male – Capital Region				8,286	269		84,992		93,546
Atolls				22,341	2,766		63,279		88,386
Manufacture, commerce, service									
Male & Vilingili									
- Public buildings, incl. Schools							3,033		3,033
- Industry, manuf., commercial							55,741		55,741
- Fishing (boats)	8,817			1,576	332				10,724
- Desalination Industry							14,388		14,388
- Waste (Thilafushi)									
- Government Buildings							31,774		31,774
Atolls									
- Public buildings, incl. Schools							40,917		40,917
- Manufacturing							3,753		3,753
- Cold stores & Canning							16,423		16,423
- Desalination Industry									
- Fishing (boats	70,204			1,675	276				72,154
Resorts (excluding transport)									
- Resorts etc.				303			240,360	815	241,478
Domestic Transport									
Hulhule Airport (operation)	2,896	297					15,201		18,394
Domestic air transport			52,063						52,063
Sea transport, Atolls	155,353								155,353
Sea transport, tourists & leisure	36,878	34,314							71,192
Vehicles, Male'	9,937	50,299							60,236
Vehicles, Atolls									
Statistical Difference	**3**	**787**		**322**	**692**		**2,994**		**4,799**
Final Energy Consumption Total	**284,088**	**85,697**	**52,063**	**34,503**	**4,335**	**-**	**572,854**	**815**	**1,034,354**
	27.5%	**8.3%**	**5.0%**	**3.3%**	**0.4%**	**-**	**55.4%**	**0.1%**	**100%**

7 Conclusions and Recommendations

7.1 Sources of information

There are reliable sources for information collection, which are able to provide solid data available in the Maldives. This includes:

- The Maldives Customs Service (MCS) has accurate and comprehensive data on imports of fossil fuels (Diesel oil, LPG, petrol, aviation gas and aviation Jet A1 kerosene, etc.).
- The State Trade Organisation (STO) has information on bunkering and stock levels of oil, LPG and other oil products.
- The State Electricity Company (STELCO) has developed an informative statistics covering the islands that they supply with power.
- The Ministry of Housing, Transport and Environment (MHTE) has been helpful with the available information regarding the transport sector.
- Official statistics from the “2006 Census”, and the annual statistical yearbooks.
- Report from JICA, Feasibility study on grid connected PV system in Male and Hulhumale Island.
- Survey questionnaire has been used to supplement the available sources.

7.2 Purpose of Energy Balance

A reliable energy balance is the fundamental requirement for establishing reliable modelling of the potential energy market development and the effects of any given market intervention.

So, is essence an energy balance is necessary to provide an understanding of the complexity of the energy sector and to assess the social, legal, technological, financial and economic effects of any measure of intervention into the energy sector.

7.3 Recommendations for future energy balances

In order to accommodate a systematic collection of the necessary information required establishing an annual energy balance additional initiatives are necessary. This should include:

- Establish regular collection/reporting routines of standardised energy information from all islands
- Establish regular collection/reporting routines of standardised energy information from all resorts
- Establish regular reporting routines of official statistics from MCS, STO, MHTE, etc.
- Establish a permanent working group in the MHTE to review, analyse and adapt information and prepare energy balance.

8 Data Annex

Imported of Selected Fuel in 2008

Table 8.0.0.1: Import of selected fuel, 2008

Code	Description	Country	Quantity (M/T)	CIF (RF)	Rate
2710191010	Marine Gas oil (Diesel)	Bahamas	59,281.41	713,840,639.15	10
2710191010	Marine Gas oil (Diesel)	Bahrain	4,320.67	47,891,411.46	10
2710191010	Marine Gas oil (Diesel)	Singapore	52,867.71	598,601,009.84	10
2710191010	Marine Gas oil (Diesel)	U.A.E	150,712.77	1,914,042,752.54	10
2710191011	Aviation Gas	U.A.E	23,459.85	224,134,259.57	10
2710191012	Kerosene Oil	Singapore	200.00	2,566,095.91	10
2710191012	Kerosene Oil	U.A.E	463.71	7,005,393.00	10
2711120000	Propane, Liquefied	Bermuda	2,248.58	26,081,686.38	10
2711120000	Propane, Liquefied	Malaysia	890.90	10,900,925.49	10
2711120000	Propane, Liquefied	Oman	2,160.14	26,693,059.31	10
2711120000	Propane, Liquefied	Singapore	5,014.86	61,384,185.81	10
2711120000	Propane, Liquefied	U.A.E	2.48	19,989.33	10
2711191010	Petrol	Bahamas	3,038.54	37,033,414.86	10
2711191010	Petrol	U.A.E	23,438.16	283,274,175.44	10
Total				**3,953,468,998.09**	

Re-Exports of Selected Fuel In 2008

Table 8.0.0.2: Re-Exports of Selected Fuel, 2008

Code	Description	Country	Quantity (M/T)	FOB (RF)
2711191010	Marine Gas oil (Diesel)	Sri Lanka	15.00	203,399.95
2711191010	Marine Gas oil (Diesel)	U.A.E	10,658.30	163,344,898.15
2711191011	Aviation Gas	U.A.E	135,925.81	1,288,388,821.05
Total				**1,451,937,119.15**