SREP Investment Plan
Republic of the Maldives

LIST OF ACRONYMS

ADB	Asian Development Bank
CIF	Cost Insurance and Freight
BOOT	Build Own Operate Transfer – a mechanism for contracting power station developers
EE	Energy Efficiency
EFIT	Existing Feed In Tariff
Energy+	Renewable Energy programme funded by the Norwegian Government
EMP	Environment Management Plan
FIT	Feed in Tariff – a mechanism for buying power form independent generators
GHG	Green House Gas
GoM	Government of Maldives
IFC	International Finance Corporation
LECReD	Low Emissions Climate Resilient Development – a programme managed by the UNDP and funded by the Danish Government
MED	Ministry of Economic Development
MESCO	Maldives Energy Services Company
METSU	Maldives Energy Technology Support Unit
MFIT	Modified Feed In Tariff proposed to improve existing FIT regulations
MFT	Ministry of Finance and Trade
MHE	Ministry of Housing and Environment
MIGA	Multilateral Investment Guarantee Agency
PPA	Power Purchase Agreement
PRG	Partial Risk Guarantee
PSOD	Private Sector Operations Department (of the ADB)
PV	Solar Photo Voltaic
RE	Renewable Energy
REIO	Renewable Energy Investment Office
UNDP	United Nations Development Programme
WB	World Bank

EXECUTIVE SUMMARY

BACKGROUND

In recognition of the existential threat posed to the Maldives by climate change, and the economic threat posed by oil price rises and volatility, President Nasheed has set an aspiration for the country to become carbon neutral (excluding aviation) by 2020.

The country is particularly vulnerable to the effects of climate change. It is also extremely dependent on oil as the sole source of energy. This makes the Maldives one of the most exposed countries in the world to the probable increase in oil prices over the medium term.

Oil imports in 2010 were approximately $240M across all sectors. In 2011 they will be ±$340M. Assuming 4.5% p.a. growth by 2020 and with a $150/bbl. oil price, oil imports could be ±$700M. The total cost of decarbonizing all sectors (including marine transport but not aviation) is estimated to be of the order of $2-$3Bn by 2020 – most of which will be borne by the tourism sector. Reducing costs of equipment – particularly energy storage, will improve this position.

The electricity sector in the Maldives can be divided into two distinct sectors:

- The Greater Malé area – which is expected to have a demand of around 60MW by 2017. It is expected that the islands in the Greater Malé area will be connected by a subsea grid within two years – allowing some flexibility in power planning.
- The Outer Islands – comprising almost 200 inhabited islands and 100 island tourism resorts. The inhabited islands have collectively a total daily average power consumption of around 20MW. Tourist islands are all privately operated, but are believed to have a further ±100MW of generation between them.

The depth of emissions reductions sought poses unique technical problems in the Maldives. The several hundred isolated island grids cannot practically be connected, and there is limited opportunity for anything other than intermittent solar energy, with possibly some small component of wind outside Malé. The use of very high levels of intermittent solar energy in very small grids creates severe technical and cost challenges. These foreshadow the problems that all grids will face in time as they decarbonise, but the Maldives will feel them more or less immediately. The Maldivian challenge is the selection and deployment of technologies within the wind and solar arena that are capable of delivering a fully renewable grid at an affordable price, rather than determining which RE resources to focus on.

OBJECTIVES FOR SCALING UP RENEWABLE ENERGY PROGRAM (SREP)

Renewable Energy in the Maldives could be at grid parity already for moderate levels of penetration, and could, with care, be at grid parity for near full penetration (90% RE including utility scale energy storage) within five years if the investment conditions were as straightforward and risk free as investment in, say, Europe.

Therefore the overarching objective of the SREP funding is to make investing in the Maldives as technically and commercially straightforward and risk free as possible. This is the key deliverable that will enable long-term affordable access to renewable electricity for all. It will transform the economics of renewable energy and move it from niche to mainstream.

The specific objectives of the SREP investment plan are to overcome five barriers to decarbonising the electricity sector; the challenge of raising capital in the Maldives; the lack of human resources and technical capability; the high transaction costs and small scale of projects;

the lack of preparedness of island power stations in the Maldives to accept high levels of renewable energy; and the challenge of internal logistics.

The GoM has already taken several key steps to overcome these barriers. These include the creation of the Renewable Energy Investment Office (REIO) in May 2011 under the Ministry of Economic Development to co-ordinate the overall policy framework on renewable energy; the Cabinet decision in August 2011 to create the Maldives Energy Technology Support Unit (METSU) and Maldives Energy Service Company (MESCO), the former to provide resource data, technical knowledge and training and the latter to reduce transaction costs, to develop funding and logistics arrangements, and to facilitate the provision of guarantees to developers against sovereign, counterparty and currency risk.

EXPECTED PROJECT OUTCOMES

Addressing the barriers to investment will enable the development of three key renewable energy projects:

- A baseload renewable energy supply for Malé which provides power at less than the marginal cost of diesel generation. This will reduce Malé's electricity greenhouse gas (GHG) emissions by approximately 50%.
- Preparing the entire country to accept 90% of its energy from renewable sources on a 'plug and play' basis.
- High level of Outer Island solar RE penetration, reducing GHG emissions from electricity in larger islands by around 30% and close to 100% for 20 or so of the smallest islands.

In addition, and alongside the SREP funded activities, the GoM will institute three energy efficiency programmes:

- Reduction of energy use in the Government Estate,
- Increase of domestic energy efficiency,
- Reduction of the losses incurred in inefficient power stations and poorly designed distribution grids.

SREP GRANT AND FINANCING

This investment plan envisages the investment of around $180M in renewable energy, split as follows:

	SOURCE OF FUNDS							TOTAL
	SREP	GOM	WB	ADB	IFC/ PSOD	PRIVATE	OTHER	
Outer Islands renewables	$17,300	$1,600	$3,000	$4,000	$0	$59,800	$9,500	**$95,200**
Male Baseload	$10,500	$1,500	$3,000	$0	$20,000	$47,000	$0	**$82,000**
T/A	$2,200	$800	$0	$800	$0	$0	$500	**$4,300**
TOTAL	**$30,000**	**$3,900**	**$6,000**	**$4,800**	**$20,000**	**$106,800**	**$10,000**	**$181,500**

TABLE 1 - FINANCING SUMMARY (IN US $ '000)

This investment will save $32M (after deducting biomass fuel costs) annually, and make a CO2 emissions reduction over the 20 year life of the projects of around 3M tonnes.

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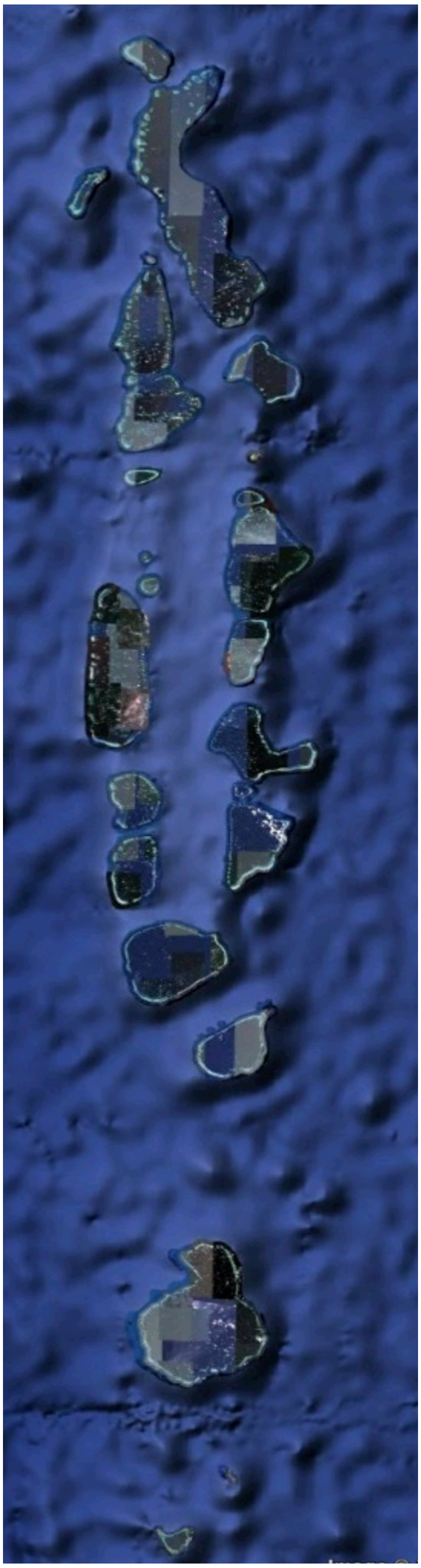


FIGURE 1 MAP OF MALDIVES

COUNTRY CONTEXT

GEOGRAPHY

The word 'atoll' is originally a Divehi[1] word – meaning a string of coral islands arranged around a roughly circular lagoon. The Maldives is made up of around 20 atolls, distributed on a North South line almost 1,000km long, and straddling the equator 750km South West of Sri Lanka.

Consequently the country is made up exclusively of corals and sand, with no point higher than 2.3m above mean sea level. There is no mineral except coral, so little soil, no rivers or bodies of fresh water at surface, and very little dry land. The total land area is around 300km^2.

In total there are about 1,192 islands (average size 25ha) of which about 200 are inhabited. A further 100 are self-contained tourist resorts.

The total population is between 300,000 and 400,000 including migrant workers.

The largest urban centre is Malé, the capital, which has a population of around 100,000-150,000 if the adjacent islands of Hulhumalé and Vilingili are included. Most people live on Malé with a total area of about 2 km^2. Other islands in the Greater Malé area include Thilafushi – the national landfill site and growing industrial centre, and Hulhulé – with the international airport.

Malé has a limited number of cars, but tens of thousands of motorcycles as the main means of transportation.

The next largest population centre is Addu in the South. Addu is a small atoll, several of whose islands are very close to each other and are joined by a 15km long causeway and road. This is the only long road in the country. Addu has around 30,000 residents.

The remaining inhabited islands have small settlements with few if any roads and almost no motor transport. They vary between having plentiful space, and being completely built up. None are more than a few hundred metres long in any direction.

[1] Divehi is the national language of the Maldives

FIGURE 2 - ISLAND AND ITS LAGOON

Separate electricity grids power all the islands. Communications are excellent, with an affordable mobile phone service that covers the entire country. Most transport is by boat with only limited air travel because of the limited possible runway sites. Tourists are transported by boat, or by small seaplanes to resorts that are distant from Malé.

The lack of land and poor soils constrains the potential for agriculture – so other than tourism the principal activity is commercial fishing. It also constrains the possibility of installing renewable energy in many places. However, the atolls contain vast areas of very shallow lagoons. Building over lagoons is common for tourist resorts, as a relatively low cost way of creating space, and may become a key component of any renewable energy installations.

ENVIRONMENTAL POLICY BACKGROUND

The Maldives, as the lowest lying country in the world, is exceptionally vulnerable to rising sea levels caused by global warming. The slow pace of international negotiations to limit global warming is therefore a cause for deep concern in the Maldives. For this reason, President Nasheed has taken a lead by declaring that his country will strive to become the world's first carbon neutral country with the almost complete phasing out of fossil fuels by 2020.

By decarbonizing the Maldives economy, the President aims to show the world that his country is not prepared to wait for an international agreement, and to encourage others to follow the path of unilateral deep emissions reductions.

The decarbonising policy is supported by a number of cabinet decisions – including the acceptance of the Renewable Energy Investment Framework (REIF) which sets out the development path for a carbon neutral electricity system by 2020. A copy of the REIF is available via the Ministry of Economic Development web site (www. trade.gov.mv).

ECONOMIC POLICY BACKGROUND

In 2011, the Maldives spent $240M on oil based imports (excluding bunker fuels). In 2012 this is expected to reach $350M, approximately 20% of GDP. If the oil price rises to $150/bbl by 2020, and consumption grows by 4% per annum, oil imports are expected to reach around $700M – or almost $2,000 per head of population. This is clearly unsustainable. Therefore, the twin objective of the carbon neutral policy, other than being a flagship for climate change, is to make the economy largely independent of oil. Decarbonisation is as much a matter of national economic security and social welfare as it is a matter of environmental concern.

Structure of Electricity Sector

Following the democratic elections in 2008 a decision was taken by the GoM to decentralize the Utility Sector. As a result seven distinct utility companies were set up – each administering a separate geographical area. Of these, the largest by far is STELCO, the State Electricity Company – which supplies Malé area and the nearby islands. All Utilities are owned at present by the Ministry of Finance and Treasury though there is an intent at some stage to introduce private capital.

Malé

Malé with 30% of the population of the country has around 40% or more of the total state owned power generation capacity, and a higher proportion of the actual power generated. STELCO's generators in Malé operate at full capacity, and cannot supply the total needs of the capital. Therefore, many businesses have standby generators, and some have their own private full time power supply. Space is heavily constrained on Malé itself, and the lack of any interconnection between islands means that there is no opportunity to generate on one island and supply another.

Outer Islands

Outside the Greater Malé area most islands are supplied by one of the Utilities. Some islands have community-operated generators, but these are being gradually taken over by the Utilities. Each island has only one supplier. In addition, where there are industrial facilities such as ice-making plants for the fishing industry, private generation is the norm.

Each island has a single Utility power station, with several diesel generators of varying ages and capacities. By and large these are manually controlled. Currently, there is no grid connecting the islands – all islands operate their own isolated power system.

Tourism Sector

All 100 islands that are operated as tourist resorts (each resort occupies one island exclusively) have their own private generating facilities. There is no accurate record of the generating capacity or power consumption – but a reasonable working estimate is 1MW per island – making the tourism sector as big as the state sector.

Capacity

Average generation across the country is set out in Table 2 below:

	Average Generation
Greater Malé Area (STELCO)	30MW
Outer Islands (Govt. Utilities)	18MW
Tourism Resorts (estimated)	70MW
Industrial Sector (Malé area)	8-10MW
Industrial Sector (Outer Islands)	Unknown

TABLE 2 - AVERAGE GENERATION

Current Demand and Supply

Currently the outer islands have, in most cases, ample supply on the basis of nominal capacity of generators. However, many island power stations have very low equipment availability, and unserviceable generators mean that there is almost no resilience in the event of failures.

Within Malé the situation is even more strained. Historically, there has been inadequate generating capacity for the needs of the population – leading to periods of supply failure. This is due to rapid growth, constrained finances, and limited planning horizons. The situation is now largely remedied with temporary installations of smaller generators, and will be finally resolved by the imminent commissioning of a new power station.

Across the country, industry has responded to the fragility of the power sector by generating its own power off-grid. This contributes to high costs and acts as a brake on economic development.

Forecast Demand

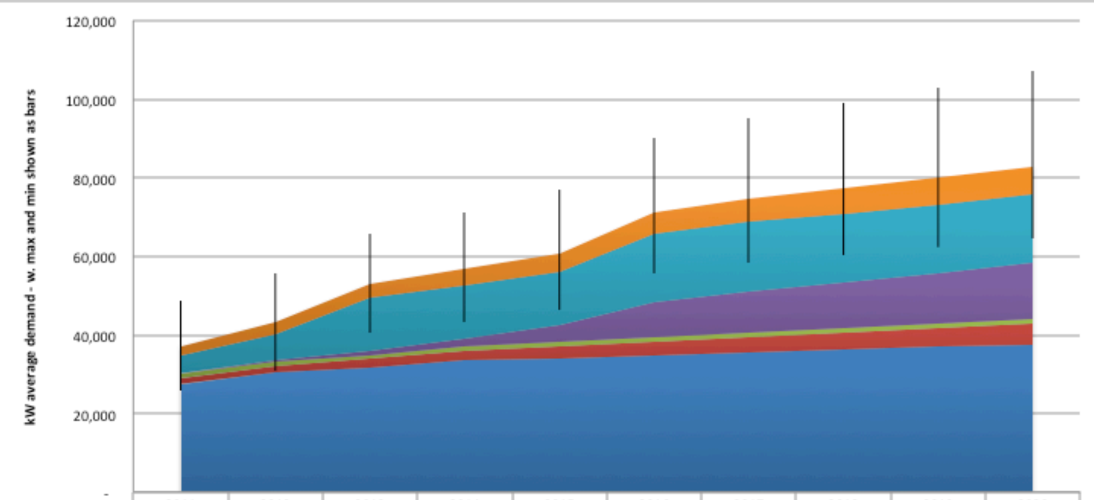
Outer Islands

Demand forecasts for the Outer Islands are not reliable or particularly helpful. Population migration to Malé and the addition or loss of large commercial loads mean that island by island forecasts cannot be supported by any rigorous data set or approach. The most reliable forecast is that power demands will grow somewhat, but previous projects that relied on such growth forecasts have resulted in poor investment decisions. However, the modular nature of proposed renewable energy systems means that growth can be managed on a piecemeal, as needed, basis into the future.

Greater Malé Area

It is intended to connect the islands of Malé, Hulhumalé, Vilingili and Thilafushi with a single 132kV grid. This will allow the integration of several major independent power consumers and producers, and enable future demand to be met by building facilities in areas where population pressures are less severe than on Malé itself.

The current best estimate for future demand in the Greater Malé region is set out in Figure 3:



	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
MWSC	2,500	3,000	3,540	4,106	4,681	5,243	5,767	6,229	6,602	6,999
GMR/Airport	4,500	6,750	13,500	13,500	13,500	17,550	17,550	17,550	17,550	17,550
Thilafushi	280	560	1,120	2,241	4,482	8,963	10,756	11,831	13,015	14,316
Villinghili	976	996	996	996	996	996	996	996	996	996
Hulhumalé	1,451	1,742	2,090	2,508	3,009	3,611	3,972	4,370	4,807	5,287
Malé STELCO	27,598	30,358	31,876	33,470	34,139	34,822	35,518	36,229	36,953	37,692

FIGURE 3 - GREATER MALÉ AREA POWER FORECAST

Special Challenges for the Electricity Sector

Historically, each island looked after its own affairs. This led to a situation where there was no need for, or tradition of, coherent energy planning across the country. This has led to a lack of investment in power generation, distribution and system maintenance. As the economy has modernised and power usage has increased the consequence is an exceptionally inefficient power sector with a lack of human resources needed to remedy the situation.

A further challenge is the geographical remoteness and the lack of transport infrastructure. Simple tasks such as delivering and moving containers are impossible on most islands because there is no way to land them or move them.

Maintenance is another crucial issue. The growth of the power sector has been haphazard, and there is a huge number of different types of generator installed, with no spares or logistics infrastructure to support them. As a result, the grids are operated by ingenuity and 'mending and making do' - often at the expense of efficiency and reliability.

Pricing and Subsidy

Table 3 sets out the current electricity pricing structure across the country as recommended by the Maldives Energy Authority (MEA). Actual pricing may vary from island to island.

Average prices across Utilities in $/kWh	**Domestic**	**Commercial**	**Government**
Lowest tier (0-100kWh/month)	$0.38	$0.43	$0.44
Middle tier (200-300kWh/month)	$0.43	$0.51	$0.55
Top tier (>300kWh/month in islands, >600kWh/month in Greater Malé area)	$0.49	$0.61	$0.62

TABLE 3 - ELECTRICITY PRICING

These prices include a fuel price escalator, and are based on a diesel price of $1.00/litre. In total an additional $25M / year is expended as a subsidy to consumers. This amounts to an estimated average of over $0.05cts/kWh.

Access and Vulnerabilities

Currently almost 100% of households have access to electricity. However, this figure masks severe issues relating to price and vulnerability:

- Electricity in the Maldives is exceptionally expensive by world standard, and most families are highly constrained in their use of power even though it is nominally available at the socket.
- The 100% reliance on diesel means that any price volatility or upward pressure on oil prices makes electricity even more unaffordable.
- The electricity supply system has been starved of appropriate investment, in some cases because funding for the sector has been consumed by the need for subsidy. This means that the system is highly vulnerable to future maintenance issues and cannot be seen as a reliable source of power.

Renewable Resources and SREP Technology Selection

The following section sets out the key renewable resources considered under the SREP and the basis of selection of the technologies chosen for funding. Note that the country has no rivers or elevation so hydro power of any sort cannot be considered.

Tidal and Currents

The Maldives has very limited tidal range so for tidal energy to be employed it will need suitable topographical features that amplify tidal flows to make them viable energy sources. These may exist in channels between islands, but no systematic survey exists of possible resources.

Marine currents have been briefly studied as a possible source of energy. The study done by the Robert Gordon University of Scotland in 2011 concluded that the principal currents were wind driven and moved from one side of the country to the other following the monsoons. In between the monsoons currents were expected to be slack. Thus there is no single location that could provide a consistent flow throughout the year.

Therefore, marine technologies are not considered immediately relevant to the Maldives energy development with the current state of knowledge.

Ocean Thermal

There is deep, cold water close to Malé. Sea surface temperatures are consistently high throughout the year. Thus the Maldives, and Malé in particular, would be an ideal site to construct an ocean thermal energy facility. This technological approach relies on the temperature difference between surface and deeper waters to drive a turbine that generates power. In the medium to long term this may be a perfect baseload power source for Malé, but no commercial plant as yet exists.

Solar

The solar resource is of reasonable quality and consistent across the country and throughout the year, though it does decrease during the monsoons. Figure 4 below shows the profile of the resource across the year (horizontal axis) and over the day (vertical axis).

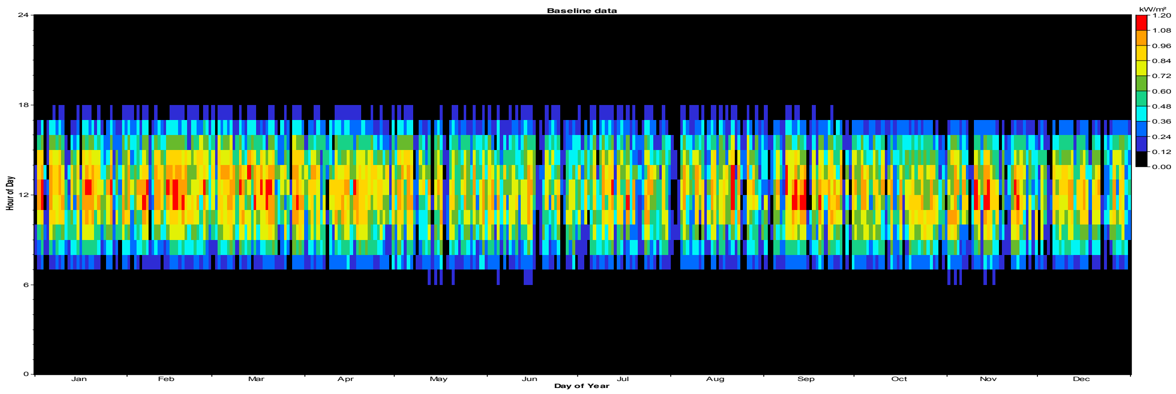


FIGURE 4 - SOLAR RESOURCE THROUGHOUT THE YEAR – NOAA SYNTHETIC DATA MODELLED IN HOMER

Solar energy is crucial to decarbonising the Maldives and a key technology for SREP support.

WIND

There is a poorly documented wind resource in the Maldives, of medium to poor quality. There is some evidence for a strong regional variability from North to South of the country, though in any region the lack of topography makes the wind resource very uniform. Its principal disadvantage is that there are long periods of the year with almost no useable wind. This is shown in Figure 5.

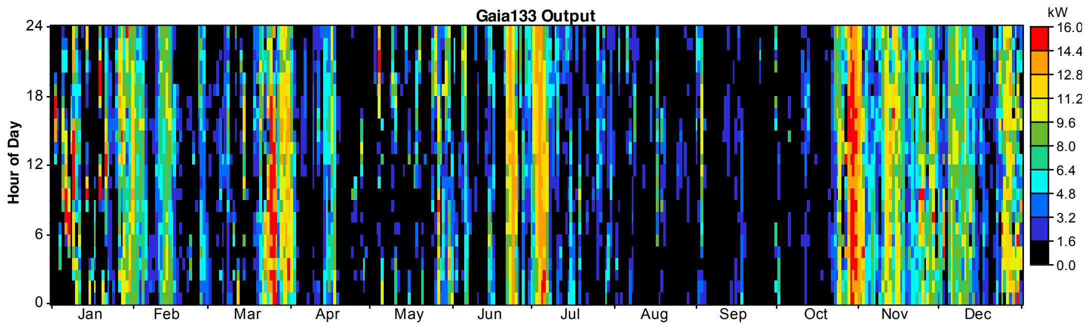


FIGURE 5 - WIND RESOURCE THROUGHOUT THE YEAR – NOAA SYNTHETIC DATA MODELLED THROUGH HOMER

However wind has the particular advantage that the resource is most plentiful for the period of the year when the solar resource is at its weakest. Thus wind may be important to maximising diesel savings in the short term, and minimising the cost of energy storage in the longer term. Wind will therefore be supported under the SREP when used in conjunction with solar PV to provide a more consistent RE supply over the year.

A large scale wind project (20MW) is contracted for the Malé area, and will not need support under SREP.

BIOMASS

LARGE SCALE BIOMASS

Biomass is an economically attractive alternative to diesel for large baseload power, and provides the ability to load-follow, albeit at a penalty in fuel consumption. It is therefore a clear candidate for supplying renewable power in the Malé region – provided the sources of biomass are assured to be sustainable.

There are only very limited biomass resources available in the Maldives. However, sustainable biomass in suitable forms can be obtained on long term contracts at prices significantly lower than the cost of diesel in energy terms. A recent quotation from ADM (one of the world's two biggest agricultural commodities traders) offered biomass in the form of pellets (the most expensive form) from Canada (the furthest possible source) at a price of $190 CIF Maldives with a price fixed for 5 years with inflation adjustments. This makes large scale biomass a key potential technology for SREP support.

SMALL SCALE BIOMASS

At a smaller scale, biomass gasifiers operate successfully in many countries. However, they require considerable maintenance, and are generally run for a limited number of hours per day. In terms of efficiency, the conversion from biomass to electricity is very low, so large quantities of fuel are required to be prepared under very tight specifications.

Introducing biomass powered electricity at small scale in the Outer Islands would require considerable investment in fuel preparation equipment, mobile equipment for transport (most islands have little or no motorised traffic), maintenance facilities, etc.

On the positive side, biomass gasifiers are an attractive possible alternative to batteries for the supply of electricity at night. As it is the intent of the GoM to consider installation of maximum levels of solar and wind to cover daytime use in the first phase, and consider energy storage or alternatives in a later phase of decarbonisation, small scale biomass will not be considered under the SREP IP. It will be considered in the later phase as an alternative to energy storage.

Biomass GHG Emissions

Taking woodchip as the most likely resource to be used in the Maldives, the major sources of GHG emissions arising from its use are chipping, and long distance sea transport. Of these, sea transport is the dominant component.

However, the two principal alternatives to biomass, diesel and solar PV, also have significant production and transport emissions. Appendix 5 examines the GHG emissions in more detail.

Biomass as an Imported Fuel

There is an argument that the Maldives should focus on resources that are indigenous, and not replace one imported fuel, diesel, with another, biomass. However, this argument fails when considering the fact that all RE equipment is imported, and has to be paid for in long term finance charges. Thus although there is an annual cost for the purchase of biomass, there is an even larger annual cost, in the form of interest and capital repayment, for the purchase of an equivalent amount of solar energy. This becomes even greater still when considering the purchase of energy storage to deliver that solar energy at night (see Table 5).

Waste to Energy

Waste collection in the Maldives is hampered by distance and low population density in all areas except Malé and Addu.

In Malé waste collection and disposal in a 3.7MW thermal 'waste to energy' plant is in hand. Elsewhere in the country anaerobic digestion is a potential candidate for the disposal of putrescible waste, though the power potential is limited for individual sites, and most islands will be unviable compared to current power prices. Conversely, at a future date when energy storage is required to deliver night time electricity, the ability to generate gas and store it at low cost to use when there is no solar resource will be attractive.

Thus thermal Waste to Energy will not be supported under SREP. Anaerobic digestion will not provide any material contribution in the next 5 years but may be important thereafter, and thus also will be placed outside the scope of SREP.

Heat Recovery from Diesel Generators

Although not strictly a renewable energy technology, potential opportunities exist for recovery of heat from larger generators to generate additional electricity. This is most typically done with Organic Rankine Cycle (ORC) units.

Commercial ORC units are available to match larger generators than are used widely in the Maldives outside Malé and Addu. In Malé there is currently no space, and plans to shift to largely wind, gas, and biomass in the immediate future mean that the future of the generators as baseload units is limited. Likewise, in Addu the imminent introduction of extensive wind and solar generation will reduce the generators to operating only intermittently and at lower than normal loads. This makes the use of ORCs less attractive. By 2020 it is expected that diesel generation will account for only a very small fragment of power generation – and ORCs will have even less to offer.

ORCs therefore are not seen as meriting support under the SREP, though once plans are finalised for Malé and Addu the situation will be reviewed.

Synopsis of RE Resources

Table 4 below sets out a summary of technology options and their status in the Maldives.

Technology	Status in Maldives	Potential in Maldives	Focus for SREP
Large Scale Biomass	Important – economically attractive	20-50MW	Yes
Small Scale Biomass	Possible alternative to batteries in future	10MW	No
Solar PV	Crucial	Unlimited	Yes
Large Scale Wind	In development	20-30MW	No
Small Scale Wind	Important supplement to solar	10-20MW	Yes
Marine Currents and Tidal	Unlikely to be economic	Nil	No
Waste to Energy - Thermal	Limited opportunities – main project already committed	5MW	No
Waste to Energy – Anaerobic Digestion	Limited - possible supplement to batteries	1-4MW	No
Heat Recovery	Not replicable or transformative	0-10MW	No
Ocean Thermal	Possibly in the future	Unknown	No

TABLE 4 - SUMMARY OF RENEWABLE ENERGY RESOURCES

Marginal Costs of Abatement

Renewable Energy Technologies

Because each island has its separate grid, costs cannot be considered for the nation as a whole, but have to be considered on an island by island basis. Indicative costs for the relevant technologies are set out in Table 5 below, based upon achieving reasonable scale for projects, and a 'normal' utility cost of capital.

Operating cost of Biomass power station for Malé	$0.16		Pure wind somewhere in here depending on scale and region
Full cost of biomass for Malé including capital	$0.20		
Solar PV supplied direct to customers – no batteries	$0.23		
Diesel (Malé and most efficient islands)		**$0.28**	**Best diesel**
Solar/wind/battery optimum mix to supply 80% power	$0.36		
Solar PV at night from batteries	$0.44		
Diesel (most inefficient islands)		**$0.70**	**Worst**

TABLE 5 - GENERATION COSTS

Costs in this table are based on known biomass power plant costs (using a database of 17 similar sized plants built around the world), fuel costs as quoted by ADM, solar capital costs based on recent firm costs for a 1MW scheme for a Maldives resort, and battery costs from public sources. Full scale modelling of solar/wind/battery combination modelling was carried out by Oxford University for Maalhos island, and separately for a power station on Laamu Gan. Diesel costs are based on Utility fuel consumption data.

Thus the potential exists, by achieving the appropriate cost of capital and appropriate scale for island projects, to transform the electricity sector to a high proportion of renewable energy at no overall increase in electricity generation costs.

The relatively high cost of solutions involving energy storage means that these components of a carbon neutral electricity system will be done after the initial low cost components – by which time costs are expected to have fallen. This means that, outside Malé where biomass is possible, generators will continue to provide around 70% of power for the next five years or so.

Conventional Generation

Given that small island generators will continue to provide the bulk of power for the next five years, the broad spread of existing power generation costs merits attention.

Figure 7 shows the reported fuel consumption of ≈120 utility owned power stations for three months. The sample excludes Malé but covers over 90% of the population outside Malé and the resorts. It reveals an extremely wide range of actual efficiencies achieved on different islands.

The data is self-reported by the power station operators, and therefore some samples maybe prone to error, though the most egregious errors have been removed. The size of the sample gives it greater significance than any one power station samples in isolation.

In general, the generators have not been sized to optimize performance at each island's demand levels, and are frequently significantly over-sized. In addition, there is no evidence that they have been chosen to operate at high efficiency over a wide range of power settings. This is believed to be a key reason for the inefficiencies. Other reasons might include low power factors, poor maintenance, old equipment, and fuel loss.

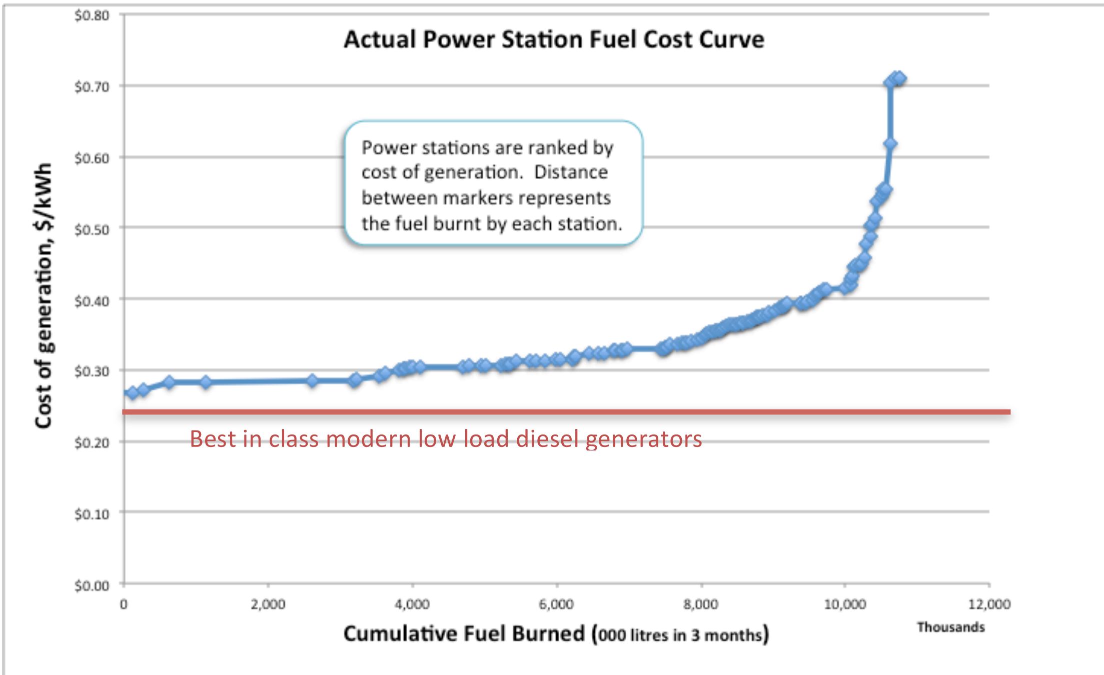


FIGURE 6 - GENERATOR FUEL COST CURVE

New generators designed to operate efficiently at low loads are capable of achieving 0.22-0.25l/kWh fuel consumption – with fuel operating costs around $0.23-$0.26/kWh.

Distribution losses are excessive in many islands, with values over 30% being estimated in some cases. These losses are in addition to the generator inefficiencies.

The cost of new generators is relatively low compared to the cost of fuel to power them, and the power houses will require very different characteristics in order to accommodate high levels of intermittent renewable power. Thus a generator replacement program would be a way to abate greenhouse gas emissions at negative cost, while carrying out the essential preparatory work for renewable installations.

Energy Efficiency

Abatement costs are difficult to derive for many classes of consumption because the variables are so great, and deriving reliable samples across the islands is difficult. Nonetheless, data has been measured for three crucial areas of demand which represent the bulk of night time energy use. These are air conditioners, fridges, and street lighting. Normal domestic lighting is universally provided by compact fluorescent lamps and offers little potential for energy saving. This was provided in a report for the SREP IP preparation exercise by PricewaterhouseCoopers (PWC).

The estimated costs and scale of abatement opportunities, based on replacing equipment at the end of its life with more energy efficient units are shown in Figure 8.

Figure 9 shows the same data but based on replacement of the equipment immediately.

It is clear that potential energy savings are highly cost effective and significant in scale. By focusing on these three items of equipment energy use at night will be significantly reduced – thus reducing the overall cost of providing 24 hour renewable energy.

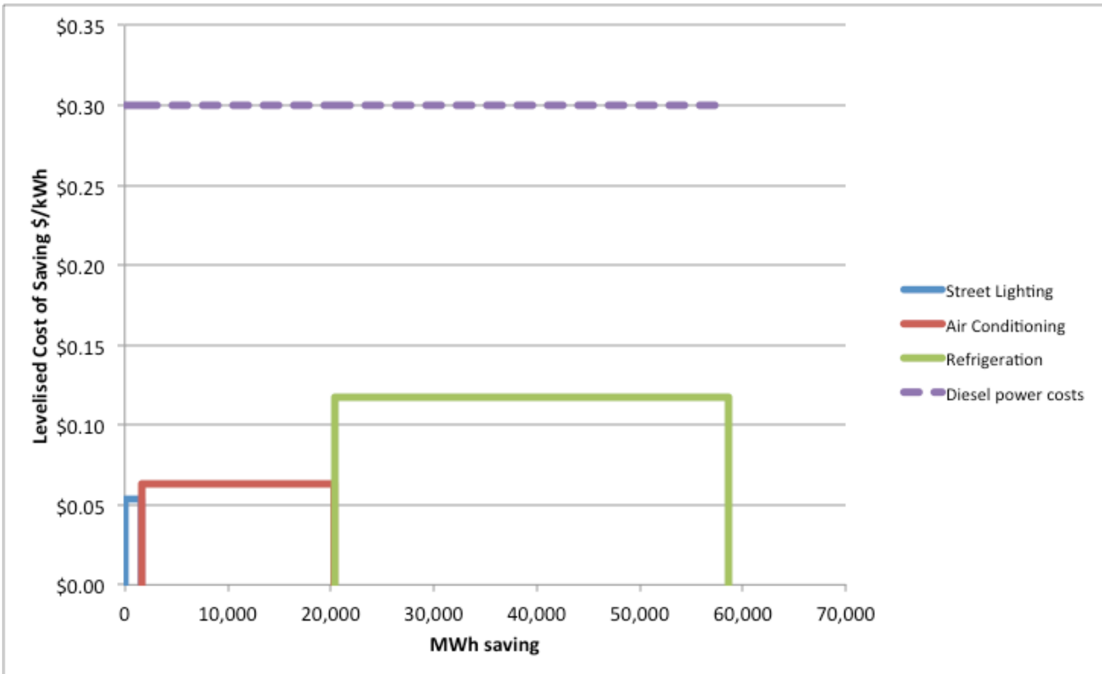


FIGURE 8 - LEVELISED COST OF SAVINGS FROM EQUIPMENT REPLACEMENT AT END OF LIFE

Savings for both graphs are shown in MWh per year. The scale of savings is based upon extrapolation from limited data, and may well underestimate the actual savings possible.

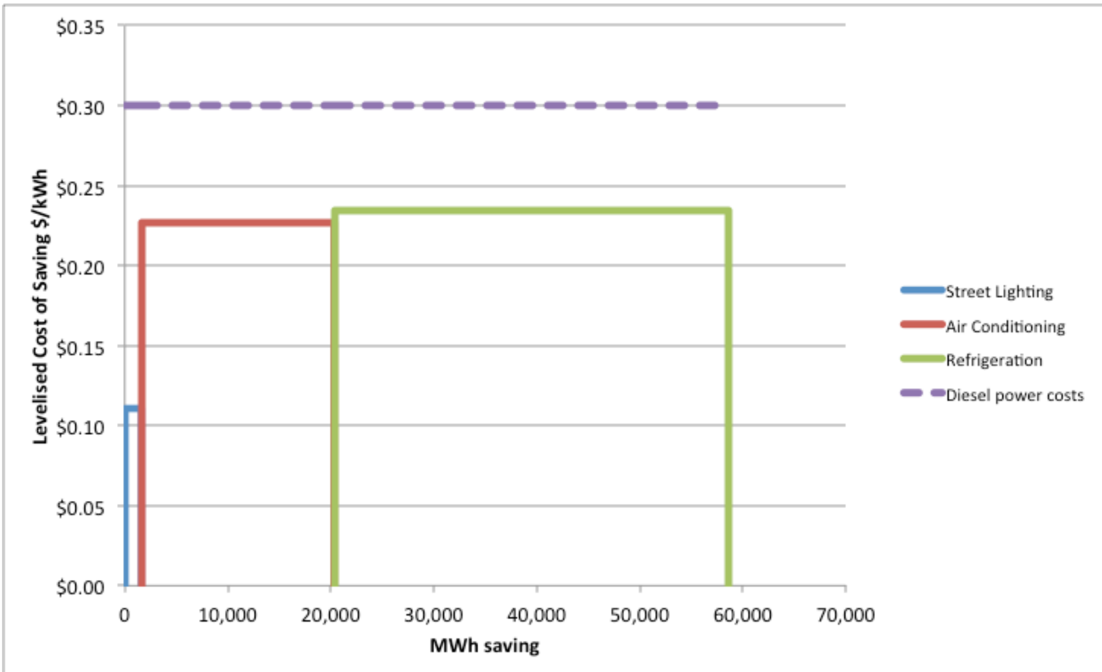


FIGURE 9 - LEVELISED COST OF SAVINGS FROM IMMEDIATE EQUIPMENT RELACEMENT

EXISTING RE PROJECTS

A recently signed contract will connect the main islands in the Malé area with a 132kV link, coupled to a 20MW wind farm and a gas back-up power station. This project will provide the opportunity for biomass and other sources of power to feed the Malé area demand from adjacent islands. These include a 3.7MW waste to energy project that has been contracted for Thilafushi, and a possible, very substantial solar roof programme on the new warehouses proposed for Thilafushi.

There are a number of other Renewable Energy projects in preparation or proposed, but most of these are held up as a result of poor contracts, lack of guarantees by central government, or poor understanding by utilities of how to enter and manage such contracts.

A World Bank funded project to introduce a low level of solar PV 200kW (about 30% of peak load) on Thinadhoo island is currently in progress. Information from this project will be used to inform the development of the projects under SREP. The project will also conduct energy audits and surveys, demonstrate high efficiency appliances, and prepare an energy efficiency action plan for Thinadhoo.

A detailed list of projects is attached in Appendix 1. This list includes projects that have some substance, and many that are aspirational and have been promoted by individual entrepreneurs and accepted by utilities. There is no certainty that these will go ahead. The list does not include a number of smaller, completed projects that are defunct or not performing for lack of support, funding, and capability in the utility.

SREP AS A KEY STRATEGIC TOOL

There are several clear barriers to the use of renewable energy, and to achieving higher levels of energy efficiency. SREP funding will allow several of these barriers to be overcome.

BARRIERS FACING RE DEVELOPMENT

High levels of renewable energy are, *prima facie*, economic at public sector discount rates, and even at private sector discount rates in a secure, low risk economy with a well-developed legal system, when compared to diesel generation. However, RE developments in the Maldives have been almost non-existent to date. The key barriers to progress are summarised below.

THE CHALLENGE OF RAISING CAPITAL

Although the overall economics of decarbonising are compelling at $150/bbl. and reasonable even at current oil prices of around $110/bbl. the challenge for the Maldives is securing capital at an acceptable price. Because of its political history and economic inheritance, the Government of Maldives is poorly placed to raise capital at normal 'sovereign' rates of interest. Similarly commercial investors also have problems raising finance for Maldives investments.

Thus a key challenge for the Maldives is to change the terms under which Utilities or investors can access capital – in order to unlock the profitable but inaccessible opportunities that exist for investment in renewable energy.

SCALE AND COMPLEXITY OF TRANSACTIONS

Although the overall task of decarbonising is large, and measured in billions of dollars, individual projects are all small. In addition, there are 100 separate hotels and tourist resorts and seven Utilities to deal with. Permits for Utility projects have to be secured from the Maldives Energy Authority and the Environmental Protection Agency, and in general Government guarantees are sought for payment. The legal system is not robust and has little track record in the commercial sphere. Thus there are hundreds of small projects to deliver in a complex legal, social and geographical space.

These problems, set in a country that major capital suppliers know little about, creates a very substantial set of transaction costs that reduce any interest in investment, reducing competition and increasing prices.

POWER STATIONS ARE UNPREPARED

Even if there were a queue of private sector developers wishing to inject solar power into the grid today, the power stations simply could not absorb it without creating serious problems of grid stability.

Power loads vary suddenly over relatively short timescales as demand rises and falls in the grid. Generators can deal with this provided the variations are relatively small as a proportion of the total load, and provided they are running at the time. The small size of Maldives grid means this is a regular occurrence – rises of 20% of generation per second are regularly seen.

The addition of renewable energy complicates matters considerably – particularly on a small island grid where all the solar resource will be affected by the same events. Thus the arrival or departure of a cloud can mean that solar generation rises or falls from a minimum to a peak in a matter of seconds.

To accommodate this without tripping out the grid because the generators cannot respond fast enough creates serious challenges. Some level of energy storage will be needed to achieve more

than a minimum level of renewable penetration, together with a reliable voltage control mechanism and a system to start and shutdown generators. In addition, generators are needed that are suitably sized for the load, and are chosen to be as efficient as possible over a wide range of loads.

Logistics

Moving plant and equipment in containers is the most straightforward and reliable method of transport. Some specialised equipment such as low load generators will come containerised for ease of testing before shipping, and subsequent installation.

The Maldives rely on marine transport to move people and goods around the nation. The transport network is fragile, and not equipped to move container traffic or to handle containers once they arrive at an island. Most islands have no crane facilities capable of offloading a full container, or any transport to move a container from beach to power station.

No developer of solar or wind power will be in a position to judge the costs of internal logistics in the Maldives without a detailed study, and particular local knowledge. All two hundred islands will also be slightly different. This presents an obstacle to developers from outside the country, adding significant uncertainty and complexity in an already challenging situation.

Human Resources and Knowledge

Decarbonising the entire economy is a task no nation has ever undertaken before. It presents significant technical challenges – reducing fossil fuel use even by 80% is much more than four times as difficult as reducing it by 20%.

The Utilities have very limited human resources, and no experience of any kind of power generation except diesel. The Ministries likewise have no technical skills, and the administrative and managerial skills they have are stretched very thinly.

Resource Data

The GoM is determined to achieve as close to carbon neutrality as possible without increasing energy costs for the population. This will require careful planning and system design, underpinned by first class data on the solar and wind resource. Such data does not currently exist.

Market Failure

In the tourism sector, as in many property sectors worldwide, operators, owners and freeholders may be different entities with different time horizons and different priorities. Operating licences may be much shorter than the lifetime of a solar panel installation. The tourist market itself is uncertain, and subject to changes of fashion and clientele. This is particularly true in a time of impending global recession.

Renewable energy projects on the other hand are long term projects that thrive best in a market where the investors, owners, and operators have closely aligned interests and time horizons. Thus although the Maldives tourism sector owns perhaps 50% of the entire country's generating capacity, securing high levels of renewable penetration in the sector will be challenging.

Using SREP to Overcome Barriers

The GoM plans to use SREP funding to overcome the following key barriers:

1. **The resource data deficit:** by collecting and supplying quality resource data to the renewable energy community.

2. **Human resources and knowledge:** by building the technical and commercial capacity to enable utilities to enter into and manage good contracts.
3. **Small scale and high complexity of transactions:** by aggregating projects, providing regulatory clarity, bulk negotiation and logistics support where appropriate to deliver SREP program, and by providing technical information and support to developers to reduce pre-contract costs.
4. **Power station readiness:** by adapting power stations to accept high levels of intermittent renewable energy on a 'plug and play' basis. This will be done in conjunction with a major power station upgrade programme to reduce fuel use – funded outside SREP.
5. **Capital availability:** by dramatically reducing commercial and sovereign risks to developers – in order to reduce the cost of capital, and by marketing the advantages of developing safe and profitable projects in the Maldives.
6. **Internal Logistics:** by providing knowledge and assistance on internal logistics.

In addition, ADB funding is being used to strengthen and empower the Maldives Energy Authority who will play a key role in ensuring both a conducive investment climate and appropriate Feed in Tariff levels.

Interaction with other Donor Programmes

There are currently three relevant donor programmes under the aegis of either REIO or MED. In addition, there are loan facilities on offer from the ADB and the IDB for energy purposes.

Name	Donor and Purpose	Location/ Sector	Description
LECReD	Danish funded sustainable livelihoods programme	Focus on Laamu Atoll	A proportion of funding available for RE and EE activities in Laamu, including R&D, and concept testing.
SREP	WB/ADB operated fund for RE, with leveraged funds from MDBs/ private sector	Nationwide, but excluding tourism sector	SREP funds for RE and RE preparatory work only, but leveraged funds to be useable in energy efficiency also. Some support for capacity building.
Energy+	Norwegian Govt. funding for access to sustainable energy	Sector based, to be discussed.	Payment by results – against pre-agreed performance markers. Funding can be used at Govt. discretion to achieve benchmarks.

Table 6 - Donor Interactions

In order to ensure that the programmes complement each other and do not overlap or duplicate efforts, it is proposed that they are oriented broadly as follows:

LECReD The funding specifically for energy in this programme is limited but tightly focused on a particular atoll. It is anticipated that it will be used to understand the challenges of using a largely solar grid to deliver despatchable electricity. This will need the issues of grid stability, load shedding, and load deferral to be explored in real world settings by developing one or two pilot ultra-low carbon islands to evaluate different approaches to both renewable energy and energy efficiency. LECReD will clear the way for developing the SREP projects in the most effective and economic way, and for integrating Energy Efficiency programmes nationwide with Renewable Energy.

SREP It is proposed that SREP funds are used to transform the economics of renewable energy by focusing on three key barriers to investment: preparing power stations to

accept high levels of intermittent renewable power efficiently and cost effectively, reducing the costs of capital by reducing sovereign and currency risks and reducing the transaction costs of renewable projects that are inherently commercial.

Private sector finance will be used to fund investments in solar, wind and biomass projects that become economic as a result of using the SREP grant. These projects will operate either under a Feed in Tariff regime or, for large projects such as the Malé biomass, a 'Build, Own, Operate, Transfer' (BOOT) regime.

Loans from the MDBs will be used alongside the SREP funding to support specific projects that are particularly difficult but have high economic value to the Government of Maldives. These will include installation of renewables in the smallest islands that have exceptionally high transaction and installation costs but where the savings to Government in reduced energy subsidies are substantial. The loans should also be used to support energy efficiency programmes with definable financial benefits to Government.

IFC/PSOD funding will be used to support the Male' baseload project.

Energy+ Energy+ financing will be used to fill all the gaps and extend beyond SREP. There is a serious need to upgrade the technical and administrative capabilities of the GoM to make the decarbonisation policy work. In addition, there are sectors such as tourism and energy efficiency that are not addressed under the other programmes.

The key ambition for the Energy+ funding will be the final stage of RE deployment in the Maldives, increasing RE penetration in the Outer Islands from around 30% to 90%, and achieving the same in the tourism and industrial sectors.

SREP Project Selection and Scale

The following projects have been selected for support under SREP, based on their economic benefits, potential scale, reproducibility, and ability to transform the power sector by overcoming important barriers. Considerable additional detail on the projects selected is included in the concept notes in Appendices 6-8.

Malé Baseload

Malé is one of the most crowded islands in the world, and thus has almost no free space for energy generation, and very high energy loads.

As the national capital, and the main industrial and economic growth point, Malé and its adjacent islands need a large, reliable source of power. As the capital grows, land on adjacent islands is at a premium, and thus there is little space today for energy generation. However, if plans for expansion of the industrial sector proceed on Thilafushi, a nearby island, space for solar installations may become available over the coming years.

The technology selection chapter sets out the possible resources available to the country. Of these only wind and solar energy are indigenous and currently feasible. Ocean thermal energy is a promising but as yet unproved technology for Malé, and marine current harvesting is both unknown and unproven. Some wind is already scheduled for the Malé area, though this is conditional on wind data demonstrating that the economics are favourable. Similarly, the proposed feed in tariff regime will support such solar PV as is possible, within the constraints of the grid's capacity to absorb it.

Given the lead times for large scale energy projects, Malé needs to address the challenge of delivering baseload power from renewable energy as a matter of urgency. The current state of battery technology makes achieving this from intermittent sources such as wind and solar expensive today. The leading contender for battery storage – lead acid batteries, will more than double the cost of electricity delivered through the battery. Battery costs are expected to fall significantly over the next 5-10 years as new technologies leave the laboratories and reach the markets, but the system losses associated with charging and discharging batteries means that power delivered from batteries will always be more expensive than energy used as it is generated.

The only non-indigenous source of renewable energy that can realistically be used immediately is biomass. It has the advantage that it is available 24 x 7 and has the ability to load follow.

Costs for biomass power stations are well known, and their operation is relatively straight-forward and well understood. Table 5 sets out the estimated generating costs of biomass compared to other alternatives. It is clear that at current biomass prices a biomass power station is probably the most economic RE option available. There are few technical risks with such a project. The principal risks are commercial and environmental.

Commercial risks centre around fuel supply and power demand. Fuel supply can be de-risked by entering into long term fixed price contracts. These can be much longer than in the oil industry – seven years has been offered by one major supplier. Fixing fuel costs and quantities however places the risk on demand and the ability of the utility (STELCO) to accept the power produced. These risks can be managed by careful planning and design, integrating the entire Malé area power system into one project.

An argument against biomass is that the fuel has to be imported, thus replacing one import (diesel) with another. However, it should be noted that biomass costs around 50% of the cost of

diesel on an energy equivalence basis. Using solar PV instead of biomass has a much higher capital cost – and will result in a greater outflow of foreign exchange to service the capital than the cost of biomass to fuel the power station.

In the longer term, biomass is expected to become a very sought after low carbon fuel, so prices will undoubtedly escalate. At the same time solar PV, and energy storage technology costs in particular, are expected to fall. Thus in 7-10 years, solar PV built on shallows in the North Malé atoll and on roofs in Thilafushi (60 hectares may be available ultimately) may provide much of the power needs, with ocean thermal energy possibly as a baseload. Even if biomass is selected as the initial 'best option' it is likely at that stage to revert to being a backup power source and for load following – to help reduce energy storage costs.

Environmental risks of biomass centre around the sustainability of the fuel supply and the GHG emissions associated with it, principally long distance marine transport. A very small proportion (perhaps 5%) of the fuel can be sourced internally in the Maldives from coconut. It may also be possible to grow some specific high yielding biomass, such as bamboo, on some islands where space is plentiful but this remains to be tested. Imported biomass is therefore expected to come from sustainable sources that are certified as FSC, or equivalent.

Based on emissions data from the Norwegian Marine Technology Research Institute (MARINTEK) report to the International Maritime Organisation (March 2000), GHG emissions have been estimated for biomass transported to Malé and compared to the emissions from diesel generation. Appendix 4 summarises this calculation. This shows that even for transport distances of 4,000 statute miles, with an assumed capacity factor of 50% (i.e. the ship returns empty to the port of origin) transport emissions are of the order of 8.5% of the direct emissions from diesel generation. This is significantly less than the emissions from refining and transporting diesel, and little more than the emissions from the production of solar PV modules.

A 4,000 mile radius would cover Southern Turkey, South Africa and Eastern Indonesia. In practice a significant proportion of the biomass is expected to come from sources much closer to the Maldives in Asia.

Thus, the current baseline proposal for the Malé area baseload supply is biomass – and this will be used as the reference technology for the SREP IP. However, given the risks of fuel supply in particular, and the falling costs of alternatives – coupled with the possible rapid introduction of new technologies such as Ocean Thermal Energy, a full range of opportunities will be examined in detail as alternatives as part of the prefeasibility study. If an alternative emerges which can be demonstrated to carry fewer risks and better economic prospects in the timescale needed to achieve the government's policy objective of carbon neutrality by 2020, then this will be in the investment plan.

WIND AND SOLAR FOR THE OUTER ISLANDS

Solar PV is less expensive than diesel generation, but more expensive than biomass, in Malé. However, the Outer Islands have little option but to use solar PV for the bulk of their power; thus solar PV projects are not only highly replicable across all the inhabited islands, but also essential to their future power systems. Although predominantly a solar PV project, where the conditions allow, a material proportion of small scale wind will be used to supplement solar PV during the windier, cloudier, months of the year. This results in lower energy storage costs, a higher proportion of diesel displacement, and lower energy costs overall.

Outer Island RE is also potentially economic in its initial stages, and therefore an ideal candidate for bringing the private sector into the energy supply system and for reducing the need for government subsidy and capital finance.

The critical nature of the programme, its ability to transform both the Outer Islands and also influence the Resort Sector (see below), its scale and reproducibility, make this project ideal for SREP support.

Technical Assistance and Capacity Building

This is a critical pre-requisite of any significant development of the renewable energy sector. Lack of skills and good data has been a major factor in holding back progress to date, and needs to be addressed first.

The renewable energy strategy for the country depends on solar resources with some support from wind. Building a high quality data set of solar and wind data across the nation will minimise the costs faced by new developers, accelerate their timescale for development, and reduce the risks (and thus the costs) of new developments. This needs to be complemented with comparative assessments of different technologies and installation options to take account of the peculiarities of Maldives environment, viz.; salty corrosive air; land shortage but ample lagoon space; high albedo from the lagoons; difficult logistics for installation and maintenance.

In addition, an entire generation of operators, technicians, engineers and management needs training to function in a fully renewable energy world, and to understand both the technologies and the opportunities they offer. Without this training and technical support the existing institutions in the Maldives will be unable to deliver any significant level of oil independence – let alone the ambitious target for decarbonising the country by 2020.

T/A and capacity building is therefore the most important single task to be managed and funded under SREP.

Projects Not Selected

Tourist Resort Sector

The resort sector is a significantly bigger power generator than the public sector in the Maldives but it is much more challenging to change as a result of its innate conservatism, unwillingness to invest long term capital, and the long term nature of renewable energy investments. Furthermore, the resorts in general operate fully autonomously, and their leases make it difficult to enforce changes of behaviour or investment.

On the other hand, the examples of good practice and cost saving from the public utilities projects, coupled with the technical support available from METSU, will be used to help persuade the resort sector to move to solar PV and higher levels of energy efficiency. A joint programme is already under discussion with one resort chain to develop a means to use solar power in the daytime to provide chilled water for air conditioning at night at a lower cost than diesel power. This will be funded by LECReD under the aegis of METSU.

Once implemented solutions are proved to be available and economic, there may be scope for fiscal incentives to be put in place to accelerate the decarbonisation of the sector.

Transport Sector

Marine transport accounts for some 22% of current GHG emissions, and the costs of fuel are a major factor in the economics of both fishing and public inter-island transport. This will

therefore be a major focus for METSU. It will require a significant R&D effort as there are no easy technical solutions, and the approach will need to focus on energy efficiency and renewable energy in equal measure and in inseparable ways.

Given the SREP focus exclusively on Scaling Up Renewable Energy it was concluded that an R&D programme with energy efficiency at its heart was less likely to be supported than the more straightforward programmes set out above.

INSTITUTIONAL SUPPORT FOR SREP

In order to support its carbon neutral policy the GoM has changed the institutional framework of the energy sector. This is in recognition of the fact that no Ministry or Utility, or Maldivian private sector entity, has the knowledge, skills or finance to deliver the massive energy sector changes that the policy will bring.

SREP is a key component of the carbon neutral policy, but does not cover all aspects of the problem. Thus the new institutions and arrangements described below will cover a much wider brief than SREP alone. They will however be crucial in supporting and ensuring the success of SREP projects and programmes.

THE RENEWABLE ENERGY INVESTMENT OFFICE – REIO

The REIO has been established by Cabinet to align the policies and actions of the three ministries most relevant to energy and carbon neutrality – the Ministry of Finance, the Ministry and Housing and Environment, and the Ministry of Economic Development.

The REIO will be governed by a committee of these three ministers, and chaired by the Minister for Economic Development. Funding will be made available from the 2012 budget to staff REIO with a mixture of Maldivian and international staff.

The REIO will set policy, allocate budget funding, and ensure co-ordination across ministries for all renewable energy and energy efficiency activity.

THE MALDIVES ENERGY TECHNOLOGY SUPPORT UNIT – METSU

Delivering a carbon neutral country by 2020 will require significant technical innovation, and very careful planning and management if the price of energy is to be maintained or reduced compared to current levels. This will require:

- Increased energy efficiency;
- Deferral of demand from night to day;
- Embracing the transport sector – marine transport alone accounts for 22% of current emissions;
- Injecting very high levels of renewable energy, with all the attendant grid stability, energy storage, and reliability issues;
- Increasing the efficiency of generators used for backup power so that residual diesel use is minimised.

The establishment of METSU has been approved by Cabinet. This will be an applied research, development, and deployment unit based in the Maldives. It will be collocated with the proposed UN funded Climate Change Centre when that is constructed. In the meantime the unit will function as a virtual assemblage of experts and staff – operating on projects and communicating via the internet. One objective is to engage international universities to complement METSU staff and provide an opportunity for Maldivians to study Renewable Energy and Climate Change issues from leading world experts without the expense of travelling overseas.

Another key objective is to build institutional continuity and a sense of team and community – in order to break away from the endless cycle of external consultants that have no long term involvement or responsibilities in the country.

In regard to the SREP programmes – METSU will contribute to removing the key barriers of the resource data deficit, and the lack of human resources and knowledge by doing the following:

- Manage the wind and solar data collection and evaluation process
- Support the evaluation of specific technologies in the Maldives
- Provide technical information for developers wishing to make investments in RE in the Maldives, and to the tourist resorts and industrial energy users.
- Advise ministries and the regulator on specific policies, tariffs, costs, and long term energy planning.
- Provide RE training to Utility operators and management; to civil servants and Government officials; to the resort sector; and to the commercial and industrial sector.

Appendix 2 contains a brief synopsis of the METSU operation plan and budgets. Note that these budgets and work streams cover a greater spectrum of activity than purely SREP.

Maldives Energy Services Company – MESCO

MESCO will operate as an independent entity initially owned by the state. Once it has a track record, and some significant capacity there are several options for disposal, including privatisation or sale to the Utilities and principal energy generators in the country.

MESCO's role will be to help overcome the barriers of transaction costs, scale, and the cost of capital. It will support the SREP programme in the following ways:

- It will act as intermediary between the Utilities and developers – helping to aggregate projects into tranches of investment of a suitable scale, across islands and utilities;
- It will arrange guarantee facilities for investors in order to make their investment in the Maldives as secure as possible from sovereign, and currency risks, and from counterparty default on the part of the state owned utilities.
- It will support the costs and administration of logistics – a factor that may well deter overseas investors who are unfamiliar with the Maldives and uncertain how to deal with the logistics of supplying remote islands where there are no roads, no vehicles or lifting gear to unload containers, limited dock facilities, and poor inter-island transport links.
- It will provide a single point of contact between developers, the Maldives Energy Regulator, and the Environmental Protection Agency
- It will market the benefits of Maldives renewable energy investment to the world community, in order to encourage the widest possible competition and uptake of opportunities.

A key factor in MESCO's activities will be support of the proposed feed in tariffs. This is set out in more detail in Appendix 2.

MESCO will also lease power generating and energy saving equipment funded by grants and donors to Utilities, in order to recover a portion of the value created. These funds will be recycled into programmes, particularly energy efficiency, which have difficulty finding funding from other sources.

MESCO will seek donor and GoM funding for its establishment. Thereafter it will be self funding – largely by leasing power production equipment funded by donors or commercial finance to the Utilities.

Maldives Energy Authority

In addition to the new institutions being created, the Maldives Energy Authority (MEA), as regulator, has a critical role to play in establishing tariffs, operating procedures, and ensuring the reliability and security of the grids on each island.

The MEA is currently understaffed, and has little capacity to fulfil its regulatory function. A program of support and reinforcement of MEA is currently being undertaken by the World Bank and the ADB.

SREP Programme Implementation

Implementation of the three main programmes proposed under SREP will be as follows:

Malé Baseload

Malé's baseload renewable power facility is currently anticipated to come from a baseload power plant constructed under a 'Build Own Operate Transfer' (BOOT) mechanism. The GoM proposes to use SREP funds to select the most economically and environmentally effective decision. The current funds allocation presumes that biomass is the baseline case –alternatives will be evaluated against this.

If the decision to use biomass is confirmed SREP funding will ensure the most economic design choices are made, and that the tender process for construction and operation of the plant is as simple, straightforward and transparent as possible – in the expectation that this will ensure maximum response and the best possible economic outcome from an invitation to tender. The following tasks will be required.

Pre-Feasibility

Preparation of a pre-feasibility study for Malé baseload:

- to confirm whether biomass is the most suitable approach or to outline the best alternative;
- to assess the maximum level of new baseload power that the system can accept given other contract constraints and growth forecasts;
- to ensure that connections will be in place to support the facility;
- to assess the approximate cost of land reclamation and construction for any proposed facility – including site civil works, fuel storage, shipping and docking facilities, and fuel handling.

System Design and Planning

The power station will be transferred to GoM ownership after the end of the agreed concession period. This will allow the station to be operated in different ways, such as for backup or load following, which may not maximise revenues for the operator. Thus, even though detailed station design will be done by a contractor, in order to ensure the optimum value at transfer the GoM will have to be involved in the approval of the system design process, especially in regard of fuel efficiency, fuel type, and equipment anticipated life and maintenance costs.

Tender Preparation

Preparation of a suitably complete and accurate tender document, and evaluation of resulting tenders, will be carried out by REIO with technical guidance from METSU.

Guarantees

It is proposed that SREP funding is used to provide the appropriate level of sovereign risk and counterparty guarantees needed to ensure that the only risks remaining to the developer are the technical risks, and the normal commercial risks associated with a plant of this type.

Marketing

In order to ensure the widest possible participation in the tender process, a modest budget will be set aside for marketing the opportunity to invest in renewable energy in the Maldives. This will complement the proposed marketing initiative proposed for solar and wind investment, but

be targeted, if biomass is chosen as the best option, specifically at potential biomass fuel suppliers and power station constructors and operators.

Grid Connection

The Greater Malé grid which is about to be constructed may require modest changes to enable connection of the new baseload power plant.

Solar Outer Islands

In order for solar power to achieve mainstream status the following plan has been developed to ensure that each stage is economically viable and will improve the financial health of utilities as well as reduce GHG emissions. The final objective will be ≈90% of power from solar or wind for the Outer Islands.

A Feed in Tariff will be the principal mechanism for deploying solar and wind power in the Outer Islands. In order to have an effective feed in tariff the power houses must first be set up to be able to absorb the solar power without compromising grid stability. This will require new power house control equipment, and some limited energy storage capacity. In the case of the more inefficient islands this also means replacing the generators with new equipment able to operate efficiently at low loads, and able to respond rapidly to very large swings in supply and demand whilst not consuming significant diesel whilst the generators are idling. This will be done in parallel with SREP activities, but not funded directly by SREP. The more efficient islands, which are generally larger, can be made 'solar ready' by modifying existing generators and controls.

The very smallest islands are judged to be difficult for outside developers to access and operate in at a commercial scale. Many are so inefficient, and so small, that a multi-stage move to renewable energy is not the most economic choice. It is proposed to convert these islands in one step to full solar/wind/battery power with diesel only for backup as needed.

Making the FIT a success at prices that are commercially viable for the GoM and the developer means that certain specific costs which are unique to the Maldives should be absorbed by the Government. These include using MESCO to aggregate projects to deliver economies of scale; ensuring developers have simple streamlined access to utility data on demand and capacity to absorb renewables; assisting with logistics and transport costs within the Maldives so that all islands can have the same power costs and tariffs; and providing guarantees to developers against sovereign, currency and counterparty risks.

Table 7 and Figure 10 below and subsequent costs are based upon a survey of 118 islands covering 90% of the population outside Malé.

The term 'plug and play' is used to denote the preparation of a power house/grid in order that a developer can add any amount of solar or wind capacity, up to the declared capacity availability under the FIT regulations, without any considerations for grid stability or ability to absorb the power. All that will be needed is a standard connection to a Utility supplied set of terminals from a suitably certified inverter. It will allow the grid operator to remain confident that within this declared capacity they will be able to offer a secure and stable grid with no need to make changes or amendments to accommodate additions or subtractions of RE capacity from time to time.

<table>
<tr><td>VERY SMALL ISLANDS (±21)</td><td colspan="3">1 - Single step to full solar/wind with batteries</td></tr>
<tr><td>INEFFICIENT MEDIUM AND LARGE ISLANDS (±32)</td><td>2 - Upgrade power houses with new efficient generators and controls to be ‘plug and play’ compatible with100% solar at midday</td><td rowspan="2">4 - Install sufficient solar PV to meet midday demand, with small amounts of storage for grid stability and power quality management</td><td rowspan="2">5 - Install PV, plus wind as needed, to meet 90% of energy demand from renewables. This will need large energy storage facilities – so not to be done until 1-4 are complete and energy storage costs have fallen further (5 yrs?).</td></tr>
<tr><td>EFFICIENT MEDIUM AND LARGE ISLANDS (± 65)</td><td>3 - Upgrade existing generators to be ‘plug and play’ compatible with 100% solar at midday</td></tr>
</table>

TABLE 7 - OUTER ISLANDS RE PROGRAMME

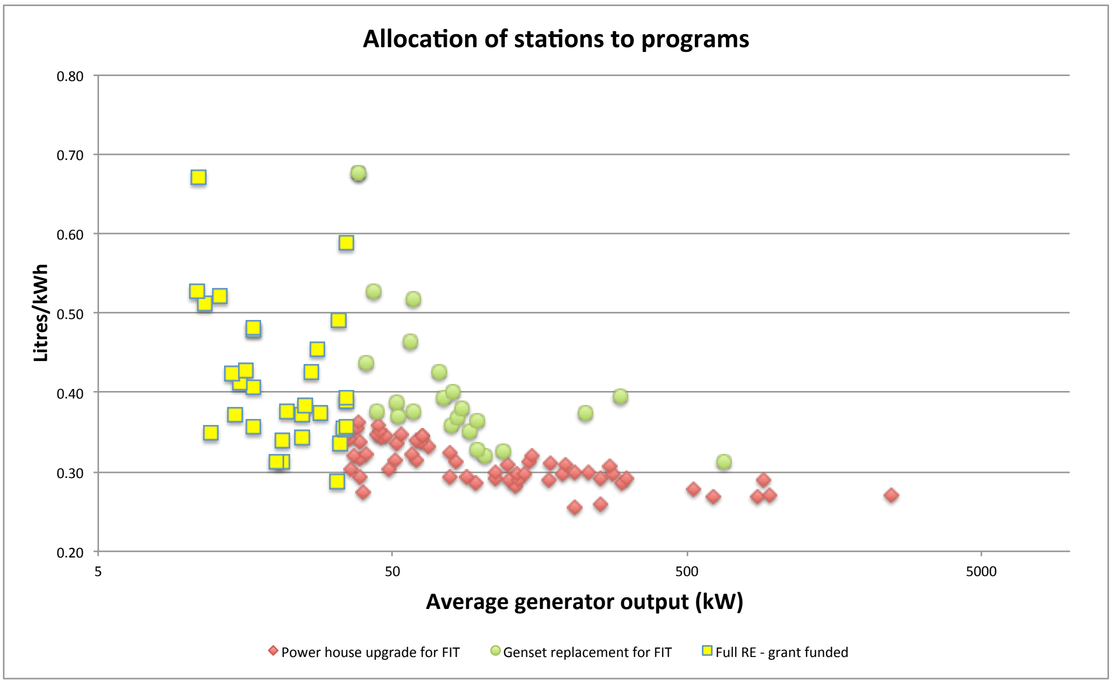


FIGURE 10 - ALLOCATION OF POWER STATIONS TO PROGRAMME COMPONENTS - NOTE LOG SCALE

MARKETING

Once a FIT regime is created, and the conditions established for developers to invest in the Maldives at low risk and with low transaction costs, it will be important to promote the opportunities to the project development community – in order to secure maximum interest in the shortest period of time. This will require only a modest budget, but is an important activity.

PARALLEL TASKS – ENERGY EFFICIENCY

In parallel with steps 1-4 above, and prior to step 5, a concerted programme of energy efficiency and demand displacement will be undertaken. This will save foreign exchange for the government, and reduce energy bills for society. It will also allow modest increases in electricity

price (if needed) to accommodate the developments in Phase 4 without increasing overall energy bills.

Energy efficiency will also serve to constrain demand growth without suppressing the use of energy services.

A widespread problem with energy efficiency is that capital is required to achieve it, but the cost of capital is too high and the availability too limited for domestic consumers – particularly poorer domestic consumers. At the same time it is difficult for institutions that do have capital and could make the investment to capture the economic benefits of domestic energy efficiency.

Energy efficiency is therefore seen as a task best funded using capital from sources such as MDB loans or the Energy+ scheme. Given the country's limited borrowing capability, it is anticipated that Energy+ finance will be used largely in this area.

TECHNICAL ASSISTANCE AND CAPACITY BUILDING

The following tasks are proposed using SREP funding:

1. Construction and management of a national network of solar and wind measuring stations, capable of providing reliable data to allow proper planning and design of wind and solar based power systems across the islands.
2. Supporting the wind and solar, energy storage, Male power planning and work streams of METSU.
3. Ensuring that Outer Island power stations are able to accept high levels of renewable energy on a 'plug and play' basis without compromising grid stability, power quality or exiting generator performance.
4. Supporting the training of managers, engineers and technicians needed to develop the new renewable energy economy.
5. Technical support and assistance to the Maldives Energy Authority in drafting feed in tariff regulations, and matching the needs of grid stability, simplicity for investors, and manageability for utilities.
6. Preparation of a strategic plan for power for the Greater Malé area – co-ordinating the principal suppliers and generators, and large loads. Integration of the plan with other work on energy efficiency, load deferral and land planning.

Financing Plan

The anticipated costs of the different components of the investment program are set out below.

The total private capital investment under programmes supported by SREP exceeds $100M. In order to ensure developer interest, and to secure the lowest possible costs of capital, the GoM plans to use a significant portion of the SREP funding for the purchase of guarantees against sovereign risk, currency risk and breach of contract by GoM owned utilities. These will be created using a blend of MIGA and PRG risk cover, coupled with commercially available guarantees as needed. In particular the PRG cover offered by the World Bank out of the IDA allocation is seen as crucial – given the amount of leverage that it can deliver. Therefore a modest proportion of WB IDA funding will be set aside for this purpose. This will also assist in the securing of both MIGA and commercial insurance as needed.

In practice the guarantees may not be needed for all projects or by all developers, and once the Maldives becomes an established destination for RE development finance the need for guarantees is expected to diminish.

Additional funding to the plan set out here will come from recycling revenue. This will be come from leasing the small island power systems, and the efficient generators, from MESCO to the Utilities at a cost lower than their current cost of generation. The revenue raised from this will be recycled to support the Guarantee scheme, on-going GoM institutional costs for REIO, METSU and MESCO and a nationwide energy efficiency campaign.

Malé Baseload

The cost estimates for bringing a 24MW biomass power station to Malé are set out in Table 8 - Malé Power Station Costs. These costs are premised upon the successful construction of the proposed 20MW wind farm and inter-island cable. In the event that this does not materialise there would be substantial additional costs associated with the installation of the inter-island cable – though these would be offset by the significantly improved economics of a larger power station. Preparatory costs would not change much under either scenario.

	SOURCE OF FUNDS							TOTAL	Lead Agency
	SREP	GOM	WB	ADB	IFC/ PSOD	PRIVATE	OTHER		
Male Baseload	**$10,500**	**$1,500**	**$3,000**	**$0**	**$20,000**	**$47,000**	**$0**	**$82,000**	
Construction					$20,000	$47,000		$67,000	IFC/PSOD
Grid re-inforcement for connection	$2,500							$2,500	ADB
Guarantee Instruments	$8,000	$1,500	$3,000					$12,500	WB

TABLE 8 - MALÉ POWER STATION COSTS (IN US $ '000)

The 'grid connection' element reflects the fact that the proposed new inter-island grid for the Greater Malé area will not be designed specifically to accommodate a new power station at its extremity. This may require some additional work outside the scope of the current construction contract to add the capability to integrate and connect the new 24MW power station.

Outer Islands Renewable Energy

Based on current best estimates of costs and requirements for approximately 120 power stations surveyed, the funding set out in Table 9 is proposed.

	SOURCE OF FUNDS							TOTAL	Lead Agency
	SREP	GOM	WB	ADB	IFC/ PSOD	PRIVATE	OTHER		
Outer Islands renewables	**$17,300**	**$1,600**	**$3,000**	**$4,000**	**$0**	**$59,800**	**$9,500**	**$95,200**	
Small islands 100% RE	$11,600		$500	$1,000				$13,100	ADB/WB
Generator replacement				$2,000			$7,500	$9,500	ADB/Other
Power house upgrades	$1,700			$1,000			$2,000	$4,700	ADB/Other
FIT Risk mitigation & Support	$4,000	$1,600	$2,500	$0		$59,800		$67,900	WB

TABLE 9 - OUTER ISLANDS RE PROGRAMME COSTS (IN US $ '000)

The data presented here is based upon approximately 120 islands for which data has been reported. A further ±70 smaller islands have not reported data to include in this analysis. GOM expects that it will fund these installations in due course directly from savings made through the SREP programme – though until the data are available this cannot be quantified.

TECHNICAL ASSISTANCE AND CAPACITY BUILDING

A preliminary budget has been prepared for METSU, amounting to about $5.0M over five years to cover renewable energy, energy efficiency, marine transport, building efficiency and training . Of this, it is proposed to fund the solar and wind energy, the energy storage and grid stability, and the Malé long term energy planning work streams from SREP for three years. In addition, it is proposed that SREP funding be used to install the national network of solar and wind resource measurement stations.

The METSU budget covers 8 separate work streams, four of which are wholly relevant to RE activities and SREP, and a fifth is partly related. A reasonable allocation of the costs to SREP would be $500k p.a. for three years – i.e. $1.5M split between institution building and technical support. This is approximately 50% of the 3 year budget.

The ADB is currently funding capacity development in the Maldives Energy Authority, and has made provision for assistance in preparatory work for project submissions.

A budget price for a network of masts for solar and wind data collection and continuous monitoring is $60,000 per unit. It is proposed that $700k of SREP funding is allocated to data collection, monitoring and analysis. Additional funding from the GoM will support energy efficiency work relating to buildings, appliances and marine transport.

The total budget for T/A and capacity building over three years to be funded by SREP is $2.2M. This is set out in Table 10. Other T/A includes the Malé pre-feasibility study and support for MDB funding applications.

	SOURCE OF FUNDS							TOTAL	Lead Agency
	SREP	GOM	WB	ADB	IFC/ PSOD	PRIVATE	OTHER		
T/A	**$2,200**	**$800**	**$0**	**$800**	**$0**	**$0**	**$500**	**$4,300**	
Data collection and management	$700	$300						$1,000	WB
Institution building	$1,000			$400			$500	$1,900	ADB/WB
Other T/A	$500	$500		$400				$1,400	ADB/WB

TABLE 10 - T/A PROGRAMME COSTS (IN US $ '000)

Financing Summary

Table 11sets out the summary of funding for renewable energy under SREP to 2017.

	SOURCE OF FUNDS							TOTAL	Lead Agency
	SREP	GOM	WB	ADB	IFC/ PSOD	PRIVATE	OTHER		
Outer Islands renewables	**$17,300**	**$1,600**	**$3,000**	**$4,000**	**$0**	**$59,800**	**$9,500**	**$95,200**	
Small islands 100% RE	$11,600		$500	$1,000				$13,100	ADB/WB
Generator replacement				$2,000			$7,500	$9,500	ADB/Other
Power house upgrades	$1,700			$1,000			$2,000	$4,700	ADB/Other
FIT Risk mitigation & Support	$4,000	$1,600	$2,500	$0		$59,800		$67,900	WB
Male Baseload	**$10,500**	**$1,500**	**$3,000**	**$0**	**$20,000**	**$47,000**	**$0**	**$82,000**	
Construction					$20,000	$47,000		$67,000	IFC/PSOD
Grid re-inforcement for connection	$2,500							$2,500	ADB
Guarantee Instruments	$8,000	$1,500	$3,000					$12,500	WB
T/A	**$2,200**	**$800**	**$0**	**$800**	**$0**	**$0**	**$500**	**$4,300**	
Data collection and management	$700	$300						$1,000	WB
Institution building	$1,000			$400			$500	$1,900	ADB/WB
Other T/A	$500	$500		$400				$1,400	ADB/WB
TOTAL	**$30,000**	**$3,900**	**$6,000**	**$4,800**	**$20,000**	**$106,800**	**$10,000**	**$181,500**	

TABLE 11 - SREP FUNDING SUMMARY (IN US $ '000)

In view of the limits on the Maldives borrowing abilities from MDBs, it is anticipated that the main loan funding from MDBs would be in the form of a commercial loan by the IFC to the developer of the Malé power station. The remaining MDB funding will come from ADB grants or concessionary loans, with anticipated concessionary loan finance offered from a further MDB (though as yet not formally committed).

Complementary Projects Outside SREP – Energy Efficiency

In order to deliver the highest possible level of GHG reductions at the lowest possible cost, a series of activities parallel to those funded by SREP will be pursued. The objectives will be to reduce the costs to society of energy use by increasing energy efficiency, and to reduce the absolute amount of power used at night, in order to reduce the costs of providing solar power through energy storage devices. (Solar power delivered through batteries can cost 250% as much as the cost of using power in the day when the sun is shining).

Much of the technical support for this work will be carried out by METSU.

Energy Efficiency in Government Estate

The GoM spends of the order of $10M a year on electricity. Major potential savings have been identified in this sector. These savings will be used to support energy efficiency programmes elsewhere to reduce subsidies and emissions. In addition, significant wastage occurs at night when demand should be low, but lighting, cooling, and appliances that are left running unnecessarily.

Domestic Energy Efficiency

Domestic energy efficiency is a key target for reducing emissions and the energy costs for consumers. Research in one of the islands shows that 25% or more of electricity is used for cooling devices (air conditioners and fridges) and that these are frequently grossly inefficient.

Complementary work on building insulation will contribute significantly to reducing cooling power consumption.

Distribution Grid Efficiency

Many island grids have evolved rather than been planned. The growth in power demand has outstripped their original capacity, with the consequence that they are now highly inefficient. In cases where measurement has taken place, grid losses over 25% have been observed.

This is a prime target for reduction of costs and emissions.

Promotion to Resort and Industrial Sectors

The resort and industrial sectors are major power generators and consumers. One key objective of METSU will be to offer these sectors working examples of energy efficiency and renewable energy generation – with complete transparency of costs – and to actively promote these to private energy generators and users. This will help to persuade and encourage these sectors to take their own steps to becoming oil independent. MESCO may also take a role in assisting with finance for investment.

The GOM may support this activity by making fiscal adjustments to encourage the transition to low carbon.

Financing Energy Efficiency

The principal energy efficiency measures identified have very rapid paybacks. These will be funded through a combination of GoM budget support, MDB loans, and private sector capital (on a shared saving basis). Savings made will be returned to MESCO and re-invested in further savings programmes.

Risk Assessment

Outer Island Programme

Technical Risks

The principal technical risks associated with this programme are as follows:

1. Preparing power stations for 'plug and play' insertion of very high levels of renewable energy is not common, and requires careful preparation and design. Doing this for 200 power stations cost effectively requires the development of solutions that are replicable, and easy to install and maintain.
2. On islands where space is a real constraint tracked PV mounted over the lagoons may be the best option available to deliver the level of power needed cost effectively. Tracking brings great potential benefits in reducing land take or lagoon installation costs and increasing the hours of the day when maximum solar power is achieved. It has a downside which is increased complexity and maintenance.
3. Corrosion is a potential challenge – particularly for solar PV installations reliant on tracking. Or mounted over lagoons.

Managing these risks will be done through METSU, and by engaging world experts in power systems management. Oxford University already have a small group focused on evaluating alternative power station configurations, with a view to testing the best under the LECRED project – prior to widespread dissemination under SREP.

Commercial Risks

Key commercial risks are as follows:

1. Insufficient interest in the FIT regime by developers. Ultimately this is about the tariff levels, perceived levels of risk, and awareness in the developer marketplace of the opportunities. MESCO will be crucial to helping determine attractive FIT levels and structures, negotiating guarantee instruments that reduce risk, and marketing the scheme to the developer community. Project scale is also a potential issue – many individual projects will be too small to be interesting to overseas capital. MESCO will aggregate projects in order to ensure that developers can find projects of a suitable scale for their needs.
2. Population migration. The lifetime of any solar PV project is measured in decades. However there is a tendency for island residents to leave smaller islands for larger ones, or Malé, where there are perceived to be more economic opportunities. Thus projections of demand, and demand growth, in the smaller islands are inherently unreliable, and systems suitably sized today may prove to be oversized a decade hence. This is not a risk that can be easily mitigated. However once power stations have been converted to 'plug and play' status, adding new RE capacity is highly modular – so there is no need to build for future demand – demand can be met as it grows. This avoids any gross errors in investment allocation.

Malé Baseload Plant

This assessment is premised on a biomass plant – which is being used as the baseline choice. A different final technology choice would involve different risks.

Technical Risks

There are many hundreds of biomass power plants of the proposed type and scale across the globe. Technical risks will therefore be minimal, and carried by the project developer.

Commercial Risks

The key commercial risks for the biomass power plant are as follows:

1. The cost of civil works, including land reclamation and wharf construction have been underestimated. In reality this is only a minor part of the overall cost of the power delivered, so relatively large variations in these costs will have very small impacts on the ultimate cost of electricity from the plant.
2. Fuel costs rise rapidly and outstrip the costs of diesel. This can be resolved by securing long term (7 years or so) fixed price contracts from fuel supply. It is much easier to secure long term biomass supply contracts than oil supply contracts – so any risks in this area can be mitigated almost completely. Beyond the life of these contracts (and well after the plant has recovered its investment) it is anticipated that solar PV and Utility Scale energy storage costs will have dropped to the point where solar and wind replace most of the biomass use – so reducing any risks of fuel price inflation.
3. The largest commercial risk is that the planned wind power project fails to be implemented, as the interconnector between the islands is to be built as part of this project. However, in this event there are two options possible:
    a. Build a slightly smaller power plant as planned, but make sales only to the airport and Hulhumalé. This would be economically attractive.
    b. Build a much larger plant than currently planned (40MW instead of 24MW). This would be sufficiently economically attractive as to be able to pay the full cost of interconnection (which was estimated at $65M by a USAID study).

Institutional Risks

The greatest risks facing this investment programme are the institutional risks. The key issues are as follows:

- The Maldives has a small population, and thus small pool of talented and educated individuals from which to draw.
- Most well qualified personnel are either employed in the private sector where they can earn substantially more than in the civil service or state owned enterprises.
- A few senior civil servants are highly experienced and capable administrators, but they are overloaded already.
- The policy of decentralising control of electricity to the regional utilities may have served to help utilities to be more responsive to their local communities and reduce the power of the centre – but it has resulted in a fragmentation of the limited commercial and technical skills in the sector – to the extent that no utility now has a critical mass of technical or financial capability apart from STELCO.
- The electricity sector has no tradition of either strategic planning or technical innovation. Even the largest utility, STELCO, has no experience outside its traditional area of diesel generation.

In order to overcome these shortcomings the Renewable Energy Investment Office has recommended, and Cabinet has sanctioned, the creation of METSU and MESCO, to provide the skills and capabilities missing from the utilities. However, REIO itself is barely staffed, and needs its own management team.

There is a real risk that the lack of personnel will be compensated for by the use of endless consultants. However, consultants bring no lasting knowledge or experience, and achieve little in the way of human resource development.

The GoM plans to mitigate these risks by employing personnel from a worldwide pool – and by building teams in association with academic and technical institutions of international repute. A core task of these teams will be the continuous training of utility operating personnel, management, civil servants, Maldivian consultants, and Ministers. This will be funded out of a combination of a small amount from SREP in relation to the solar component, supplemented by support from LECRED, Energy+ and using savings made from the energy efficiency and renewable energy programs to be implemented.

Cost Over-runs and Under-runs

Given the challenging technical and geographical nature of these projects – particularly the outer island RE, there are significant uncertainties on actual costs. Although traditionally these are thought of in terms of over-runs, falling technology costs and increasing experience (as most islands are repeats of each other) under-running the cost estimates is possible. These can be accommodated simply by flexing the exact number of islands included in the projects.

Transformative Impacts and Co-Benefits

Direct Impacts

Outer Islands

The proposed programme will establish Renewable Energy as the mainstream energy supply for the Outer Islands. It will do this by demonstrating the economic and technical viability of the technologies, overcoming the substantial logistic challenge, preparing all power stations to accept renewable power and to expand their RE inputs in future on a 'plug and play' basis, and by training a generation of technicians, engineers, managers and civil servants to understand the technologies and their costs.

Malé Area

The establishment of a baseload RE power station in Malé will prepare the area to become fully carbon neutral at a lower cost than diesel. Whether the initial plant is a biomass plant or some alternative, the cost of power will fall compared to current levels. Even if a biomass plant is chosen, ultimately it will be necessary to add utility scale energy storage – but the costs of this are expected to decline sharply over the next decade. There are sufficient options available for Malé to expect electricity generation costs to be maintained at current or lower levels for the foreseeable future.

Social and Economic Benefits

Poorer Island Bias in the SREP Programme

A key factor in the Maldives is the extent to which smaller islands, and those more remote from Malé are in general poorer. It is crucial for the stability of society and to reduce pressure on Malé to ensure that these islands neither suffer as a result of the higher cost of delivering energy there, nor by feeling somehow neglected by the centre.

In recognition of this, the per capital spending is planned to be highest in the smallest islands, lower in those of intermediate size, and lowest in Malé. As part of this commitment the programme proposes two specific interventions to complement the general allocation of funds:

1. The smallest islands will be the first to receive full Renewable Energy systems, covering most of the energy needs 24 x 7.
2. Developments in the very inefficient Outer Islands will have the cost of logistics required to develop their RE schemes paid for from SREP funds. This will help ensure that they are not at a disadvantage compared to Malé, and to ensure that power costs across the islands are kept uniform.

Youth unemployment

The emergence of healthy and growing Renewable Energy and Energy Efficiency sectors will contribute to the creation of intellectually stimulating high quality jobs around the atolls where most of the work will take place. Youth unemployment is a major issue in the Maldives. Reported unemployment statistics for youth stands above 20% on average. Being a technology focused sector, RE and EE are promising sectors for creating jobs for the unemployed youth. They are expected to have sufficient appeal to help hold the population in the atolls rather than migrating to Malé in search of opportunity.

Business viability

Businesses pay exceptionally high energy costs. Although consumer energy prices are unlikely to fall, the cost of RE generation is likely to be materially lower than the rates most businesses pay. This will help ensure that small and medium sized enterprises that are reliant on the grid for power supplies face lower costs – thus improving their profitability and sustainability.

Larger businesses, such as fish processing, will be exposed to technologies that can reduce their costs substantially – thus improving their sustainability and competitiveness.

These two factors, coupled with improved employment opportunities, will help make island communities economically more resilient and self-sufficient.

Co-Benefits

The SREP Investment program will achieve more than reducing the GHG emissions of the Maldives. Some of the key co-benefits are as follows:

Energy Security – Price and Volatility

Maldives energy is totally dependent on the price of oil. The Chief Economist of the IEA has publicly stated the view that conventional oil production peaked in 2006[2]. Although there will be some new supply, and growth in high cost unconventional supplies, the rate at which oil fields are declining means the industry will have difficulty maintaining production levels.

At the same time, the pace of economic growth in the emergent economies is such that the next decade will see as much economic growth as there was over all time up to the year 2000. In such an environment there is a real risk that oil prices will rise to a level that means that many Maldivians will be unable to afford electricity – even if it is available. By reducing the dependence on oil, and eventually phasing it out, this risk is eliminated.

In addition to the possibility of a rising average price of oil, there is a strong possibility of a very rapidly fluctuating oil price – as the tension between inelastic supply and short term inelastic demand plays out. Fluctuating prices create additional costs as the economy is unable to make plans and allocate resources optimally. High levels of RE penetration will reduce price volatility considerably.

Improved Reliability

The current electricity system across the Maldives is exceedingly fragile and unreliable. By replacing the existing systems with new high efficiency generators, and then using them only part of the time – with the bulk of supply coming from solar PV with no moving parts, or wind turbines with one moving part, the opportunity exists to substantially reduce maintenance costs, and improve the system reliability.

Demonstration to Resort and Private Sector

For reasons related to the history of licence awards, and the structure of the industry, the resort sector in the Maldives is not easily steered by government policy. However by demonstrating the real practical and economic possibilities of RE and EE, and by developing a cadre of competent technicians and engineers, it should be possible to lead the resort sector, and the rest of industry, to a RE future out of pure self-interest.

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[2]IEA interview with the Australian Broadcasting Corp. http://www.youtube.com/watch?v=iKkISqOCnVA

Global Demonstration

A key driver in President Nasheed's announcement that the Maldives would become carbon neutral by 2020 was the desire to break with the conventional international positions of many developing countries in global climate negotiations, and demonstrate that it was a country prepared to lead by example.

The SREP Investment programme will provide the key to unlock the delivery of this policy, and demonstrate to the world that a country can benefit by leading the fray on decarbonising, instead of always seeking delay and reduced action.

A further potential benefit will be that the Maldives gains the opportunity to use its skills and staff around the world to help build the new and necessary energy economies. This could be a valuable outlet for the skills and capabilities of the new generation of RE 'savvy' Maldivian engineers and managers.

MONITORING AND EVALUATION

For future monitoring and evaluation of the results of the SREP funded activities, an indicative results framework for the IP is presented below.

Results	Indicators	Base-line	Targets	Means of Veri-fication	Respons-ibility for Collection	Data Source
Outputs						
Renewable energy installations on the islands	% of islands with significant operating RE installations	0%	70% of the population to have >20% RE in their supply	Project M&E	Project Coordinator/ Utilities	Utilities/ MEA
GWh of renewable energy produced per year	GWh produced	±0	200GWh/year	Country M&E	Project Coordinator/ Utilities	Utilities/ MEA
Trained technicians and engineers	# of re-trained personnel (technicians, engineers& managers	TBD	Sufficient # to enable industry self support	Country M&E	REIO	REIO, Utilities, METSU
Informed Utilities and Energy Developers	# of published standards and advice regarding most cost effective decarbonisation of minigrids	NIL	Standard Operating Procedures for utilities for design of lowest cost RE for 90% grid penetration	Country M&E	METSU	METSU publication / MEA
Reliable consistent regulatory and pricing framework	published regulatory framework and feed in tariffs	interim FIT and minimal regula-tion	regulatory framework sufficient to attract private capital with minimum additional intervention	Country M&E	MEA / REIO	Utilities/ MESCO
Outcomes						
Reduced cost of electricity generation	Full cost of electricity generation (including subsidy)	TBD	Reduction to <$0.40/kWh delivered to small island consumers (0$0.30/kWh in larger islands)	Country M&E	REIO/MoFT	MoFT
Increased funding available for social and infrastructure programs	a) reduction in government electricity bills	±$25m/ yr TBC	20% reduction–(or $5m /yr)	Country M&E	REIO/MoFT	MoFT
	b) Reduction of government electricity subsidies	±$15m/ yr TBC	20% reduction -$5m /yr	Country M&E	REIO/MoFT	MoFT
	c) revenue from equipment lease to smaller islands	0	±4m/yr	Country M&E	REIO/MoFT	MoFT
Reduced diesel use	Specific fuel consumption (l/kWh generated by utilities)	TBD	30% reduction	Project M&E	Utilities	MoFT/Utilities

Results	Indicators	Base-line	Targets	Means of Veri-fication	Respons-ibility for Collection	Data Source
Increased energy security for women and men	Reduced sensitivity of electricity costs to diesel price changes ('% change in cost' per '% change in diesel price'	TBD	30% reduction in sensitivity	Country M&E	METSU	METSU/ MEA
Increased proportion of RE in energy mix	kWh(RE)/kWh (diesel)	0%	30% in state sector	Country M&E	Project Coordinator/ METSU	METSU/ MEA
Sustainable renewable energy sector	Cost of RE at high penetration is less than cost of diesel power	TBD	$/KWh of 80% RE penetration<= $kWh of diesel power at current efficiencies	Country M&E	Project Coordinator/ METSU	METSU/ MEA
Reduction of GHG emissions from the public electricity sector	kg CO2/KWh generated	TBD	30% reduction	Country M&E	Project Coordinator/ METSU	METSU/ MEA
Catalytic Replication						
RE spread through tourism sector	% of GWh generated from RE	0	10%	Country M&E	REIO	REIO/ MED
RE spread through private industrial sector	% of GWh generated from RE	0	70%	Country M&E	REIO	REIO, DNP statistical databases
International information dissemination	Reference to Maldives program in international RE literature	NIL	Widespread recognition of Maldives progress, and replication of Maldives institutional, financing and regulatory approach	Country M&E	TBD	Inter-national publication s
Transformative Impact						
Renewable Energy competitive with diesel at high levels of penetration	$/kWh at 90% RE penetration	Not yet achieved	$/kWh at 90% penetration = $/kWh of efficient generation from diesel	Country M&E	Project Coordinator/ METSU	METSU

TABLE 12 - RESULTS FRAMEWORK

M&E Institutional Arrangements

The Renewable Energy Investment Office (REIO) established under the Ministry of Economic Development will be responsible for the overall implementation and oversight of SREP activities in the Maldives. The REIO Ministerial Council comprising of MED, MHE and MFT which oversees the functions of REIO will take joint responsibility in making policy decisions related to the governance of SREP. The day to day management and coordination will be undertaken by REIO in collaboration with MHE. For coordination purposes, REIO will set up a technical-level coordination committee comprising of relevant agencies. The physical implementation of the program will be facilitated and implemented by the private sector and by Utilities with the guidance and support of the two new institutions, METSU and MESCO, proposed under the SREP institutional arrangements. MEA will be responsible for setting the standards and the regulatory framework governing the energy sector while EPA, whenever necessary, will be responsible for

review and approval of the environmental framework or impact assessment for projects to be implemented under SREP.

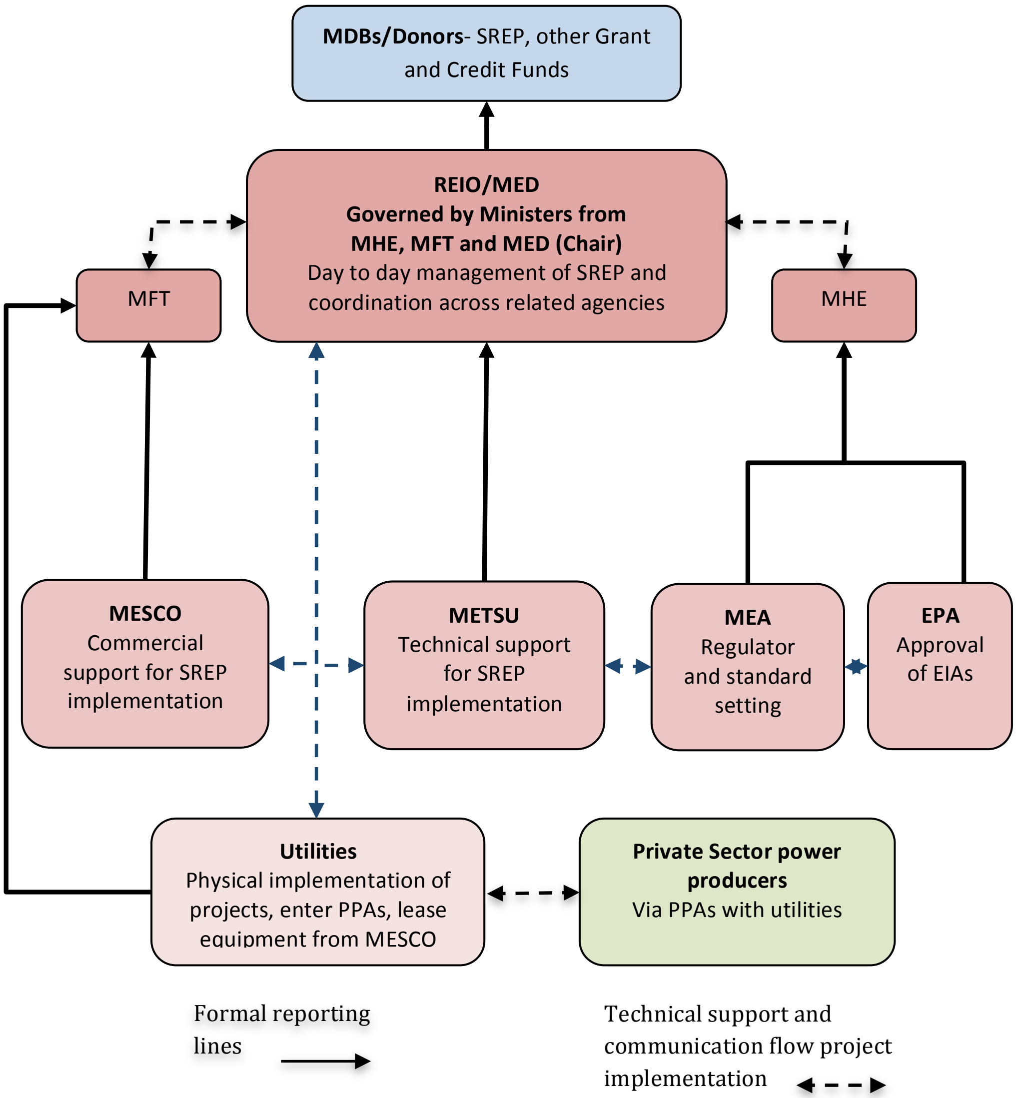

FIGURE 11 - INSTITUTIONAL ARRANGEMENTS

Monitoring and Evaluation - System Management

The following table sets out the key responsibilities for monitoring and evaluation.

Responsibility	Function
REIO	Overall direction and oversight Manage progress reporting to MDBs and external stakeholders. Request regular project performance updates from all implementing agencies in line with the agreed procedures from the relevant government agencies and MDBs Integrate project reporting from other agencies and monitor project or program implementation Manage M & E process and assess/rectify capacity gaps and weaknesses Monitor catalytic replication and transformative impact indicators
METSU	Establish mechanism for knowledge sharing and documentation of SREP lessons learnt Regular reporting to REIO on progress for Outcome and Output indicators
MESCO	Manage and establish M&E system for each individual project Regular reporting to REIO on progress for Outcome and Output indicators
MEA/EPA	Manage and establish M&E system for each individual project Regular reporting to REIO on progress for Outcome and Output indicators

TABLE 13 - M&E RESPONSIBILITIES

KNOWLEDGE MANAGEMENT AND INFORMATION SHARING

METSU will play a critical role in building the capacity of local citizens and stakeholders in the renewable energy space as well as undertaking research on existing and emerging renewable energy technologies which would be of relevance to the island and small scale grids elsewhere. Knowledge gained and lessons learned will be disseminated to local entities and other related agencies. METSU will collaborate with the Regional Climate Change Centre of Excellence[3] in disseminating the information to wider international community.

TECHNICAL NOTES – MONITORING AND EVALUATION

Monitoring and Evaluation of the Maldives SREP programme will be straightforward compared to many other RE projects.

OUTER ISLANDS

In the Outer Islands there is currently limited reliable data to determine diesel consumption by island, and how this relates to electricity use. The data set used to prepare this report was self-reported by the power house operators. Random checks on a few power houses demonstrated

[3] UN is supporting the GoM in establishing such a centre in the Maldives in the near future. This initiative is being pursued as part of the LECReD funded initiatives

that, whilst most of it is likely to be correct within tolerable limits, the lack of any scrutiny of the data historically has meant that there are no systems in place to ensure accuracy.

The first step of a monitoring and evaluation program will therefore be to institute rigorous data collection, reporting and verification procedures. This will not only allow evaluation of SREP programmes against a meaningful baseline, but will also serve to guide the priorities for intervention during the programme.

Subsequently the success of the programme will be measured by reference to the changes in diesel consumption per kWh of electricity delivered to customers.

The Maldives has an effective nationwide 3G mobile voice and data network. This will be used to monitor, in real time, energy and fuel use – so allowing immediate intervention at any sites where performance is deviating from the norm for any reason.

Certain aspects of the programme, such as the provision of guarantees and logistics support will be tested from time to time. This can be done by varying the level of support to assess the consequences, though this may prove disruptive and slow the programme down. Initially therefore the effectiveness of the programme will be explored by discussions with market participants to assess the level of price differential they would need to be offered to compensate for these. If the responses are positive, an economic assessment will be carried out to determine if a higher price would be a better use of funds than guarantee and logistics support.

Malé Region

In the Malé region the project is essentially a single traditional engineering project. The project will be large enough – whichever technology is chosen, to merit the full traditional suite of engineering design, due diligence and contractual penalties for non-delivery. Performance therefore will be judged largely against contractual terms under a probable Build Own Operate Transfer contract.

Environmental And Social Management Framework

In implementing the proposed projects under the Investment Plan, the government will put in place measures and mechanism to ensure that the work is carried out in an environmentally and socially sustainable manner. In pursuing this objective, the government will further strengthen the existing mechanism in place for undertaking EIAs and adopt an Environment and Social Management Framework (ESMF) to enable communities and power producers to screen projects and to identify measures to address adverse environmental and social impacts associated with the projects.

The ESMF will outline the positive impacts on the island's environment and remedial measures, preventative and control strategies for potential negative environmental and social impacts due to proposed project activities. It would also help to propose measures which comply with the regulations in the Maldives as well as address the World Bank/ADB Safeguard Policies, where applicable.

The ESMF will be in line with Environment Act, national EIA regulations, and the World Bank's and ADB's Safeguard Policies, where applicable.

Environmental and Social Screening Process

The ESMF illustrates the stages of the environmental and social screening process leading towards the review and approval of projects to be implemented under the Investment Plan. The screening process would assist in: a) identifying positive environmental and/or social impacts on the communities; b) determining the likely negative environmental and social impacts and setting the appropriate mitigation measures; and c) to monitor environmental and social parameters during the implementation of project activities.

In spite of the environmental and social setting of each project, each one of them has to undergo screening as recommended in the national EIA Regulations. If detail environmental assessment is needed, then scoping process would be undertaken and detailed EIA would be recommended. The extent of this environmental work for each project in the SREP Investment Plan will depend on the outcome of the screening process described below.

Screening Steps

The process of screening can be broken down into the following steps:

Screening IP Projects and Sites

The initial screening for each project or sub-project will facilitate the identification of potential environmental and social impacts, determination of their significance, assignment of the appropriate environmental category, proposal of appropriate environmental mitigation measures, and conduct of an EIA, if necessary.

Assigning the Appropriate Environmental Categories

The assignment of the appropriate environmental category to a particular project activity will be categorizing a sub-project activity either as A, B, or C.

- Category A: activities requiring an environmental impact assessment,

- Category B: activities requiring an initial environmental evaluation statement or the implementation of simple mitigation measures compiled in and environmental scoping report.

- Category C: activities neither requiring an environmental impact statement nor an environmental impact assessment. This will be compiled into a project brief and submitted to EPA for approval.

Carrying Out Environmental Due Diligence

Having identified the appropriate categorization of the project or program and thus the scope for the environmental and social due diligence required, the project will make a recommendation to establish whether: (a) the implementation of an environmental management plan including mitigation measures will suffice; or (b) a separate EIA will be carried out. According to the results of the screening process, further environmental and social due diligence would be carried out specific to proposed project interventions.

Review and Approval

EIAs prepared for specific projects will be reviewed and approved by the EPA. By issue of decision note which governs the manner in which the project activities must be undertaken.

Public Consultations and Disclosure

Stakeholder consultations will take place during the screening process and results will be part of the environmental and social due diligence and incorporated into the EIA or EMP as appropriate.

Environmental Monitoring and Follow-up

Monitoring of environmental and social due diligence will be carried out through project/program implementation to ensure compliance with relevant documents and implementation of proposed mitigation measures where applicable.

Monitoring Indicators

The following indicators will be used to assess and monitor environmental and social impacts under the proposed SREP projects/programs:

- Compliance with the Environmental Guidelines
- Best practice in the implementation of project activities
- Community awareness and education on environment
- Contractor compliance with EMPs

Environmental and Social Impacts

Minor environmental impacts are expected as a result of the proposed SREP investment projects due to the nature of activities which include minor civil works for the construction of new electricity generation sources, rehabilitation of existing power generation systems, installation of the new renewable energy generation systems, future decommissioning of RE installations, batteries, etc., and disposal of inefficient or old appliances.

Further risks may be associated with the loss of biodiversity, land or other assets, solid waste from construction debris, oil spill from motorized construction equipment, etc.

Identification of negative impacts that occurs at the construction and operational phase would be carried out during the screening process. Potentially identifiable environmental and social impacts and mitigation measures for the technology options used in the proposed projects in the Investment Plan are summarised in Table 14.

The majority of the proposed projects are expected to have substantial positive environmental and social benefits while having minimal negative impacts, mainly during construction and installation. However, an ESMF would be developed for all projects to identify potential adverse environmental impacts from projects and the mitigation measures to address those.

	Solar PV	Wind Energy	Biomass	Energy Efficiency
Environment Impacts Identified Environmental impacts for the proposed projects consider the impacts from construction and operation stage of the project.	Possible impact on the marine environment due to fixing poles in the lagoon for lagoon mounts schemes. Reclamation and coastal protection associated with the projects that are marine based if land reclamation is involved. The solar PV system may create visual impacts due to presence of numerous highly geometric and highly reflective surfaces. Construction waste The operation will have negligible environmental impact. There will be no waste products, no requirements for cooling, no moving parts, no noise, and no impact on flora and fauna. Indirect impact on the lagoons from reduced sunlight for lagoon mounted structures .	Possible impact on the marine environment due to fixing poles in the lagoon for lagoon mounts schemes. Reclamation and coastal protection associated with the projects that are marine based if land reclamation is involved. Dealing with construction waste and impacts from work force. Visual impact as any wind energy system will be mounted on tall masts in clear spaces. Noise and dust during the construction may be nuisance to the neighbourhood.	The construction will involve activities that will create environmental disturbances normally encountered in major construction projects. Improper storage of biomass, waste dumps and other sources of contaminants may lead into ground water pollution. Chemical storage facilities at the construction site have the potential to impact the environment. Noise and dust during the construction may be nuisance to the neighbourhood. Construction waste Emissions from the combustion of biomass Management of ash.	It is not anticipated that there would be environmental impacts associated with energy efficiency projects. However, large scale and rapid nationwide implementation of energy efficiency programme if implemented would result in large amount of 'white goods' be discarded in the waste stream. Large number of inefficient generators, refrigerators, air conditioners and lights would be discarded into the waste stream

	Solar PV	Wind Energy	Biomass	Energy Efficiency
Social Impacts	Reduced fossil fuel-based power generation and reduced dependency on fuel import costs – increasing community resilience.	Reduced fossil fuel-based power generation and reduced dependency on fuel import costs – increasing community resilience.	Reduced primary fuel costs will help reduce energy costs and improve community resilience.	The proposed energy efficiency project would reduce the energy consumption and hence reduces the amount spent on electricity.
Proposed Mitigation Measures The anticipated environmental impacts of the projects will be minor, localised and manageable.	Large numbers of such installations are present all over the Maldives with limited observed negative impacts. Using local expertise to undertake marine based work would help reduce the impact on the marine environment during construction. To minimise the social impacts, efforts need to employ Maldivians during the construction and operation stage of the projects. Proper siting decisions can help to avoid aesthetic impacts to the landscape and seascape. Siting decisions will be taken in consultation with all local stakeholders.	Locating the wind turbines need to consider the direction of the monsoonal wind. This would reduce the impact on noise on to the island. Implementation of an on-site training and skills development programme to maximize the number of people from local communities employed as skilled labour in the operation stage of the project.	Best practicable technology to effectively control gaseous emissions need to implemented to control the air quality.	An appropriate waste management strategy will be developed to manage the large amount of waste that may be generated when inefficient air conditioners, refrigerators and lights are replaced

TABLE 14 - ENVIRONMENTAL AND SOCIAL MONITORING FRAMEWORK

APPENDIX 1 – EXISTING RENEWABLE ENERGY PROJECTS

Project	Company	Finance Source	Progress	Remarks	Size (kW)
ONGOING PROJECTS					
Project for Clean Energy Promotion in Male	contracted to Toyota Tsusho Corporation		on-going	Install 675kWp solar PV grid connected system on selected public rooftops in Male.	675
Clean Energy for Climate Mitigation (CECM)	KEMA Netherland B.V	CCTF	on-going	200kWp on Thinadhoo plus ancilaary work and some energy efficiency planning and demonstration	200
Solar Grid Connected System for Small Island (K.Dhiffushi)	contracted to KEPCO on Behalf of GSEP	GSEP, ADB	on-going	35-40kW PV will be installed on Dhiffushi whose max demand is about 100kW-300kW.	40
Green Building Project	Contech Pvt Ltd, RIYAN Pvt Ltd, Renewable Energy Maldives	Indian Government	on-going	Sustainable Building	
DANIDA Green Facility	contracted to UNEP Risoe	DANIDA	on-going	Development of CDM Capability	
PROBABLE/POSSIBLE PROJECTS					
Wind in Male Region -power Purchase Agreement (STELCO)	X.E.M.C New Energy	private sector	Agreement Signed	Will deliver Malé area inter-island grid	20,000
PV for Hdh. Kulhudhuhfushi	Renewable Energy Maldives	private sector	Agreement Signed	1MW Solar PV	1,000
PV power for 6 islands in Male' atoll; total installed capacity 448kW	Renewable Energy Maldives	private sector	Agreement Signed		448
Establish a renewable Energy System in Upper North Province (UNUL)	Renewable Energy Maldives	private sector	Agreement Signed	43.2 kW wind	43
ASPIRATIONAL PROJECTS					
Wind in Southern Province	SUZLON	None yet found	Agreement Signed	25MW Wind diesel - Govt guarantee sought	25,000
Establish a Renewable Energy system in the Upper South Province (USUL)	B.B.M Infra Limited	None yet found	Agreement Signed	2MW - Govt. Guarantee sought	2,000
Solar in Southern province	B.B.M Infra Limited	private sector	Agreement Signed	Status unclear	
Wind in in South Central Province	GAMESA Wind Turbine Pvt	private sector	Agreement Signed	Status unclear	
SUCCESSFULLY COMPLETED PROJECTS					
PV powered mobile phone masts	Dhiraagu	Dhiraagu	Completed	Total 258kW PV in 174 locations	258
Solar PV system	Soneva Resort	private	Completed	70kWp solar array in the resort	70
Solar PV grid connected system	Sungevity	MHE	Completed	11.1 kWp Solar PV grid connected system	11
Rooftop Solar PV System	JICA	Japanese Govt.	Completed	10kWp rooftop solar PV	10

TABLE 15 - RE PROJECT LIST

APPENDIX 2–MALDIVES ENERGY TECHNOLOGY SUPPORT UNIT

The Maldives program for decarbonising by 2020 is ambitious for any country, let alone one with so few technical and administrative skills and personnel. However the advantage that the Maldives has is that many of the problems and their solutions are repeats – most islands have power systems and RE and EE solutions that are very similar if not almost identical. This means that the number of problems to solve is relatively limited, each being repeated many times across the seven utilities.

In order to avoid attempting to create the technical, financial and administrative skills needed to implement the decarbonisation policy separately each utility, REIO has elected to create two central agencies – the Maldives Energy Technology Support Unit (METSU), and the Maldives Energy Services Company (MESCO) with the mandate of supporting both the utilities and the private sector.

Electricity represents only 44% of the Maldives current GHG emissions. Other major sources of emissions are marine transport, waste, and internal air transport. Thus the mandate of METSU goes some considerable distance beyond satisfying current power needs with renewable energy.

This document outlines in broad terms the overall scope of METSU activities, although only a portion of them fall directly within the scope of SREP.

In all, nine separate work streams are proposed; each will need at a specialist programme manager together with support staff and appropriate facilities. The costs of these will be a tiny proportion of the total costs of becoming carbon neutral (*less than 0.5%*). METSU will, however, help avoid expensive mistakes and its advice will result in much lower energy costs than will be achieved by simply progressing *ad hoc*.

Each work stream represents a coherent area of research, evaluation and knowledge that can be managed by a specific team of people. Within each work stream the objectives of the team will be as follows:

- To scan the technology space to identify new technologies and developments as they emerge.
- To evaluate promising technologies and to test them in real world conditions so that the best can be chosen for the Maldives.
- To liaise directly with the technology developers and manufacturers to ensure a complete understanding of the technology and how to minimise the costs of acquisition, installation and maintenance.
- To negotiate the least cost route to acquiring, installing and maintaining selected equipment and technologies.
- To interact with other work streams to ensure a coherent approach to problems and opportunities.
- To develop standardised solutions that can be applied easily and reliably across the entire Maldives.
- To provide Maldives government, the private sector and civil society with the results of its work, and recommendations for how best to use the technologies being evaluated.

- To ensure that Maldives government and state owned industries get best value for money in their purchasing and policy decisions.

- To ensure that the deployment of the new technologies can be done in a low risk and investment friendly manner, so that it is as easy as possible to attract the lowest cost funding possible.

It is envisaged that the work would be carried out both in the Maldives and overseas, and that additional technical support would come from one or more prestigious international universities. This would also allow bright young Maldivians to work alongside world-class experts, and develop skills which will be increasingly needed around the world in the coming decades.

Common to all work streams, and a key objective of METSU will be education and training not only for engineers and operators, but also for executives, politicians and civil servants.

Key METSU work streams

The principal work streams will be as follows.

Workstream 1 - Wind and Solar PV

These two technologies are complementary, and will nearly always be used together in some degree. Both are available as 'off the shelf' purchases. However it would be a mistake to believe that this means they can simply be bought 'from a catalogue'. Some of the complications and challenges are as follows.

As the Maldives is seeking to achieve close to 100% of power from RE, issues of matching and optimising the time of day that power is delivered and used, the sources of power (wind and solar), and the battery or other energy storage needed are critical. These in turn interact with energy efficiency measures, and demand deferral measures – whereby demand is shifted from periods when it has to be delivered from batteries to periods when it can be delivered directly as it is generated.

The Maldives is not an ideal location for wind, which varies significantly from North to South, and from season to season, but it can play an important role in minimising power costs. There appears, at first sight, to be a relationship between windiness and sunshine – it is less sunny when it is windier. Modelling of island power systems has demonstrated that minimising the cost of power from wind does not necessarily minimise the overall cost of electricity, because smaller turbines are capable of generating over a larger range of wind speeds and therefore for more hours a year, and thus reducing energy storage needs.

Solar PV is a rapidly advancing area, and new products will emerge from laboratories and factories regularly over the next decade. Understanding what is coming, and when, will be important in deciding implementation strategies for the Maldives. This timing is particularly important, as costs will inevitably fall over the coming years.

Unlike solar PV, wind is a relatively mature technology and dramatic cost falls are not expected. This suggests that a phased approach to carbon neutrality might be adopted, with wind installed first and then solar following. Modelling carried out by Oxford University and GOM consultants indicated that this could be significantly cheaper than installing solar PV first, or both together. Such a strategy needs to be further evaluated with more accurate data than is currently available.

Workstream 2 – Energy Storage

In the Maldives most renewable energy will come from wind and solar resources that cannot be controlled. To make the maximum use of these it is necessary to store energy when it is

available, and release it when consumers need it. Energy storage is therefore a critical, and potentially very expensive, part of the Maldives carbon neutral electricity mix.In addition, energy storage will undoubtedly play a major part in a carbon neutral maritime transport system.

Energy storage can be done in a number of ways. There are many types of battery available, and many new developments are coming on stream soon. In addition energy can be stored as hydrogen – to be released using fuel cells, or using mechanical methods such as compressed air or high-speed flywheels.

An important consideration for the Maldives will be the extent to which energy storage is used and the timing of its introduction. The pace of development means that in some cases it may be wise to build renewable energy systems initially with generators to provide load balancing, and then introduce energy storage as a later addition. Understanding the economics of this trade-off will be an important task for the energy storage work stream.

Workstream 3 – Control systems, Grid management and integration

Integrating solar, wind, diesel or biodiesel and batteries into a single grid is a non-trivial task. Doing so in a way that minimises power losses, and minimises the use of batteries and other capital equipment will contribute significantly to securing low power costs for the next 20-30 years.

Several focus areas are set out below:

- Reducing grid losses. Grid losses on some islands are reported to be as high as 35%. With a well-designed small system these could possibly reduced substantially. Eliminating unnecessary grid losses will have a capital cost, but it may well be less than the cost of installing the renewable generating capacity required to overcome them.

- Management of storage and despatch systems. Deciding how to operate the integrated system to avoid as much as possible the use of batteries, and backup diesel requires sophisticated modelling and computer programs, but is essential to the economic operation of a system.

- Smart metering and load deferral. Load deferral offers significant opportunities to minimise the use of electricity at times when natural sources of generation are inadequate – such as on a still windless night. Smart metering and load deferral may also mean that new billing systems need to be developed and deployed.

- Improved system management. There is already significant inefficiency and thus money wasted in the operation of island grids. Integrated fully renewable grids are more complex, and need to be monitored carefully at all times to detect failure or underperformance and to ensure maintenance is carried out promptly. Every island's power system should be monitored remotely in a central station, and maintenance and operation controlled in the same way. Appropriate systems will therefore need to be developed.

Workstream 4 – Marine Transport

Marine transport amounts for around 22% of GHG emissions in the Maldives. Several approaches are needed to minimise the emissions from marine transport:

- Improving the design of boat hulls could have a major impact on the energy needed. Work in this arena is already taking place through the recently awarded contract for the ferry system in the North of the country. The winners of the contract believe they can reduce energy requirements by significant amounts by using radically new designs.

- The use of electrical propulsion (even if powered by a biodiesel or diesel generator) has the potential to reduce energy requirements even further.

- The use of stored electricity, coupled with on-board generation of electricity, will reduce the need for liquid fuels

- Finally, wind has powered Maldivian boats for centuries. New approaches to wind power, using computer designed masts and sails, can be used to deliver a modern approach to an old skill. This could be further improved by coupling with satnav facilities that integrate information about marine currents.

Developing and integrating these various strands into economic and practical vessels will be a significant technical challenge, and an area in which the Maldives could reasonably aspire to become a world leader.

Workstream 5 – Building efficiency

Lighting and cooling in buildings are major uses of electricity. Good building design, insulation, and improved control systems, can dramatically reduce the need for cooling, in particular.

A priority work stream will therefore be the development of building codes for new building, plus retrofit solutions to economically reduce cooling loads and improve comfort levels in existing buildings.

Workstream 6 – Domestic appliances

The major electric loads are lighting, cooling and refrigeration. Initial investigation shows that there are significant opportunities to materially improve the efficiency of some of these as well as improving safety and service levels. (*In an investigation in Baa atoll, inefficient fridges were found operating at temperatures that are unsafe for food storage. Replacing these would reduce energy bills significantly and reduce food spoilage.*) In addition, cooling devices can be re-designed to allow load to be added and shed from the grid as needed. This could help reduce night time demand by shifting it to day time, and also improve grid stability by having a rapid response load that can be added or removed automatically as needed.

Replacing the fleet of cooling appliances (fridges and air conditioners) would also ensure the rapid elimination of HFCs from the country in accordance with government policy.

In many instances it is cheaper to replace old appliances with new efficient ones than to buy the solar panels and batteries needed to supply the old ones with the extra electricity they use.

METSU would seek to identify the most efficient and cost effective appliances, and seek to ensure that these were deployed in the consumer market ahead of any others. It would also seek to implement a European style energy efficiency labelling scheme that helps customers choose those appliances that are cheapest to operate and most efficient.

A further energy load comes from cooking which is currently done either with wood or gas. Gas cooking is not compatible with a carbon neutral future unless the gas is biogas. Huge advances have been made elsewhere in the world in making cooking more efficient and sustainable. METSU would evaluate these for suitability in the Maldives.

Workstream 7 – Malé and Environs

Male and its environs present special problems. The population density is very high, and there is insufficient space for locally generated solar and wind power to make a significant contribution to the power needs. In Malé therefore different approaches are needed to the other islands.

Designing Malé's power systems will be complex, given the relatively large size compared to the other islands, and the challenges of population density, lack of space, and the need to interconnect several islands, from Thilafushi to Hulhumalé. The ultimate system will probably include a major element of biomass, some wind and solar, and utility scale energy storage to manage the grid whilst letting the power station operate at maximum efficiency. Eventually it will also possibly include power from marine currents and ocean temperature differences. These may displace the biomass in 10-15 years.

WORKSTREAM 8 – BIOMASS, WASTE TREATMENT, WATER

Given the need for despatchable electricity, sources of energy such as waste biomass (e.g. coconut husks and shells), energy crops (e.g. bananas, bamboo) and domestic waste are high value fuels. In addition, some such as bananas and coconut can be used to make liquid fuels that can be used in slightly modified conventional engines.

Waste from kitchens, as well as sewage, is widely converted into a biogas which can be used for a variety of things, including cooking, electricity and transport.

Producing water is a major power user, but new technologies may allow water to be produced with very low power consumption, and have the benefit of creating highly productive greenhouses at the same time.

All these three areas of energy interest need to be evaluated by METSU to determine if they can offer any significant contribution to making the Maldives carbon neutral. Trial units will have to be built, and operated in 'real world' conditions to determine their suitability.

METSU DRAFT BUDGETS

The work that METSU has to do will be spread over a number of years, with different emphases at different points in time. This section looks at funding requirements over five years.

This exercise is, of necessity, a very preliminary pass at determining budgets. Its purpose is to indicate the broad scale of costs likely. The actual budgets will depend on both a more detailed analysis of the work streams – something that will only emerge once they have begun; and detailed negotiations with partner organisations. There are more than one international class universities that would be keen to become involved in such a programme. Engaging such partners will significantly enhance the amount of inputs that will be possible with any given budget.

A preliminary budget has been prepared (overleaf) based on the following assumptions:

- A part time Chair, with international experience of carbon policy and renewable energy technologies
- An Advisory Board made up of international experts in particular areas of interest and technology who would meet on a regular basis to advise the Chair, and the CEO, and approve any technical advice or recommendations formally made by METSU
- A full time CEO
- A number of 'Workstream Leaders'. These could be either locally based and full time, or alternatively based in research institutions or overseas universities but spending a material proportion of their time in the Maldives. The advantage of part-time employees would be that, by being world experts in their field based in academia or research, they will continually be exposed to new ideas and developments in what promises to be a

very fast moving field over the next decade. Each Work Stream Leader could take on one or more work streams – depending on the intensity of work required. Work Stream Leaders would be expected to travel extensively to visit equipment suppliers, technology developers and attend conferences.

- A small fabrication and general engineering workshop – able to build test rigs, install equipment, and do all the tasks needed to operate a series of test facilities, data collection equipment and trial installations.

- A number of research assistants/trainees. These would be Maldivians aiming for a career in renewable energy and energy efficiency. They would spearhead data collection, operate test rigs, help with evaluation of programmes, and help design 'real world' trials.

Role	**Commitment**	**US$**	
Chair	Part Time	24,000	
Advisory Board Member	Part Time	12,000	Entitled to Work Travel Budget
CEO	Full Time	80,000	
Workstream Leader	Full Time	100,000	
Chief Engineer	Full Time	60,000	
Workshop Engineers	Full Time	30,000	
Research Staff/Trainees	Full Time	12,000	
Annual travel budget per person		15,000	

Staff Numbers	**Yr 1**	**Yr 2**	**Yr 3**	**Yr 4**	**Yr 5**
Chair	1.00	1.00	1.00	1.00	1.00
Advisory Board Member	3.00	4.00	4.00	4.00	4.00
CEO	0.50	1.00	1.00	1.00	1.00
Workstream Leader	2.00	4.00	5.00	5.00	5.00
Chief Engineer	0.50	1.00	1.00	1.00	1.00
Workshop Engineers	1.00	1.00	1.00	1.00	1.00
Research Staff/Trainees	2.00	4.00	5.00	5.00	5.00
Staff Costs					
Chair	$24,000	$24,000	$24,000	$24,000	$24,000
Advisory Board Member	$36,000	$48,000	$48,000	$48,000	$48,000
CEO	$40,000	$80,000	$80,000	$80,000	$80,000
Workstream Leader	$200,000	$400,000	$500,000	$500,000	$500,000
Chief Engineer	$50,000	$100,000	$100,000	$100,000	$100,000
Workshop Engineers	$60,000	$60,000	$60,000	$60,000	$60,000
Research Staff/Trainees	$60,000	$120,000	$150,000	$150,000	$150,000
Total Salaries	$470,000	$832,000	$962,000	$962,000	$962,000
Overheads					
Travel costs	$97,500	$150,000	$165,000	$165,000	$165,000
Office admin	$50,000	$50,000	$50,000	$50,000	$50,000
Purchase of workshop equipment	$50,000	$20,000	$10,000	$10,000	$10,000
Recruitment costs (10% of senior staff salary)	$41,000	$30,200	$10,000	$0	$0
IT etc	$10,000	$16,000	$18,000	$18,000	$18,000
Total Overheads	$248,500	$266,200	$253,000	$243,000	$243,000
GRAND TOTAL	**$718,500**	**$1,098,200**	**$1,215,000**	**$1,205,000**	**$1,205,000**

TABLE 16 - METSU PROVISIONAL BUDGET

The total budget over 5 years is estimated to be around $5M.

Appendix 3 – Proposed Feed in Tariff

The proposed Feed in Tariff regime is expected to form the core of RE development in the Outer Islands, and a significant component of RE supply in the Greater Malé area. MESCO will have a key role in supporting the Maldives Energy Authority in implementing and securing the success of this FIT. To support this it is proposed that the existing feed in tariff regime be supplemented with a new FIT regime aimed at meeting the needs of larger developers at the same time as delivering national policy.

The Existing FIT regime

The existing Feed-in Tariff (FIT) is a helpful step towards decarbonizing the economy, but it has technical weaknesses, and is not yet a major commercial success.

If these weaknesses are resolved as set out here the FIT should provide a very low cost, streamlined and effective way of decarbonising the national electricity system at high speed. The recent huge cutbacks in FIT regimes in Europe mean that there may be many companies with the skills and capacity to step in and make major investments in very short order.

Problems with the Existing FIT regime

Energy Storage

Although electricity demand follows reasonably predictable patterns there is substantial variability, depending on holiday patterns, temperature, and random fluctuations. Serious consideration must be given to the way in which these demand fluctuations will be absorbed by the system, and how they should be matched to any commercial obligations made by the utilities to take power at the FIT price.

Self-supply

Electricity in a solar grid is over twice as expensive at night as it is in the daytime. Therefore if a consumer connects solar PV to the grid in their own premises, to supply their daytime electricity load, they put a burden on the utility to supply only night-time electricity. This will either increase Utility losses and increase the need for government subsidy, or it will require the Utility to put up average electricity prices, either with a single tariff, or by introducing a second, higher, night time, tariff. Increasing subsidy is not sensible or affordable, and both of these tariff options would disadvantage poorer households who could not afford solar panels – and thus be in direct contradiction to all sensible policy goals.

This needs to be resolved therefore by ensuring separate licencing and metering of solar PV connections by consumers to the grid – so that the FIT is paid for all electricity generated, and the correct revenue amount offset against the overall electricity bill.

Economies of Scale

There are two hundred small islands whose power systems need conversion, spread across 7 separate Utilities that have limited experience of entering into contractual arrangements to buy power. Thus while the total solar power demand is high, the individual projects will be small and expensive to set up and develop. This will lead to higher power costs than are needed.

Demand Matching

If the FIT is set at an attractive level European experience shows that it will result in a rush of companies to install equipment; there will be more companies wishing to add capacity to the grid than there is ability in the grid to absorb it. This will be particularly true if the capacity added is

all using fixed installations as opposed to tracked ones. These produce all their energy around a relatively sharp midday peak. Some mechanism needs to be put in place to reward companies that produce power over a wider peak.

It is also necessary to have a mechanism which sets out how much power the utility is prepared to buy, and how to prioritise applications to supply.

Seasonality

Both solar and wind power are seasonal. Delivering high levels of RE penetration therefore needs account to be taken of varying resource availability.

Pricing and Risk

The Maldives is perceived to be a high-risk investment area. Under the current FIT companies need to see relatively long periods of stability and secure income to justify investment. Without addressing these issues of risk, only limited amounts of capital will be attracted to the sector.

There are ways to address this issue, by arbitraging between the high discount rates needed by companies to justify investment, and the much lower discount rates used by sovereign nations to make investment decisions. This is not considered in the existing FIT.

Using the Existing FIT

The existing FIT is not ideal, but can be applied if its use is limited to a very low percentage of any island's power system. It is suggested that the existing FIT (henceforth eFIT) should be limited to peak power output of no more than 5% of any island grid baseload[4]. Any single installation should be limited to the lower of 1% of the island's baseload or 4kW(peak).

The purpose of these limitations is to ensure that unregulated and unplanned installations do not arise that could leave the grid over-capacity, or with insufficient energy storage to accommodate generating peaks.

The only modification may be that the eFIT is subject to the grid connection and metering regulations proposed elsewhere in this document.

The intent is that the existing FIT will satisfy the demands of household level power producers on the small islands, and be exceedingly simple to operate. In the greater Malé region it will also serve the needs of commercial property owners with some roof space that they wish to use without entering into the complexity of the new FIT proposed below.

Modified FIT Regime

This proposal aims to reshape the FIT to address most or all of the existing shortcomings. Much technical detail needs to be resolved and the principle remains to be approved by Cabinet. If accepted, these proposals will then give effect to the REIF commitment to use MESCO as an aggregator, and vehicle for assisting with the provision of leasing finance and security for projects. Any concerns by the utilities about the role of MESCO will be allayed by making the utilities the principal shareholders in MESCO.

[4]Clear definitions will be needed of how the baseload should be established. This relates to the problems of defining capacity more generally, and thus the capacity of the grid to absorb more power.

MFIT Tariff Components

Balancing the needs for efficient land use, maximum penetration of renewables into the grid, and minimum cost of power, mean that the MFIT needs to be slightly more complex than a simple payment per kWh. Although it may seem overly complex for relatively small projects, these projects are potentially very large in proportion to any individual island grid.

Three components are proposed, a land rent and a capacity reservation charge payable BY the developer, and the tariff itself payable TO the developer. The tariff will be set high enough to compensate for the rent and capacity reservation charges in a well performing project

Land Rent

A substantial land rent is needed to ensure the project developers use land efficiently. There should be active encouragement also to use space that cannot be used in future for development

Capacity Charge

The Utility needs to have a clear understanding of how much power any developer is likely to produce and the capacity to absorb it. By taking up a slice of capacity a developer is denying this slice to another potential developer. Thus there needs to be a mechanism to 'reserve' capacity, and to provide strong encouragement to a developer to actually deliver their reserved capacity, or alternatively to release it if a project is not performing to specification.

In addition, the Utility has a need for power over as long a period of the day as possible instead of in a single peak. This will reduce storage and voltage stabilisation requirements. With solar PV this can be achieved either by tracking, or with some interesting new mounting geometries.

Therefore a Capacity Reservation Charge is proposed. To be effective the Capacity Reservation charge needs to be high; six months Capacity Reservation charge will be payable immediately upon the signature of the agreement with the utility in order to secure the commitment of the developer. After six months the charge will be levied monthly.

The Capacity Reservation Charge will apply equally to wind or solar PV. Combined wind and solar installations may be managed by the developer to ensure that when operated together they do not exceed the capacity booked even if the sum of the nameplate capacity of the devices is greater than the booked capacity. They can do this shedding some power generation at the infrequent times of year that they exceed the booked capacity.

The Reserved Capacity will be fixed at the time of application by the developer for the MFIT. The amount of capacity reserved must be supported by technical details of the planned scheme and expected generation.

The developer may change the Reserved Capacity subject to 3 months notice and, in the event of increase, there being sufficient grid capacity to accept the increase. The capacity that the Utility guarantees to take will change accordingly.

The Developer may change reserved capacity twice over the life of a project – to prevent gaiming of the system. In addition the Developer must give three months notice of intent to terminate the project. At termination all equipment will be removed from the site, and the site returned to its original condition, and free for a new developer to occupy it.

Penalties will be imposed on developers whose project fails to achieve at least 80% of reserved capacity within 24 months of contract signature.

Tariff

The disadvantage of FIT mechanisms is that they do not offer price discovery through competitive tendering. The tariff needs to be set at a level that attracts developers, without giving away more than is necessary. This can only be ascertained by careful market research and discussion with potential developers.

Tariff and Charge Reviews

Once established, the tariffs and charges for a project will not be changed over the lifetime of the project. For new projects, the Government of the Maldives may:

- review tariffs upwards at any time.
- review tariffs downwards, and rents or Capacity Reservation charges upwards, at any time, subject to a six month notice that such a review may take place.

New Regulation on MFIT Power Purchases

New regulations on power purchases other than under the eFIT need to be introduced as a complement to the operating mandate of MESCO.

Regulation is proposed to ensure that the Utilities are the ultimate buyers of all privately generated electricity, except where a supplier and consumer are not connected to any Utility and place no burden on the public purse for the provision of power. This covers all installations except resorts and possibly some isolated businesses. This ensures that all installations are separately metered, and that the Utility can manage the balance of supply and demand over seasons, days, and within any day and night economically. Without it there is a real risk of night-time electricity becoming more expensive, as consumers use daytime solar generation to supply their own needs at an effective price equal to the current power tariff, and leave the burden of night-time generation to the Utility.

Utilities should have a duty to publish their power purchase capacity. This will be a time series based on average current demand profiles[5], and the sum of contracted power purchases and expected power purchases. This will allow project developers to see what scope exists for new projects in any island. It will also allow MESCO the visibility needed to put together multi-island project deals.

Stakeholder Perspectives on the MFIT

Developer Perspective

The developer will have a strong incentive to build the project rapidly as the Capacity Reservation Charge will be levied whether the project is performing or not.

The provision of guarantees will allay most of the concerns related to investment in the Maldives, and MESCO should effectively provide aggregation, simplicity of negotiation and logistics support.

Utility Perspective

The payment of the capacity charge up front will give the Utility time and funds to prepare the island to accept the new project, and to put in place such measures as are necessary to ensure grid stability, energy storage, and load deferral.

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[5] This needs to be in an agreed format, and with a consistent statistical basis, so that firm contracts an be entered into with little or no risk of supply exceeding demand.

The initial years of the FIT regime will see electricity generating costs fall compared to existing diesel generation – thus allowing the utilities to build their balance sheets and become viable economic units.

Subsequently, utilities will be in a much stronger position to invest in the energy storage capacity needed to deliver the second round of RE penetration – lifting total RE supply to around 90%.

Government Perspective

This tariff regime will save money immediately for all the Utilities not operating at maximum efficiency. Other Utilities will not see any noticeable increase in power costs.

Donor funding will help secure guarantees in the first years of the FIT regime. Over time, as MESCO builds its reputation and some capital base, the cost of the guarantees will decline.

Interface between FITs and MESCO

Although the Feed in Tariffs will be operated by the Maldives Energy Authority, there needs to be strong interaction between the MEA and MESCO. This may be summarised as follows.

Proposal	***Purpose***
MESCO will have the right to lease equipment to Utilities at prices that are acceptable to the MEA, in order to enable Utilities to acquire complex or capital intensive plant as needed to enable them to meet their carbon neutral, oil independence objectives.	This will allow MESCO to receive donor and concessionary funding, and use it to lease equipment for use in Utilities. Utilities will pay a fair price for use of the equipment, thus allowing them to make savings on generation or distribution and prepare for the FITs. MESCO will be responsible for ongoing support as needed. MESCO will recycle its income stream from these operations to support additional activities in pursuit of carbon neutrality and oil independence.
MESCO will be empowered to promote the aggregation of RE projects into portfolios of a commercially attractive size and to promote the opportunities these portfolios create to RE developers in the Maldives and elsewhere	This will allow MESCO to help FIT project developers assemble single deals that cover many islands – thus gaining economies of scale and saving transaction costs. It will place the onus of negotiating with individual Utilities on MESCO rather than the project developer
MESCO will be empowered to charge the utilities a modest fee to cover its costs of operating, and of providing such guarantees or financial support to project developers as are needed.	MESCO will facilitate the offer of guarantees against sovereign default or counterparty default to FIT developers. Initially the cost of these will be covered by donor support, but ultimately MESCO has to recover these costs.

APPENDIX 4 – SECONDARY EMISSIONS FROM BIOMASS

All power sources have secondary emissions associated with production and transport. Table 17 sets out approximate emissions from the three key alternatives in Malé (ignoring the issue of energy storage which cannot yet be resolved) in kg CO2/MWh electricity. This shows that whilst biomass is somewhat worse than solar (ignoring batteries) it is considerably better then diesel, whose energy costs in refining are considerable.

Emissions in kgCO2/MWh(e)	**Woodchip**	**Diesel**	**Solar PV**
Transport Emissions	56[6]		
Production Emissions	5[7]	98[8]	40[9]
TOTAL INDIRECT EMISSIONS	**61**	**98**	**40**
Direct emissions	0	650[10]	0

TABLE 17 - PRIMARY AND SECONDARY EMISSIONS FROM MALÉ ALTERNATIVES

[6]Assuming a 4,000 statute mile one way trip with return empty. Data from Marintek report to the IMO. http://unfccc.int/files/methods_and_science/emissions_from_intl_transport/application/pdf/imoghgmain.pdf . 4,000 statute miles encompasses Southern Turkey, South Africa and Eastern Indonesia.

[7] The biggest single energy consumers in preparing woodchips is chipping. Based on quoted consumption of a small semi-commercial chipper. Full scale commercial machinery is more efficient. http://www.greenmech.co.uk/downloads/Resources/CS_100_10-09.pdf

[8]Based on 10g/MJ energy for refining. Refining data uses the bottom of the range of estimates from http://www.newfuelsalliance.org/NFA_PImpacts_v35.pdf, with cross checking by reference to http://www.biomassenergycentre.org.uk/portal/page?_pageid=75,163182&_dad=portal&_schema=PORTAL. Transport and production emissions assumed to be *de minimis.*

[9]Based on NREL estimates of 2 year energy payback for solar PV modules, but ignoring the emissions associated with installation, frames, etc. http://www.nrel.gov/docs/fy04osti/35489.pdf

[10]Based on 37% average efficiency for Malé generators

APPENDIX 5– STAKEHOLDER CONSULTATIONS

The following stakeholder consultations have been held:

1. A public consultation meeting was held on September 7, 2011 to solicit comments on the Renewable Energy Investment Framework (REIF) – which forms the basis of government policy and thinking on renewable energy and underlies the preparation of the SREP IP. The following aspects where highlighted by the participants:
    a. Renewable energy sector developments in the Maldives were to focus on energy efficiency and use of solar photovoltaics for renewable energy generation.
    b. Concerns were raised regarding energy security in the proposed shift from dependence on diesel imports to imported biomass which is proposed for the Malé region.
    c. Emphasis on local private sector playing a role came across strongly in the consultations and stressed that private sector should play a greater role in the development and implementation of renewable energy initiatives.
    d. Clarity was requested regarding the role of the proposed institutions to be created, namely Maldives Energy Services Company (MESCO) (then referred to as Maldives Energy Finance Corporation (MEFCO)) and Maldives Energy Technology and Support Unit (METSU) with respect to ensuring that competition will be enhanced and that these organizations do not bias project development and technology selection.
    e. Concerns were raised on whether MESCO and METSU would be creating new bureaucracies and that priority should be given to strengthening existing institutions.
    f. Highlighted that there is a strong need to build local expertise and have less dependence on foreign consultancies to roll out the RE program.
2. The REIF was placed on the web for public comment in October 2011.
3. A consultative meeting was held on November 28, 2011 with all the major Malé area power producers to understand better the forecasts of demand and plans for supply. The following key points were highlighted by the participants:
    a. Reflected the uncoordinated nature of power planning in Male' area and importance of operationalizing a coordination mechanism to establish a holistic approach to power planning for the greater Male'.
    b. Highlighted the importance of a strong independent energy sector regulator to ensure sector development in an orderly fashion to safe guard interests of both producers and consumers of power.
    c. Establishment of an Energy Ministry or a Ministry which has "Energy" in its title was proposed to reflect the significance of the sector and establish a central authority that will provide information and direction on energy sector development.
    d. Suggestions were made to establish more clarity on which government agency is driving the energy sector to ensure roll out of a consistent and coherent energy policy framework nationwide.
4. A draft of the SREP IP was placed on the Ministry of Economic Development web site on January 8, 2012. No formal comments were posted online.
5. A consultative meeting for all the major power producers (utilities and private) outside the resorts was held in Malé on January 17, 2012 to review the latest draft of the SREP IP. The discussions mainly surrounded on the proposal for having a biomass plant as a baseload power for Male' region and building local capacity of utilities to implement RE projects. The following key points were highlighted in the meeting:

a. To undertake an independent detail study to determine the best technology option for Male' baseload.
b. Not to discount totally the future prospects of Ocean thermal and marine currents as possible future technology options for baseload or backup power.
c. To integrate STELCO as a key player in implementing the baseload power project for the Male' region.
d. Considering the many developments planned for the Male' region, it was highlighted that timing when to commission the proposed baseload power plant was critical.
e. All utilities expressed commitment and interest in rolling out the proposed investment plan but highlighted the importance of building adequate local capacity and re-train a whole carder of workforce that are trained on diesel generation.

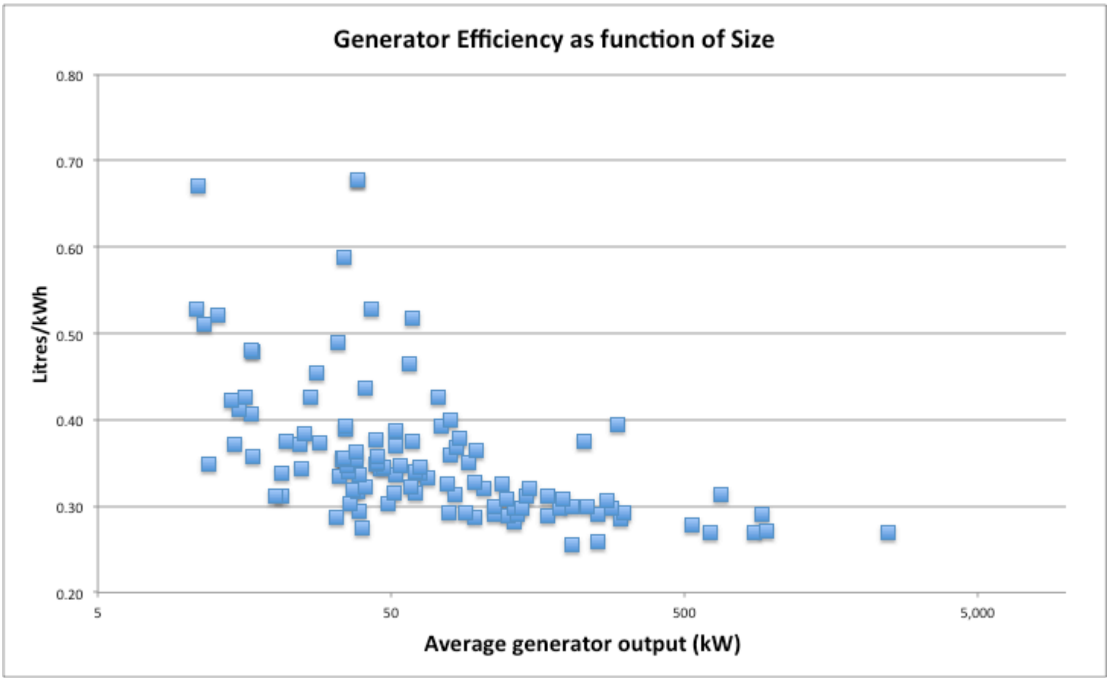
6. A public consultation on the SREP IP was held in Malé on January 18, 2012 open to all comers. It was attended by a wide selection of stakeholders including NGOs, the Bank of Maldives, major power generators and consumers, renewable energy entrepreneurs, and senior ministers. The meeting revealed that most of the concerns addressed by stakeholders on September 7, 2011 have been reasonably addressed in the draft IP that was published in the MED website for public consultation on January 8, 2012. In the consultation session, the following were highlighted;
    a. Mild levels of concerns were expressed purely on environmental grounds to the proposal to consider bio-mass as a reference case for Male' baseload. Participants were reassured that the technology option for Male' area will be determined based on an independent study to verify the best technology option. Most participants were satisfied with the approach and expressed support for the study.
    b. Suggestions were made not to discount the available technology options, particularly ocean thermal and marine currents.
    c. Proposals were put forwarded to consider micro-grids and adopt a cluster approach to deliver power in some of the outer islands.
    d. The need for strengthening the regulatory framework was highlighted to facilitate take up of both RE projects and EE measures. It was also highlighted the importance of integrating these aspects in the design phase with better and improved building codes, Feed in Tariffs etc. Discussions also surrounded in using incentives and regulatory options to increase the compliance and take up of RE/EE pathways by the tourism sector.
    e. The importance of building and engaging local talent was highlighted during the discussions.

APPENDIX 6 – OUTER ISLANDS RE CONCEPT NOTE

THE CURRENT STATE OF GENERATION

Generation in the outer islands is exclusively by diesel generator. The systems have evolved rather than been designed, in most cases. In most cases generators have been added *ad hoc* with no regard for maintenance issues, or the cost of operation. Maintenance is carried out by able and resourceful local personnel; but there is no provision for a national spares stock, or any centralised expertise.

In consequence many generators are wrongly sized for their load, many lie is pieces on the floor, and most are consuming much more fuel than is necessary. The graph below shows the (self) reported distribution of fuel consumption for about 120 of the 190 inhabited Outer Islands (i.e. excluding Malé area).



In addition to problems with generation, there are major issues with the distribution grids. There are grids where the losses on distribution are estimated to be up to 35%, though no fully reliable study has been made to confirm this. It is however consistent with the visual evidence.

STUDIES DONE TO DATE

There have been numerous studies in earlier years of the potential for RE in the Outer islands, but they have largely been unsystematic, and not considered the opportunities that exist for integration of wind, solar, and demand management in order to deliver the lowest cost of energy.

Two informative recent studies were the ones on which the SREP IP re is largely based. One was a supervised Master's dissertation for Oxford University and based on a small island in the North of the country. The second was commissioned by the GOM specifically for the SREP IP based on an island in Laamu Atoll, south of Malé.

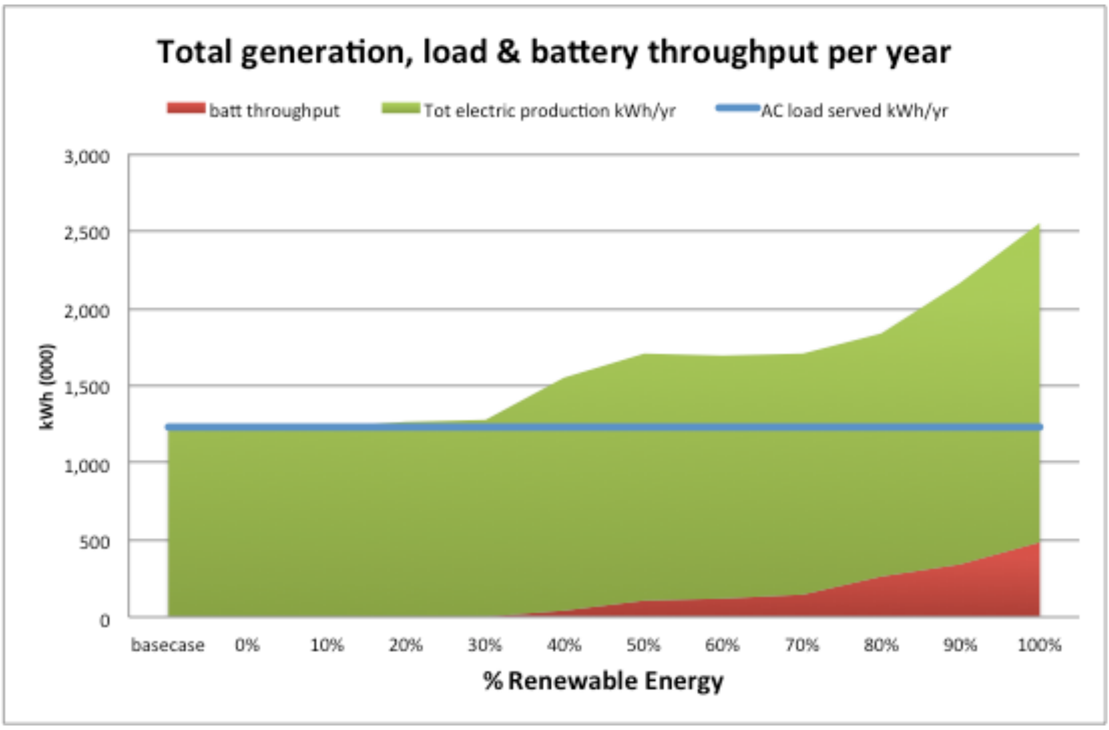
Both studies[11] used HOMER models to assess the cost of RE at various levels of penetration, and with varying levels of energy storage. However they both rely on wind data which is unverified. The importance of wind to the overall lowest cost energy mix – and the complete absence of a national wind data set is a major barrier to the cost effective deployment of RE in the Maldives.

A further grid stability study was commissioned by the GOM and funded by SREP[12]. This looked at grid stability issues for various levels of solar energy penetration – in order to assess the practicality of inserting high levels of solar PV into the grid without compromising grid stability.

ANALYSIS

Lara Kesterton's detailed study on one power station used one generator option as an alternative to using the existing generator – namely to use a proprietary Low Load package designed to support intermittent generation to very high levels of penetration.

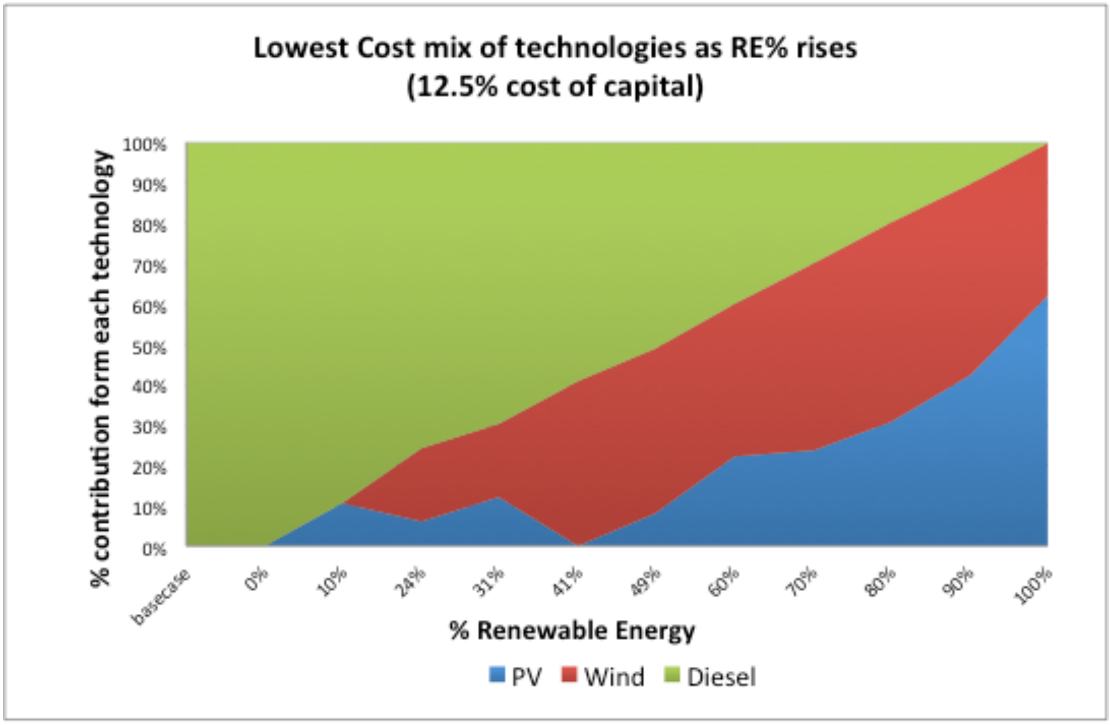
Key results from that study are as follows:



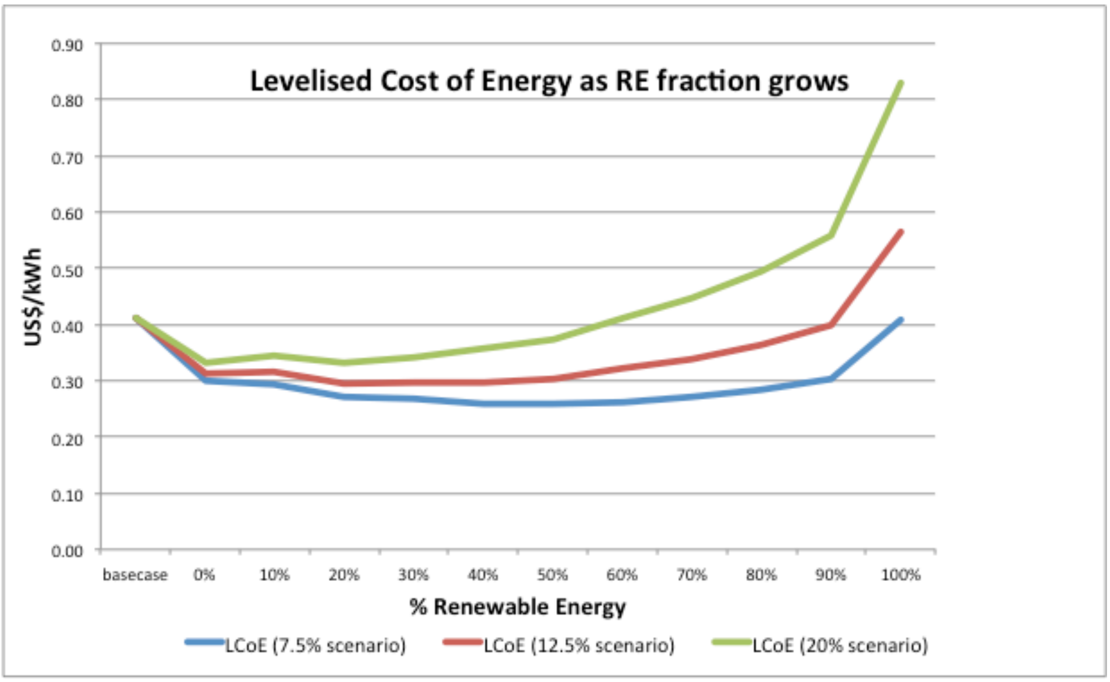
Using the wind and solar data available, LK demonstrated that, ignoring the needs of grid stability, no substantial energy storage would be needed up to around 30% RE penetration. The following graph shows how the RE makeup varies as the penetration level increases. (The slight irregularities in the chart are created by adding or subtracting complete wind turbines – creating discontinuities).

[11] Both were done by Lara Kesterton (LK) who is currently 'Head of Decarbonisation' at the Six Senses group of resorts who manage three of the 100 Maldives resorts. Costs are based on current quoted costs for a live project at one of the resorts. .

[12] Studies carried out by Dr. McCulloch (McC)– Head of the Power Engineering Dept. at Oxford University.



The final graph in this series shows how the cost of RE varies as the proportion of RE increases, for a range of costs of capital.



Although the analyses are consistent with other work, in particular LK's work in Maahlos, they rely heavily on the synthetic wind and solar data used. This does not provide a detailed correlation of the wind and solar resource over time – rather the two data sets are treated as more or less independent. Furthermore, the wind data from different sources is difficult to reconcile, and leaves serious questions over its reliability. For this reason the most important first step is to acquire a high quality data set of wind and solar data covering the country.

In all the above graphs, the base case is the current generator, and the 0% case involves replacing this generator with a modern efficient, low load diesel generator fully equipped to handle intermittent loads. Although a very expensive piece of plant – in all circumstances replacing he existing generator reduces both emissions and costs.

Lara Kesterton's study shows the large reliance that needs to be placed on energy storage systems to achieve close to 100% RE penetration, and the substantial cost that it adds. Current investigations give some confidence that the costs of energy storage will actually fall substantially over the coming three to five years[13]

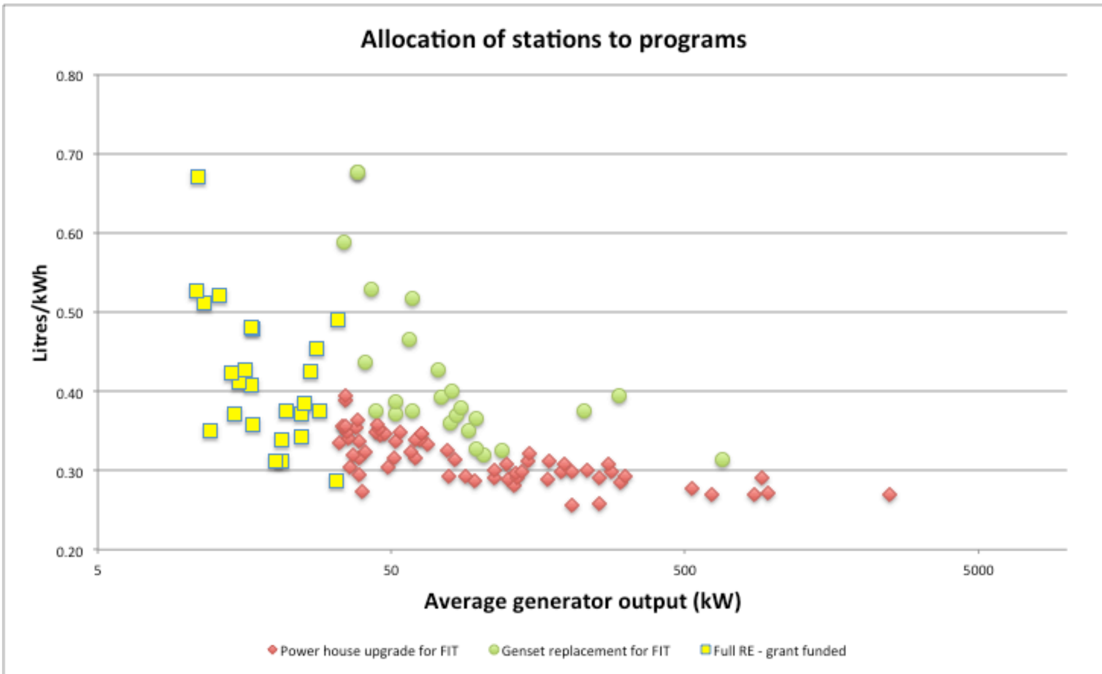
Dr. McCulloch's study considered the challenges of grid stability at this level of RE penetration. It concluded that 30% RE penetration was practical, but that some measure of energy storage would be needed to accommodate the swings in demand and supply, coupled with changes to the generator control systems. Most of this storage is expected to be produced from lead acid batteries, but with the possible addition of ultracapacitors to reduce the cycling, and thus extend the life. Further modelling and testing needs to be done on this.

Based upon these studies the SREP IP proposes replacing the generators that are least efficient and then installing around 30% RE. This offers the lowest total cost of energy at any reasonable cost of capital with no requirement for large scale energy storage. A subsequent phase, taking RE to almost 100%, will be tackled once energy storage costs have fallen.

Notwithstanding the above, there are a number of islands whose very small size makes them unlikely targets for developers to operate under the Feed in Tariff, and whose highly inefficient diesel generators mean that there is value in taking them out of service completely. For these it has been judged best to proceed to full RE supply in one step – seeking to minimise the overall costs by reducing, in particular, night time demand.

The following graph shows how the 120 islands for which good data exists are thus allocated to the three different components of the Outer Island RE programme; full RE, 30% RE (i.e. approximately 100% of midday demand met by RE) with generator replacement, and 30% RE with power station upgrades but no generator replacement. Further study is expected to find lower cost alternatives to generator replacement than evaluated so far, and thus increase the proportion of replacements, and reduce emissions further.

[13]A leading contender for this application is the Zinc Air battery. This is expected to have a 20,000 cycle life, and a capital cost of under $200/kWh. These batteries are going into commercial testing in 2012 in the USA, and are anticipated to be available for the Maldives as an early customer in 2013-1024.



Feed in Tariff Economics

The principal mechanism for the development of RE in the Maldives is expected to be the Feed in Tariff. A broad overview of the proposed feed in tariff structure is set out in an appendix to the SREP IP.

The underlying economics of the FiT have been derived from modelling the financial impacts of different charges and tariff rates for different construction options. The basic data derives from actual project costs for a planned commercial project in the Maldives, and includes all costs except minor local ground clearance and preparation costs.

An instance of the spreadsheet model is shown overleaf. Only the first 7 years are shown. The input data (blue text on yellow background) is variable and illustrative. Actual levels of tariff components remain to be set. However the model demonstrates that attractive rates of return (above inflation, and with guarantees on all aspects except technological performance) can be offered to developers whilst satisfying the needs of the Utilities to have power at attractive prices. The spreadsheet relates to 1kW peak installation.

THREE COMPONENT FIT CALCS

Inflation Rate	3.50%	
Rent	$60,000	/yr/ha
Capacity charge	$200	/kW annually
Panel Efficiency	15%	
Initial Tariff	$0.40	/kWh
Follow on tariff reduction	0%	
Follow-on Tariff	$0.40	/kWh
Years of Initial tariff	0	
RE System Losses	20%	
Percentage of cloud free time	80%	
Operation and Maintenance (O&M)	1%	of initial capital cost
Annual deterioration of panels	1%	declining balance

	Typical untracked installations			
	Ground mounted	Roof mounted	Lagoon mounted	Lagoon tracked
Capital Cost/watt peak	$2.70	$2.70	$3.20	$3.70
Build time (months	4.00	4.00	6.00	8.00
Proportion of area not covered by modules	20%	-	-	-
Module Area (m2)	6.69	6.69	6.69	6.69
Gross rentable area (m2)	8.36	-	-	-
Annual rent per kW(p)	-$50.15	$0.00	$0.00	$0.00
Annual generation (kWh/kWp)	1,569	1,569	1,569	2,072

Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Annual cost & revenue inflator	*1.000*	*1.035*	*1.071*	*1.109*	*1.148*	*1.188*	*1.229*
Onshore - ground mounted - untracked							
Generation	1,046	1,553	1,538	1,522	1,507	1,492	1,477
Tariff Revenue	$418	$643	$659	$675	$692	$709	$726
Rent	-$50	-$52	-$54	-$56	-$58	-$60	-$62
Capacity Charge	-$200	-$207	-$214	-$222	-$230	-$238	-$246
O&M	$0	-$27.95	-$28.92	-$29.94	-$30.98	-$32.07	-$33.19
NET REVENUE	$168	$356	$362	$368	$374	$380	$386
Investment	-$2,700						
NET CASH FLOW	-$2,531.74	$356.23	$362.05	$367.90	$373.79	$379.71	$385.66
IRR for developer	**15%**						
Net cost/kWh to Utility/GoM in money of the day	$0.16	$0.23	$0.24	$0.24	$0.25	$0.25	$0.26
Net cost/kWh to Utility/GoM in 2012 money	**$0.16**	**$0.22**	**$0.22**	**$0.22**	**$0.22**	**$0.21**	**$0.21**
Roof mounted - untracked							
Generation	1,046	1,553	1,538	1,522	1,507	1,492	1,477
Tariff Revenue	$418	$643	$659	$675	$692	$709	$726
Rent	$0	$0	$0	$0	$0	$0	$0
Capacity Charge	-$200	-$207	-$214	-$222	-$230	-$238	-$246
O&M	$0	-$27.95	-$28.92	-$29.94	-$30.98	-$32.07	-$33.19
NET REVENUE	$218	$408	$416	$424	$431	$439	$447
Investment	-$2,700						
NET CASH FLOW	-$2,481.59	$408.14	$415.77	$423.50	$431.34	$439.27	$447.31
IRR for developer	**18%**						
Net cost/kWh to Utility/GoM in money of the day	$0.21	$0.26	$0.27	$0.28	$0.29	$0.29	$0.30
Net cost/kWh to Utility/GoM in 2012 money	**$0.21**	**$0.25**	**$0.25**	**$0.25**	**$0.25**	**$0.25**	**$0.25**
Lagoon mounted - untracked							
Generation	785	1,553	1,538	1,522	1,507	1,492	1,477
Tariff Revenue	$314	$643	$659	$675	$692	$709	$726
Rent	$0	$0	$0	$0	$0	$0	$0
Capacity Charge	-$200	-$207	-$214	-$222	-$230	-$238	-$246
O&M	$0	-$33.12	-$34.28	-$35.48	-$36.72	-$38.01	-$39.34
NET REVENUE	$114	$403	$410	$418	$426	$433	$441
Investment	-$3,200						
NET CASH FLOW	-$3,086.19	$402.97	$410.42	$417.96	$425.60	$433.34	$441.17
IRR for developer	**14%**						
Net cost/kWh to Utility/GoM in money of the day	$0.15	$0.26	$0.27	$0.27	$0.28	$0.29	$0.30
Net cost/kWh to Utility/GoM in 2012 money	**$0.15**	**$0.25**	**$0.25**	**$0.25**	**$0.25**	**$0.24**	**$0.24**
Lagoon mounted - tracked							
Generation	691	2,051	2,031	2,010	1,990	1,970	1,951
Tariff Revenue	$276	$849	$870	$892	$914	$936	$959
Rent	$0	$0	$0	$0	$0	$0	$0
Capacity Charge	-$200	-$207	-$214	-$222	-$230	-$238	-$246
O&M	$0	-$38.30	-$39.64	-$41.02	-$42.46	-$43.94	-$45.48
NET REVENUE	$76	$604	$616	$629	$642	$655	$668
Investment	-$3,700						
NET CASH FLOW	-$3,623.74	$603.91	$616.26	$628.82	$641.61	$654.61	$667.83
IRR for developer	**18%**						
Net cost/kWh to Utility/GoM in money of the day	$0.11	$0.29	$0.30	$0.31	$0.32	$0.33	$0.34
Net cost/kWh to Utility/GoM in 2012 money	**$0.11**	**$0.28**	**$0.28**	**$0.28**	**$0.28**	**$0.28**	**$0.28**

PLAN

The project will comprise a series of sub-components.

SUB-COMPONENT 1 - SMALL POWER STATION RE CONVERSION

This sub-component relies on having reasonable wind and solar data, which will be provided by the network of weather masts to be constructed under the T/A component. It will also build on information learnt from the LECReD project being operated on Laamu which will build and operate the first full RE power station as a learning exercise.

Approximately twenty of the smallest power stations (<±35kW average demand) will be converted to full RE using an optimum mix of wind and solar PV, with lead acid batteries to provide energy storage. These have been selected because they are the most difficult to fund commercially and because they involve tight integration, at small scale, of wind, solar, energy storage and generator control. The learning from this sub-component will in turn support the design of feed in tariff structures, and operational systems for the eventual full RE penetration across all islands.

IMPLEMENTING AGENCY

The implementing agency in the Maldives will be the Maldives Energy Service Company (MESCO), using one or more Engineering Procurement and Construction (EPC) contracts. MESCO will lease the equipment to the island Utilities and retain responsibility for technical support as the skills needed are not available within the Utilities. By sharing the technical skills across all seven national utilities MESCO will reduce the training need and the overheads of operation.

The lease rates will be substantially lower than current generating costs. The revenue raised will form part of MESCO's operating income – which pay for the technical support (supported by METSU – the Maldives Energy Technology Support Unit); excess funds will be recycled into further RE and EE projects.

FUNDING

Total anticipated cost is $13.1M. Any cost over-runs may be dealt with by reducing slightly the scope of the SREP funded elements, and using the MESCO revenue stream to make up the shortfall. Cost under-runs, which may be achieved by either learning or by equipment prices falling, will be accommodated by extending the number of islands covered.

OUTCOMES

Anticipated outcomes are:

- ±20 power stations converted to full RE
- >5,000 MWh/year of RE delivered
- >2 million litres diesel saved per year
- ±100,000 tonnes CO_2 saved over equipment life.
- Considerable learning to support eventual decarbonisation of remaining larger stations.

LEAD AGENCY

ADB/WB – split by geographical region

SUB-COMPONENT 2 - GENERATOR UPGRADES

This sub-component is not an SREP element, but is a necessary pre-cursor to the introduction of high levels of RE to the larger Outer Island power stations that have inefficient generators.

The project involves replacing all the most inefficient generators around the country with a small range of modern, electronically controlled, generators adapted to run efficiently at low loads and able to stabilise the grid in situations where the percentage of instantaneous demand met by renewables can vary from 100% to near zero in a matter of seconds, or alternatively, demand peaks exceed the inverter and RE capacity.

There are two alternative approaches to this from a technical perspective, with different cost and complexity issues. The sub-component has been costed on the basis of the most technically simply to implement but the most costly to purchase approach. Further evaluation under the LECReD program will resolve this issue and lead to a clear choice.

If the lower cost option is chosen the number of power stations to be upgraded will increase as the payback period shortens. This will result in additional emissions and cost savings.

Implementing Agency

The implementing agency in the Maldives will be the Maldives Energy Service Company (MESCO), using one or more EPC contracts. MESCO will lease the equipment to the island Utilities and retain responsibility for technical support as the skills needed are not available within the Utilities.

This approach will allow a very limited range of generator sets supply a major part of the Outer Island power. This fleet rationalisation will reduce spares holding costs, improve system reliability, and by sharing technical skills across all seven national utilities it will reduce the training need and the overheads of operation.

The lease rates will approximate costs of ownership of existing generators (including maintenance but excluding fuel and consumables). The revenue raised will form part of MESCO's operating income – which pay for the technical support (supported by METSU – the Maldives Energy Technology Support Unit); excess funds will be recycled into further RE and EE projects.

Funding

Sub-component 2 will be funded through MDB loan and grant outside the SREP program. Total budget is anticipated to be $9.5M. Cost over and under-runs will be accommodated by flexing the number of generators upgraded. This can be achieved by varying the payback threshold – so ensuring that the most economically efficient upgrades are selected.

Outcomes

Anticipated outcomes are:

- ±30 power stations upgraded for high penetration of RE with efficient generators.
- 1.9 million litres diesel saved per year.
- ±5,000 tonnes CO_2 saved per year.
- Reduced generator maintenance costs, and increased reliability.

Lead Agency

ADB/Other

Sub-component 3 – Powerhouse Upgrades For Grid Stability

All those power stations in the Outer Islands not covered under sub-components 1 and 2 need to be upgraded to be ready to accept high levels of RE under a Feed In Tariff (FIT) on a 'plug and play' basis. To achieve this the power stations need to have their generators given automatic start and stop, sufficient energy storage to provide grid stability, a mechanism for dumping excess power, and a control system to integrate the components and make despatch decisions.

One of the two proposed LECReD power station interventions will be used as the test unit to develop the approach, and enable the work on the remaining power stations to be specified accurately.

Implementing Agencies

The power station upgrade work is intimately integrated with the operations and equipment already installed in power stations. It will therefore be carried out by the Utilities themselves, supported and advised by METSU. Actual engineering work will be done either by Utilities or under EPC contracts where the Utility is lacking the skills and resources needed to carry out the task.

Funding

Total funding for sub-component 3 is anticipated to be $4.7 million.

Outcomes

Anticipated outcomes are:

- 69 power houses upgraded to be 'plug and play' ready for high levels of RE
- 93 islands supported with logistics and project aggregation for FITs
- modest fuel savings from improving the despatch algorithms for generators

Lead Agency

ADB/Other

Sub-component 4 – Feed in Tariff

The feed in tariff will be the principal mechanism for introducing renewable energy into the Outer Islands. Initially the feed in tariffs will only apply to solar PV, even though wind is *prima facie* the lower cost source of RE. The reasons for this are as follows:

- There is insufficient quality wind data available to allow the lowest cost options to be determined. This will only become available once the T/A programme has been operating for 2 or more years.
- As islands approach 90% RE or more, the evidence from modelling is that the levels of solar PV needed will comfortably exceed the amount that is planned to be installed under this sub-component. Thus decisions taken on solar, even with imperfect data, will not result in excess capacity being installed.
- The complexity of introducing a feed in tariff for two sources of generation that are largely uncorrelated and may be delivered by different companies is substantial. The challenges occur when both are generating at maximum capacity and the grid is spilling power. This is an inevitable consequence of needing to balance supply and demand across the day and across the seasons (see graph on page 2). This issue will be decided once greater experience has been obtained of the FIT mechanism, and corporate appetite for investment and risk.

Logistics support and project aggregation will be provided to ensure that FIT projects are both of sufficient scale to attract investors, and the complications and costs of logistics when dealing with remote Outer Islands do not result in large islands close to Malé being preferred over small remote islands.

Implementing Agency

Development will be by private sector enterprises, under contract to the Utilities. MESCO will have a role in aggregating projects and supporting internal logistics, and METSU will support the Utilities in assessing the technical suitability of projects bidding to supply under the FIT.

Funding

The principle funding source, estimated to be approximately $60 million, will be private capital. The scale of individual development projects will be too small to accommodate the IFC and PSOD cost effectively. Support to the developers will be provided in the form of guarantee instruments to mitigate sovereign, currency and counterparty risks. $2.5M has been set aside for guarantee instruments from the Maldives IDA budget, with a further $5.6M in additional support.

Outcomes

Principal outcomes will be as follows:

- Installation, under a FIT, of 30% or thereabouts RE (equivalent to around 100% of the midday peak demand) on ±93 islands – predominantly using solar PV.
- Annual generation of ±50GWh of renewable energy per year
- Annual reduction in diesel use of ±12 million litres/yr
- Total emission reduction of ±600,000 tonnes of CO_2 over the project life.

Lead Agency

WB

Appendix 7 – Malé Baseload Concept Note

Malé has many shared characteristics with the smaller islands, simply two orders of magnitude bigger. However it also differs in important ways. Key differences are as follows:

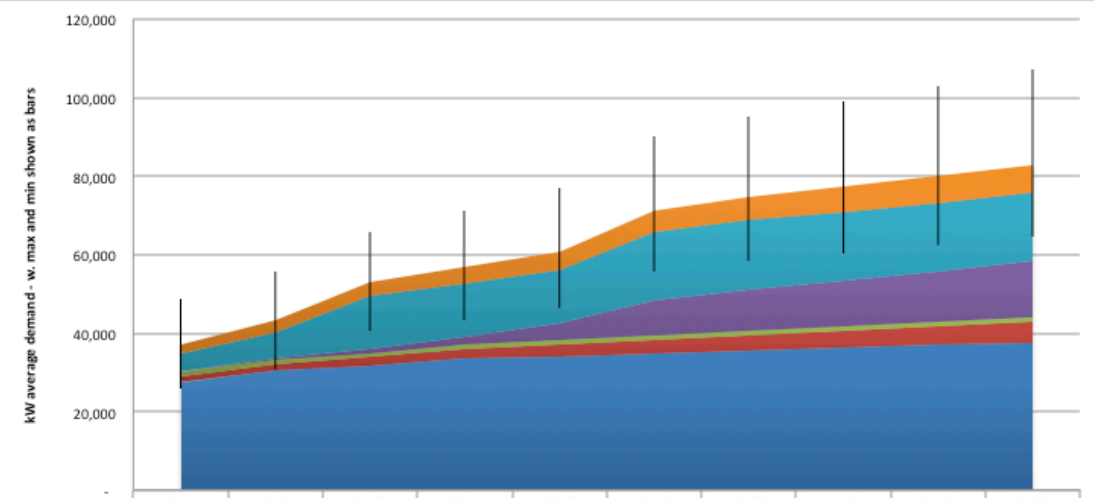
1. Generation in Malé is currently the most efficient in the country – and thus the marginal cost of generation is the lowest. This affects the relative economics of renewable energy.
2. The greater Malé area is currently in need of a distribution grid to connect the islands in order to improve efficiency and security of supply as well as to make accessible a new site to cope with additional generation requirements as the area grows.
3. There is very little space available for generation – particularly using land hungry technology such as solar PV. Most of the lagoon areas in the vicinity will ultimately be used for industrial or residential development. Space for solar PV will become available on rooftops if the proposed industrial development areas proceed, but this is dependent on other factors outside the control of energy policy.
4. There are real opportunities in Malé for technologies that are uneconomic at smaller scales, but economic at the Malé scale.

Current and Forecast Demand

Malé itself is not forecast to grow much as the island has little space for development. Key issue for Malé therefore will be developments on the islands and lagoons surrounding. Major projects anticipated include:

- Redevelopment of the airport
- New residential communities on Hulhumalé
- Movement of the port from Malé to Thilafushi
- The development of extensive new industrial and commercial premises on Thilafushi
- The growth of water demand to accommodate these new projects

An estimate of total demand until 2020 is shown below.



	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
MWSC	2,500	3,000	3,540	4,106	4,681	5,243	5,767	6,229	6,602	6,999
GMR/Airport	4,500	6,750	13,500	13,500	13,500	17,550	17,550	17,550	17,550	17,550
Thilafushi	280	560	1,120	2,241	4,482	8,963	10,756	11,831	13,015	14,316
Villinghili	976	996	996	996	996	996	996	996	996	996
Hulhumalé	1,451	1,742	2,090	2,508	3,009	3,611	3,972	4,370	4,807	5,287
Malé STELCO	27,598	30,358	31,876	33,470	34,139	34,822	35,518	36,229	36,953	37,692

Thus by 2017 demand is expected to average around 75MW with a baseload of around 60MW. Of this 15-20MW is expected to come from wind, under a pre-existing contract. This leaves the

potential for up to 40MW of baseload. Assuming some savings will be made through energy efficiency, and that the contracted waste to energy plant also performs as expected (≈3MW) there is secure demand for around 20-30MW baseload power with the potential for more.

Indigenous Resource Possibilities

There is a strong preference within the local energy community for using indigenous resources if possible. The immediately available indigenous resources are solar and wind.

Solar

Solar energy (without batteries) for Malé will be slightly cheaper than diesel, but suffers from the problem that there is almost no useable roof space today – and no other land is available to provide the scale of energy supply needed to make a material difference to the energy system.

This may change in the near future if a proposed structural plan for the development of the Malé area clarifies the development and land reclamation priorities for the lagoons, and determines a timetable for the construction of extensive new warehouses alongside the proposed new port.

Wind

A wind contract has already been issued, with a plan to use an LNG powered turbine to stabilise the supply. The contract envisages the supply of 20MW or more of wind power – though this is dependent on the results of a wind energy survey which has yet to be completed.

Ocean Thermal Energy

Offshore of Malé the water is very deep, and the possibility exists to employ the temperature difference between the deep ocean and the warm surface to drive a low temperature turbine. This technology (Ocean Thermal Energy – OTE) has been a potential technology for a considerable number of years without achieving commerciality. Nonetheless the economic and environmental circumstances today probably favour it more than in the past, and there are reports that it is imminent. It certainly merits serious consideration and some extensive due diligence.

Compressed Air Energy Storage

Although this is not an energy generating technology it is a potentially crucial energy storage technology which would also make use of the very close deep water off the coast of Malé.

Compressed air energy storage (CAES) operates by using surplus energy at times when it is available to compress air, and inject it into a vast lightweight (made of fabric) balloon parked on the sea floor at depth. The water depth retains the air without putting any stress on the balloon fabric, and ensures that the pressure is maintained constant as the balloon is emptied. Energy recovery is achieved by bringing the air back to surface through a turbine.

A further detail is that the heat produced during compression can be stored in molten salts or solids such as concrete, and used to re-warm the air which will cool as it passes out through the power generating turbines.

Energy storage is the issue that prevents wind delivering more than around 20-30% of total energy used, and makes solar expensive also. CAES offers the promise of reducing the costs of energy delivered from storage by an order of magnitude, and allowing very long term (i.e. seasonal) storage of energy.

Studies Done to Date – Biomass

Background

The key non-indigenous resource possibility is biomass. Biomass energy is currently half the cost of diesel, and can be used in a power station almost as efficiently. It requires more capital than a diesel plant, but the savings in fuel cost make it an exceptionally attractive option. This is helped by the possibility of building a power station directly adjacent to a deep water channel, by reclaiming some land on a lagoon. Although this would take a little more land mass than a diesel plant, it is considerable less than wind or solar.

Biomass also has the advantage that it is a baseload plant which can be used to load follow – albeit at a penalty in energy efficiency. This makes it an extremely attractive component of the Malé area energy mix.

Considerable modelling work has been done on a biomass plant, supplemented by some price information on fuel, and a report by a biomass power expert on worldwide experience and the options for Malé.

Fuel Supply

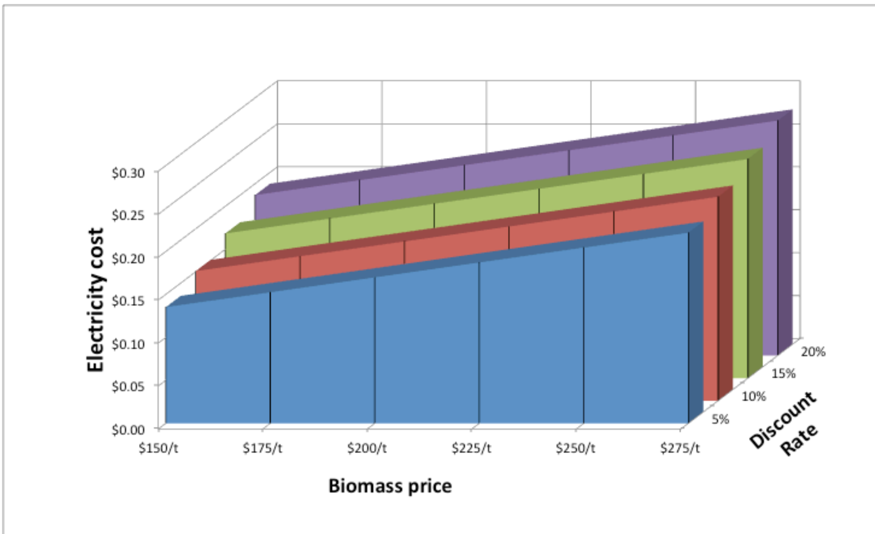
The Maldives has very little potential for indigenous biomass as a result of its limited land mass and the low fertility of its coral soils. There are perhaps 2-5MW in total, though this has not been verified.

Fuel would have therefore to be imported. As a 'worst case' position an indicative fuel supply quotation was obtained from a subsidiary of Archer Daniels Midland – one of the world's largest agricultural commodities traders. The basis was pellets, delivered from Canada, from a sustainable source of supply for a 5 year fixed price.

In reality, Asian or South African sources of wood chip would offer a much lower cost fuel.

Economics

The spreadsheet extract overleaf illustrates the economic model used to determine the cost of electricity from biomass. The results are summarised in the following graph.



Choose scenario=>	Small plant + pellets	Small plant + chip	Small plant + pellets	Large plant + chip	Large plant + pellets	Cheap small plant + chip	Cheap large plant + chip
		Scenarios					
Capital Cost/MW	$ 2,166,667	$ 2,166,667	$ 2,166,667	$ 2,166,667	$ 2,166,667	$ 1,500,000	$ 1,500,000
Biomass Terminal & handling	$ 15,000,000	$ 15,000,000	$ 15,000,000	$ 15,000,000	$ 15,000,000	$ 15,000,000	$ 15,000,000
Subsea cable cost	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Size of power station MW	24	24	24	45	45	24	40
Utilisation factor	85%	85%	85%	85%	85%	85%	85%
Efficiency	30%	30%	30%	31%	31%	25%	25%
Biomass price (index linked)	$ 240	$ 150	$ 240	$ 150	$ 240	$ 150	$ 150
Moisture content	10%	30%	10%	30%	10%	30%	30%
Electricity price to Stelco (index linked)	$ 0.24	$ 0.24	$ 0.24	$ 0.24	$ 0.24	$ 0.24	$ 0.24
IRR over 30 years	**17.53%**	**over inflation**					

Inflation Rate	0.00%	
CV of biomass per ODT	19.5	GJ/odt
LHV of water	2.4	GJ/t
O&M	2%	of capital cost
Management & Labour	$ 100,000	
CV/tonne biomass	17.31	GJ
Cost/GJ	**$ 13.86**	
Capital Cost	**$ -67,000,000**	
Fuel cost	**$ 166.38**	**per MWh**
Annual Costs		
Annual generation	176,256	MWh
Fuel cost	$ 29,325,088	
O&M	$ 1,040,000	
Management & Labour	$ 100,000	
TOTAL COST	$ 30,465,088	
Operating cost of electricity	**$ 172.85**	**per MWh**
Annual biomass required	**122,188**	**tonnes/year**

Instructions for use

Blue numbers on a yellow background are inputs that may be changed by the user.

Blue text on the white background is a selection the user makes from the drop down menu that will appear when you enter the cell.

Set the data you want for each scenario in the table above (note - you can change the names of the scenarios in each column if you wish).

Select the scenario you wish to analyse by choosing from the list in B1. If you have changed the scenario names in the columns this will automatically appear in the dropdown list. The data for that scenario will automatically be transferred to column B, and the IRR will appear below the data (cell B11).

The worksheet is locked to prevent inadvertent changes. If you want to

	Construction Year	Y1	Y2	Y3	Y4	Y5	Y6
Revenue Stream	$ -	$ 42,301,440	$ 42,301,440	$ 42,301,440	$ 42,301,440	$ 42,301,440	$ 42,301,440
Cash Costs (Capex + Opex)	$ -67,000,000	$ -30,465,088	$ -30,465,088	$ -30,465,088	$ -30,465,088	$ -30,465,088	$ -30,465,088
Cash Flow	$ -67,000,000	$ 11,836,352	$ 11,836,352	$ 11,836,352	$ 11,836,352	$ 11,836,352	$ 11,836,352

Pellets from Canada have been chosen as the fuel in the illustration and graph above. This is more or less the most expensive fuel that could be found for the Maldives, and demonstrates that extremely attractive IRRs are available to incoming investors – which can be complemented by guarantees provided through SREP funding.

ANALYSIS

Clearly biomass is attractive, though it does expose the nation to fuel costs beyond the life of any fixed price contract. On the other hand the rates of return are such that an investment could be structured around a relatively short contract (7 years?) followed by a buyout by the Utility which would allow the plant to be switched from baseload to load following. This would be attractive if, by then, energy storage costs have declined to the point that solar and wind energy, or alternatively OTE, displace biomass on the cost curve.

There are a number of alternatives however. These range from including waiting for OTE, or using a mix of wind and solar in anticipation of energy storage costs coming down, to detailed investigation of CAES potential and even a re-assessment of tidal or current flows between lagoons.

It is proposed, therefore, that the first stage of a Malé baseload RE plan will be to conduct a full investigation of the alternatives, in order to develop a ranked hierarchy of options compared to biomass – which will serve as a baseline. This will need to be integrated with a proposed planning exercise for Malé region which will examine issues such as land allocation, power and water distribution, and waste flows.

Based upon this study biomass or its better alternative will be developed as the proposed Malé baseload plant to be supported under SREP.

PLAN

The plan assumes a biomass base case. Alternative solutions will be used if they prove to be more economically and strategically attractive. All costs and other data are therefore premised on biomass as the worst case.

The biomass plant is assumed for the purposes of this analysis to be a 24MW plant, but it will be whatever size is deemed most suitable from the pre-feasibility analysis. The likely size will be bigger, but this has no impact on the preparatory costs, and the improved economics will create space to accommodate any additional support needs. Preparation of the Malé energy plan, pre-feasibility study, tender documentation etc. is covered under the T/A task.

SUB-COMPONENT 1 – CONSTRUCTION

Construction will be by a private sector developer under a 'Build Own Operate Transfer' (BOOT) agreement. Land will have to be allocated by the GOM, for plant construction and to land and store fuel.

IMPLEMENTING AGENCY

The implementing agency will be STELCO, with support form METSU and MESCO.

FUNDING

Plant costs are anticipated to be of the order of $52M, with a further $15M presumed for land reclamation and the unloading facilities. Of this, it is anticipated that IFC will lend $20M and the private sector developer will provide $47M.

OUTCOMES

The following outcomes are anticipated:

- 24MW of baseload power being generated from renewable energy
- ±12M litres per year of diesel saving
- Net emissions reductions (after accounting for transport) of 2.2M tonnes of CO2 over the project life.
- Electricity supplied at a lower cost to STELCO than the current marginal cost of generation from diesel, creating an anticipated budget saving of $5 million per year.

LEAD AGENCY

IFC/PSOD

SUB-COMPONENT 2 – GRID REINFORCEMENT AND CONNECTION

Although there is a contract in place to connect the islands of the Greater Malé Area with a 132kV line with ample capacity for anticipated future growth, the contract does not anticipate the provision of a baseload facility such as is proposed here. This facility may also be sited, for reasons of site availability and demand patterns, at the end of the grid furthest from existing planned generation facilities.

All power stations require some amendment of the grid locally to accommodate the power inputs. In the case of Malé this may be more than simply providing transformers and a connection point. Some local grid reinforcement may therefore be necessary, coupled with modest changes to ensure the grid is maintained within statutory and operational limits and that controls are integrated.

Implementing Agency

The implementing agency will be STELCO, with support form METSU and MESCO.

Funding

A provision of $2.5M has been made for this work. This is anticipated to be provided by the SREP programme

Outcomes

The sole outcome of this sub-component will be to enable the safe interconnection of the new private biomass power station with the STELCO grid.

Lead Agency

ADB

Sub-component 3 – Guarantee Instruments

In order to reduce the cost of capital, and increase the range of developers wishing to compete to develop and operate the power plant, the decision has been taken to allocate a substantial component of the effort and funds available to reduce the sovereign, currency convertibility and counterparty risks. The risk instruments will be by negotiation, but it is expected that they will comprise a mix of PRG, MIGA, and a sum set aside to use to cover first loss. This of course will be recyclable once an appropriate period has elapsed.

Implementing Agency

MESCO will be instrumental in working with STELCO, the IFC, PSOD and the WB to develop the instruments. Actual implementation will be through the Ministry of Finance and Trade.

Funding

A total of $12.5M has been set aside for this purpose. $3.0M is expected to come from the WB IDA allocation, $8M will be set aside from the SREP grant, and the remaining $1.5M will come from GOM funds – largely from savings arising from the lower cost of power.

Outcomes

The availability of guarantee instruments will allow a wider range of bidders to participate in the tender, and allow the winning bidder to accept a lower cost of capital. Each 1% reduction in the cost of capital is worth an annual sum of $650k. The difference between a risk covered contract and one where the risk is not covered may be as much as 5% or more, or $3.25M over the five year life of the SREP project, and over $15M over the life of the power station. However as time passes the insured risk will decrease, and the first loss sum 'set aside' will be released.

When the first loss sum is released it will be recycled into further investments to reduce emissions.

Lead Agency

World Bank

APPENDIX 8 - TECHNICAL ASSISTANCE CONCEPT NOTE

NEW INSTITUTIONS

The GOM has determined that it will create three new institutions to enable it to meet its carbon neutral goals. These are the Renewable Energy Investment Office (REIO), the Maldives Energy Services Company (MESCO) and the Maldives Energy Technology Support Unit (METSU). In addition it is strengthening substantially the Maldives Energy Authority (MEA) as regulator of the sector.

The overarching reason for the new institutions is that the level of technical and commercial innovation needed, and the level of cross departmental co-ordination required, is unprecedented for a country as small and with as limited human resources as the Maldives. The new institutions are designed to centralise resources, and deliver the economies of scale that cannot be achieved by the separate utilities acting alone.

REIO

The Renewable Energy Investment Office is a new policy development unit of government. It is chaired by the Minister of Economic Development, and its governing body includes the Minister of Finance and the Minister of Housing and Environment. It will help to bring a common outlook across the three ministries, and ensure policy development is co-ordinated and implemented consistently

METSU

The Maldives is embarking on a very bold strategy of near total decarbonisation by 2020. This cannot simply be done by buying technology under contract. Many aspects of the challenge are not well understood. In particular, whilst it is not overly difficult to install large amounts of renewable energy, doing so in the most cost effective way is critical to ensuring that RE joins the economic mainstream, and becomes independent of on-going subsidy. The complexity increases when dealing with very small grids, because the operating characteristics of specific units (types of PV and models of wind turbine) make a significant difference to overall out-turn costs[14].

Additional issues arise with factors such as corrosion which can make supplier warranties difficult to achieve for, for example, solar plant over salt water.

METSU has a mandate to cover 8 separate work streams, ranging from cooking, to building efficiency, to marine transport. These are all aspects that need to be addressed if the Maldives is to achieve its goal. The solar, wind and energy storage work streams are particularly relevant to the successful outcomes of the projects outlined here.

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[14] As a simple example of the issues, whilst buying RE at low levels of penetration under a feed in tariff is straightforward, matters become massively more complex when there are two technologies (wind and solar) that interact with each other and with both storage and demand. It becomes necessary to manage accurately the installed balance of wind, solar, battery and electricity demand to ensure that consumer bills do not rise as utilities are forced to buy power they don't need, or to store power they need at a different time of day. As an example, consider what happens when the wind is blowing, and the sun is shining, and there is more power than is needed. How does the Utility operate in these circumstances – how can it establish what would have been generated if it were in a position to use the power, and how does it manage FIT contracts which give it an obligation to take all power? If legacy contracts exist for, say 25 years, these may also constrain its ability to operate in the most cost effective manner

MESCO

Until recently the Maldives had numerous independent generators covering the islands. These have now been coalesced into the seven utilities which cover almost all the inhabited (i.e. not resort) islands. Resorts are still fully independent.

The utilities therefore are new, have little technical or commercial experience, and no experience in the complex arena of renewable energy. Furthermore, the utilities are all small, so none of them is able to benefit from economies of scale.

MESCO's key role therefore is to remedy these problems, by being aggregator of projects, and a single source of commercial advice and support. MESCO will also play a crucial role in introducing the new equipment into utilities, by buying and onward leasing productive equipment (generators, solar PV etc) to utilities. This will allow MESCO to benefit from the economies of scale that come from supplying and supporting common equipment across a range of sites, whilst ensuring that the utilities gain the benefit of being able to access the new equipment without the complication of buying and supporting it.

TASK COMPONENTS

SUB-COMPONENT 1 –DATA COLLECTION

There is no consistent, reliable, publicly owned, data set of wind and solar resources across the islands. Studies consistently indicate that it will be a careful exploitation of the interplay between these resources that minimises the cost of RE. To achieve this the resources need to be measures at each site simultaneously to allow the statistical relationship between them to be extracted and exploited.

Additional data is needed about patterns of energy use and loss, and opportunities to reduce, in particular night time, energy in ways that allow energy storage requirements to be minimised.

IMPLEMENTING AGENCY

This will be implemented by METSU

FUNDING

$1 million have been allocated to this. $700k is to come from SREP and the balance will come from the GOM.

OUTCOMES

This task is critical to ensuring the lowest cost energy supply system for the Maldives.

LEAD AGENCY

ADB

SUB-COMPONENT 2 – INSTITUTION BUILDING

The MEA exists but has significant capacity constraints. The other institutions are new. REIO will be funded internally by the GOM, with support from GIZ. It is proposed that METSU and MESCO be staffed initially by a combination of local Maldivian staff, international consultants under long term contracts to supply both skills and training, and academic staff from international universities able to contribute both to the investigation and evaluation of novel solutions to the Maldives carbon neutral challenge, and also to offer world class training and educational opportunities to Maldivians. Over the coming 3-5 years the emphasis would move from consultants to national staff, though in a nation of only 350,000 people some reliance on international staff will be inevitable.

Implementing Agency
This will be implemented by REIO

Funding
$1.9 million have been allocated to this; $1.0m from SREP funding and a further $900k from the ADB and associated sources of which $400k has been allocated to MEA.

Outcomes
This task is critical to ensuring the lowest cost energy supply system for the Maldives, and that the RE project is sustainable for the indefinite future.

Lead Agency
World Bank/ADB

Sub-component 3 – Other T/A
Mobilising the level of funds that will be needed to deliver a carbon neutral Maldives will require a substantial effort. The tasks will range preparation and evaluation of tender documents, negotiations, compliance with MDB procurement procedures, through to marketing the attractiveness of the Maldives as an investment destination for RE entrepreneurs. They include the comparative evaluation of the Malé Baseload alternatives.

Implementing Agency
This will be implemented by MESCO with technical work by METSU.

Funding
$1.4 million have been allocated to this; $500k from the GOM, $500k from SREP and a further $400k from the ADB.

Outcomes
This task is critical to ensuring the lowest cost energy supply system for the Maldives, and that the RE project is sustainable for the indefinite future.

Lead Agency
ADB/WB

APPENDIX 9- REQUEST FOR FUNDING

T/A WIND AND SOLAR MAST NETWORK

SREP PROGRAM **Project/Program Preparation Grant Request**			
1. **Country/Region**:	Maldives	2. **CIF Project ID#**:	(Trustee will assign ID)
3. **Project Title:**	*T/A component; wind and solar data collection*		
4. **Tentative SREP Funding Request (in US million total) for Project at the time of Investment Plan submission (concept stage)**::	*Grant:* $700,000	*Loan:*	
5. **Preparation Grant Request (in USD):**		*MDB: ADB*	
6. **National Project Focal Point**:	Yusuf Riza		
7. **National Implementing Agency (project/program):**	Renewable Energy Investment Office		
8. **MDB SREP Focal Point and Project/Program Task Team Leader (TTL)**:	Jiwan Acharya	Len George	

9. **Description of activities covered by the preparation grant:** The grant will be used to construct a national network of wind and solar data collection stations that will allow the optimization of wind, solar and energy storage components of the island power systems. Wind data will be collected at a range of heights up to ±50m, and solar data will include direct and diffuse radiation, and radiation reflected of lagoon surfaces. A proportion of the funds will be allocated to data collection, monitoring and analysis.

10. **Outputs:**

Deliverable	**Timeline**
Network of masts and solar measuring stations covering the country in a representative fashion	12 months from approval
Real time data collection and distribution	12 months from approval
Model interface to HOMER or similar RE systems optimization model to allow statistical assessment and optimization of RE components for all islands.	12 months from approval

11. **Budget (indicative):**

Expenditures	**Amount (USD) -** estimates
Consultants	$50,000
Equipment	$400,000 including installation
Workshops/seminars	

Travel/transportation	$100,000 to cover freight and inter-island transport
Others (admin costs/operational costs)	$100,000 to include 3 years real time data collection and analysis
Contingencies (max. 10%)	$50,000
Total Cost	**$700,000**
Other contributions:	
• Government	$0
• MDB	$0
• Private Sector	$0
• Others (please specify)	
12. **Timeframe** (tentative) 12 months from approval	
13. **Other Partners involved in project design and implementation**: None	
14. **If applicable, explanation for why the grant is MDB executed:**	
15. **Implementation Arrangements** (incl. procurement of goods and services)**:** Tender to design and construct a network of meteorological masts across the country to collect simultaneous solar and wind data to a GoM specification, suitable for island power planning. Standard ADB procurement guidelines will apply. A government officer (or a consultant hired for this purpose) will be trained on ADB procurement guidelines to ensure adequate capacity and adherence to them.	

MALÉ BASELOAD POWER PROJECT: T/A PRE-FEASIBILITY STUDY AND TENDER PREPARATION

<table>
<tr><td colspan="4">SREP PROGRAM
Project/Program Preparation Grant Request</td></tr>
<tr><td>16. Country/Region:</td><td>Maldives</td><td>17. CIF Project ID#:</td><td>(Trustee will assign ID)</td></tr>
<tr><td>18. Project Title:</td><td colspan="3">Malé Baseload Power Project: T/A component; Malé region assessment of resource options and economics, pre-feasibility study and tender preparation</td></tr>
<tr><td>19. Tentative SREP Funding Request (in US million total) for Project at the time of Investment Plan submission (concept stage)::</td><td>Grant: $500,000</td><td colspan="2">Loan:</td></tr>
<tr><td>20. Preparation Grant Request (in USD):</td><td></td><td colspan="2">MDB: WB</td></tr>
<tr><td>21. National Project Focal Point:</td><td colspan="3">Yusuf Riza</td></tr>
<tr><td>22. National Implementing Agency (project/program):</td><td colspan="3">Renewable Energy Investment Office</td></tr>
<tr><td>23. MDB SREP Focal Point and Project/Program Task Team Leader (TTL):</td><td>Gevorg Sargsyan</td><td colspan="2">Abdulaziz Faghi</td></tr>
<tr><td colspan="4">24. Description of activities covered by the preparation grant: The grant will be used to carry out an economic and technical analysis of the RE options available to the Greater Malé area, given the geographical, marine, geological and demographic constraints, and Malé area development plans. Following that the results will be presented to stakeholders, and the outcome of this process will be a decision on the most appropriate plan and technology for a baseload power facility in the Malé region. This decision will be used to develop a tender for the construction of the agreed power plant on a ‘Build, Own Operate and Transfer’ basis, or such other basis as is deemed more suitable following the study. Bids will be evaluated and a suitable qualified bidder selected.</td></tr>
<tr><td colspan="4">25. Outputs:</td></tr>
<tr><td colspan="2">Deliverable</td><td colspan="2">Timeline</td></tr>
<tr><td colspan="2">Report setting out the options, their economic and environmental consequences, and the risks they present.</td><td colspan="2">6 months from approval</td></tr>
<tr><td colspan="2">Workshop to present the results to stakeholders</td><td colspan="2">1 month from completion of the report</td></tr>
<tr><td colspan="2">Development of tender document and invitations to bid.</td><td colspan="2">2 months from stakeholder consultation</td></tr>
<tr><td colspan="2">Promotion of opportunity to potential bidders to solicit maximum interest and competition</td><td colspan="2">3 months from stakeholder consultation</td></tr>
<tr><td colspan="2">Invitation to tender</td><td colspan="2">3 months from stakeholder consultation</td></tr>
</table>

Selection of best bids	6 months from stakeholder consultation
26. **Budget (indicative):**	
Expenditures	**Amount (USD) -** estimates
Consultants	$450,000
Equipment	
Workshops/seminars	$10,000
Travel/transportation	$40,000
Others (admin costs/operational costs)	$20,000
Contingencies (max. 10%)	$50,000
Total Cost	**$570,000**
Other contributions:	
• Government	$70,000 in kind and time of GoM advisors
• MDB	$0
• Private Sector	$0
• Others (please specify)	
27. **Timeframe** (tentative) 13 months from approval	
28. **Other Partners involved in project design and implementation**: STELCO (the relevant Utility); Private Sector generators in the Greater Malé area; Malé municipality	
29. **If applicable, explanation for why the grant is MDB executed:**	
Implementation Arrangements (incl. procurement of goods and services)**:** Tender to provide the service. Standard WB procurement guidelines will apply. A government officer (or a consultant hired for this purpose) will be trained on WB procurement guidelines to ensure adequate capacity and adherence to them.	