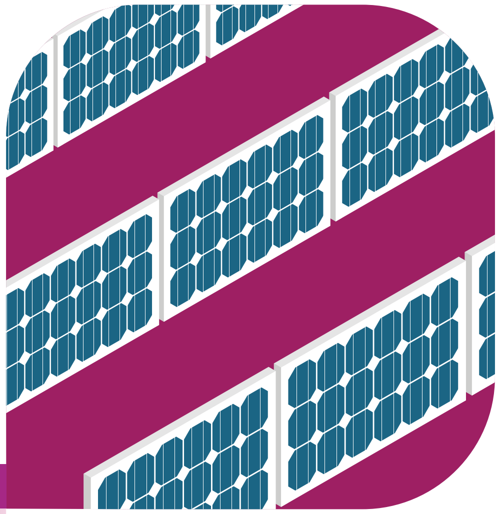
THE REPUBLIC OF MARSHALL ISLANDS

RENEWABLES READINESS ASSESSMENT



June 2015

About IRENA

The International Renewable Energy Agency (IRENA) is an intergovernmental organisation that supports countries in their transition to a sustainable energy future, and serves as the principal platform for international cooperation, a centre of excellence, and a repository of policy, technology, resource and financial knowledge on renewable energy. IRENA promotes the widespread adoption and sustainable use of all forms of renewable energy, including bioenergy, geothermal, hydropower, ocean, solar and wind energy, in the pursuit of sustainable development, energy access, energy security and low-carbon economic growth and prosperity.

Acknowledgements

A special thanks for their generous assistance in preparing the Renewables Readiness Assessment goes to Angeline Heine, Walter Myazoe Jr., Steve Wakefield, David Utter and David Paul as well as the many people who agreed to be interviewed by the facilitator or took part in the discussions during the RRA workshop held in Majuro.

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REPUBLIC OF MARSHALL ISLANDS

RENEWABLES READINESS ASSESSMENT

FOREWORD

from the Minister of Resources and Development

Renewable energy is the future of clean energy and the bona fide alternative to fossil fuels. It will be essential to reduce poverty, improve health conditions, safeguard the environment and stimulate socio-economic development. Such a future, however, is not preordained. It must be strategically supported by a framework that is sustainable, affordable and accessible to all.

In 2008, the Marshall Islands experienced unprecedented increases in the costs of imported petroleum fuel and staple-food items. The global price surge forced our government to declare a state of economic emergency, with the nation no longer able to pay for the imported diesel required to generate power. This led to the endorsement of the 2009 National Energy Policy, along with the Energy Action Plan, which aims for "an improved quality of life for the people of the Marshall Islands through clean, reliable, affordable, accessible, environmentally appropriate and sustainable energy services."

This energy mandate is consistent with "Vision 2018", the Marshall Islands Strategic Economic Development Plan for 2003-2018. Together, these have motivated our government in pursuing renewable energy development.

More than 95% of our remote, outer island communities, spread out over a million square kilometers in the Pacific Ocean, now have access to clean energy through stand-alone photovoltaic systems. We intend to introduce an additional 1 megawatt of solar energy in our urban centers, reducing our dependence on fossil fuels by a further 20%. We could potentially go further by improving grid stability, reducing transmission losses and maximising energy efficiency.

This Renewables Readiness Assessment (RRA) is instrumental, as it complements the National Energy Policy and the Energy Action Plan. It identifies specific missing links that must be addressed and essential actions to improve and sustain renewable energy services in the country. Such gaps and remedies were highlighted by energy stakeholders from the government, private sector and civil society who took part in the preparatory consultations and dialogues.

Along with helping realise our national energy vision, the RRA supports Green Energy Micronesia, a sub-regional initiative that aims to reduce fossil fuel imports 20%, increase energy efficiency 30%, and increase renewable energy use 20% by 2020.

On behalf of the government and people of the Marshall Islands, I wish to join others around the world in congratulating Mr. Adnan Amin on his reappointment as Director-General of the International Renewable Energy Agency (IRENA). In addition, I extend my heartfelt appreciation and gratitude to IRENA for initiating this important activity and developing the RRA report for the Marshall Islands.

The Marshall Islands fully supports the IRENA mandate and will continue to join other countries in our global effort to promote renewable energy.

Honorable Michael Konelios
Minister of Resources and Development
Republic of the Marshall Islands

FOREWORD
from the IRENA Director-General

Across the Pacific, small island states face daunting costs for fuel imports and recurrent risk from global oil price volatility. The Republic of the Marshall Islands has resolved to improve its energy security and contribute to combatting climate change based on a balanced portfolio of indigenous renewable energy resources.

The country's Renewables Readiness Assessment (RRA), undertaken in co-operation with the International Renewable Energy Agency (IRENA), has produced a holistic evaluation of the current condition of the sector and identified key actions that can be taken to overcome barriers to increased renewable energy deployment. This is a country-led process, with IRENA providing technical support and expertise to facilitate consultations among different national stakeholders.

Since 2011, more than 20 countries in Africa, the Middle East, Latin America and the Caribbean, and the Asia-Pacific region have undertaken the RRA process, which generates knowledge of best practices and supports international co-operation towards the accelerated deployment of renewable energy technologies. The Marshall Islands, a strong and consistent supporter of IRENA's mission, is one of those countries.

To develop grid-connected renewable power, the country will need a well-articulated action plan, including provisions for financing and training. For off-grid systems, the key challenge remains the sustainability of operation and maintenance, particularly with solar photovoltaics (PV). Each outer island will need the institutional framework for rural electrification, as well as training programmes to deliver expertise to villagers assigned to maintenance.

- Converting existing diesel-powered mini-grids to solar PV can help to address the serious problem of fuel-drum leakage on outer islands. In addition, coconut oil – a plentiful, indigenous Pacific bioenergy source – could be expressed from freshly harvested copra at small-scale local production mills.

IRENA wishes to thank the Honorable Michael Konelios and his energy planning team at the Ministry of Resources and Development for their strong and valuable support. Their extraordinary contribution is much appreciated as we work towards facilitating further RRAs in the Pacific and beyond.

I sincerely hope that the outcomes of the consultations will strengthen the Marshall Islands' pursuit of accelerated renewable energy deployment. IRENA stands ready to provide continuing support in implementing the actions identified, as the country strives to progress toward a sustainable energy future.

Adnan Z. Amin
Director-General, IRENA

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ABBREVIATIONS

ADB	Asian Development Bank
ADMIRE	Action for the Development of Marshall Islands Renewable Energies
EU	European Union
GDP	Gross domestic product
IRENA	International Renewable Energy Agency
JICA	Japan International Co-operation Agency
KAJUR	Kwajalein Atoll Joint Utility Resources
kWh	kilowatt-hour
kWp	kilowatt-peak
LPG	Liquid Petroleum Gas
MEC	The Marshalls Energy Company
MRD	Ministry of Resources and Development
t	tonne (metric)
MW	Megawatt
MWh	Megawatt-hour
OTEC	ocean thermal energy conversion
O&M	Operation and Maintenance
PV	Photovoltaic
RMI	Republic of the Marshall Islands
RRA	Renewables Readiness Assessment
SEIAPI	Sustainable Energy Industry Association of the Pacific Islands
SPC	Secretariat of the Pacific Community
Wp	Watt-peak

EXECUTIVE SUMMARY

Since independence, the Republic of the Marshall Islands (RMI) has been heavily reliant on external assistance, with grants averaging 60% of gross domestic product (GDP). Like other island nations in the Pacific, the RMI suffers from high and volatile fuel prices while lacking any known fossil fuel reserves of its own.

Following a major fuel price spike in July 2008, the RMI Government declared a state of economic emergency. This rapidly drew increasing attention to the scale-up of renewable energy as a fossil fuel replacement. Thus far, the emphasis has been mainly on solar — a familiar technology in the RMI. There are thousands of solar installations on households in the outer islands. The wind resource is under evaluation but no generation trials have yet taken place. In addition, the use of coconut oil as a power generation and transport fuel is being seriously considered. Tobolar, the coconut mill owned by the government, has conducted pilot projects, while electricity generation trials using coconut oil as a fuel are planned by the Marshalls Energy Company (MEC), one of the key utilities.

To help progress towards large-scale use of solar or wind energy on the grid, MEC and the Kwajalein Atoll Joint Utility Resources (KAJUR) need to analyse and predict the effect of connecting large amounts of highly variable solar and wind generation at various points on their grids.

The National Energy Policy approved in 2009 is under review at the time of this report. The aim is to assess the actions currently appropriate to implement the policy, and to consider whether amendments to the policy are needed. Many of the actions proposed at the time the National Energy Policy was adopted have been initiated, and substantial progress has been made in reaching the targets set in the policy. Given technological advancements, and especially the greatly reduced production cost of solar photovoltaics, the review aims to modify these actions and initiate a new round over the next five years.

Given this background, a comprehensive study has been completed known as an Renewables Readiness Assessment (RRA). This was carried out under the leadership of the Energy Planning Division at the Ministry of Resources and Development (MRD) in close collaboration with the International Renewable Energy Agency (IRENA).

Marshall Islands hospital with PV panels
Photo: H. Wade

The aims of the RRA process are outlined as follows:

- Improve the understanding of the present status of renewable energy development in the RMI by conducting a comprehensive review of the energy sector.
- Identify and analyse the key gaps in the 2009 National Energy Policy associated with developing and utilising renewable energy resources.
- Formulate actions to close the policy gaps while scaling up renewable energy development and deployment.
- Develop a portfolio of actionable initiatives that will exploit the renewable energy development opportunities revealed by examining the renewable energy subsectors and through extensive discussions with multiple stakeholders. The portfolio should be jointly developed by participating stakeholders.

The RRA study has identified key challenges that have to be addressed to scale up renewable energy in the RMI. Recommended actions have been communicated to the RMI Government in collaboration with development partners.

The recommendations listed are as follows:

1. To address the challenge of legislation and institutional co-ordination, two actions have been proposed:

    a. Review existing acts relating to energy, and enact enabling legislation to create a national energy agency; legislate the responsibility and authority needed to establish and enforce standards for renewable energy systems generating electricity for public use.

    b. Establish an energy working committee. This would co-ordinate renewable energy implementation and review any national design standards proposed for renewable energy installations. It would propose training programmes supporting renewable energy development available at the College of the Marshall Islands or other educational institutions, and serve as a forum on renewable energy in the RMI.

2. An articulated action plan using a systems approach should be adopted for grid-connected renewables development. The following actions should be taken:

    a. Prepare a dynamic computer model of the grid to help MEC predict the effect of individual on-grid photovoltaic (PV) systems on the power quality of feeders and low voltage distribution lines.

    b. Develop and enforce standardised technical design, installation and interconnection requirements.

    c. Design workable financing schemes following the model in Palau.

    d. Design effective capacity building programmes and also roll them out by training trainers. The training programme should be designed to meet local needs.

3. The key challenges facing off-grid renewable energy still relate to long-term operation and maintenance (O&M). A customised approach is therefore recommended to ensure sustainable O&M through actions including the following:

    a. Conduct a comprehensive survey of factors causing the failure of sustainable O&M (particularly for solar PV systems), and develop a remediation plan.

    b. Develop an institutional arrangement for rural electrification to ensure it suitable for each individual outer island and sustainable in long-term operation.

    c. Deliver training programmes using local knowledge and language to provide know-how in ways that can be understood by local villagers assigned with maintenance.

    d. Develop and enforce design and installation standards for off-grid installations.

4. Fuel drum leakage has been a serious problem for outer islands. Existing diesel powered mini-grids need to be converted to solar PV systems to eliminate this problem. Outer island diesel -to-solar energy conversions in other Pacific island countries need to be studied and followed by similar programme preparations for the RMI.

5. Coconut oil looks promising if concerns about its supply, quality and price can be successfully addressed. It may be worth further exploring the solution provided by small-scale on-site coconut oil production capacity. This allows coconut oil to be extracted using small mills on site where the copra is harvested and still fresh.

The key challenges and the recommended actions both emerged from consultations with the widest possible range of stakeholders on renewable energy in the RMI. However, the RRA only provides a snapshot of the situation, with the recommendations being those considered important at the time it is completed. Nevertheless, effectively carrying out these recommendations would improve the country's energy readiness to increase renewable energy use. This would help realise a sustainable energy future for the RMI.

It is necessary to convert the recommended actions into practical projects. Discussions on this took place during and after the RRA workshop. A basic project structure outline was developed assigning specific roles to stakeholders involved, developing lines of activity, estimating a timeframe, and defining key success indicators for monitoring and evaluation. Many of the challenges and recommended actions discussed above should be managed and linked through the range of individual projects. Five activities have been drafted, each identifying the key project concept.

For example:

- Activity 1: Large-scale project to support private investment in on-grid solar both with and without energy storage

- Activity 2: Provide sustainable electricity provide sustainable electricity supply to residents on outer islands supply to residents on outer islands

- Activity 3: Convert outer island diesel grids to solar generation

- Activity 4: Shift coconut oil production from Majuro to the outer islands to lower cost and improve oil quality

- Activity 5: Review the 2009 National Energy Policy and enabling legislation for MEC and a national energy office

The RMI MRD Energy Planning Division should review these project concepts and, using any necessary external support, develop the project concepts into full project proposals to be submitted to development partners for funding.

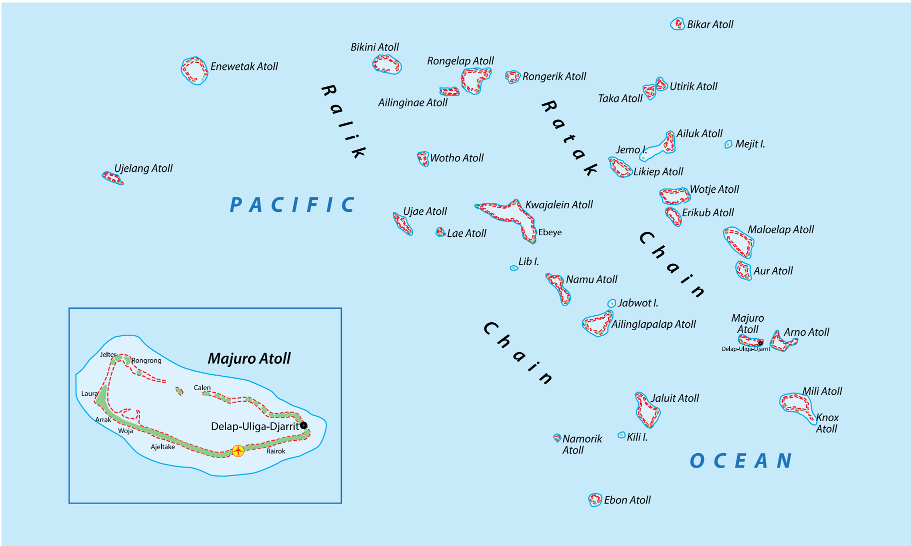
Solar PV street lighting in island community
Photo: H. Wade

I. INTRODUCTION

1.1 COUNTRY BACKGROUND

The Republic of the Marshall Islands (RMI) is in the northern Pacific Ocean and is part of the larger island group of Micronesia, as illustrated in Figure 1. The RMI has built a very close relationship with the United States since 1944, when the US gained military control of the Marshall Islands from Japan. It subsequently provided defence, subsidies and access to social services under a Compact of Free Association that entered into force in 1986.[1] This was amended in 2003 to provide around USD 70 million each year over the period 2004-2024 (US Department of State, 2014).

Figure 1: Geographic location of the Republic of the Marshall Islands



The boundaries and names shown on this map do not imply any official endorsement or acceptance by IRENA.

The RMI consists of two groups of atolls and islands in the Central North Pacific Ocean about 3,200 kilometres (km) away from both Honolulu and Tokyo. Twenty-two of the 29 atolls and four out of the five small raised coral islands are inhabited. The atoll islands are typically several kilometres long and are rarely more than 200 metres (m) in width. The maximum height above sea level of almost all the land is rarely more than 2 m.

The last RMI census, held in 2011, identified 53,158 inhabitants, of which 74% were on two urban atolls: Majuro and Kwajalein. Steady emigration to the US continues to explain the low annual population growth rate. This was estimated at 1.72% in 2014 (Secretariat of the Pacific Community (SPC), 2012).

The islet of Ebeye in the Kwajalein atoll - the primary home for the thousands of local workers at its US military facility - is probably the most densely populated island in the Pacific (Kwajalein Atoll Joint Utility Resources (KAJUR), 2008). The 2011 census counted 9,614 people there per square mile (3,711/km^2) (SPC, 2012).

Majuro is the capital atoll. Many of the small islets that made up the original atoll have been connected by causeways. This makes it in effect a 30 mile (48 km) strip of coral typically less than a quarter of a mile (400 m) wide. Its highest point 30 feet (9 m) above average sea level, and it has an average elevation of around six feet (1.8 m).

[1] www.rmiembassyus.org/RMI-US%20Compact.html

For renewable energy project development, climate is an important factor. The RMI climate is moist and tropical with a wet season from May to November. The annual average temperature is 27°C, typically 30°C maximum during the day and 25°C minimum at night. The relative humidity typically ranges from 76% at midday to 83% at night. Rainfall is 1,000 millimetres (mm) - 1,750 mm (39.4-68.9 inches) in the North and in the South, 3,000 mm - 4,300 mm (118-169.3 inches). Tropical cyclones and droughts are not frequent but do occur, though the cyclones are rarely as intense as those seen further west.

The economy of the RMI is heavily dependent on external assistance, with grants averaging 60% of the gross domestic product (GDP), since independence in 1986 mostly through the Compact of Free Association with the US. However, the Chinese Taipei, European Union (EU) and Japan are major donors too.

In 2012, GDP was estimated[2] at USD 186.9 million, making the per capita GDP about USD 3,516. Grants have averaged 60% of GDP since independence,
Most of the outer island population is a subsistence economy. On the urban atoll of Majuro, the government is by far the largest employer and is heavily dependent on US Compact and development partner inputs. Known as bunkering, imported diesel fuel is resold to foreign fishing fleets operating in the area, providing some export income. Remittances from family members overseas — mostly in the US — are also significant. Income from the US military base on Kwajalein completely supports the Ebeye population.

Like other island countries in the Pacific, the RMI is suffering from high and volatile fossil fuel prices. For this reason, the country has been actively exploring alternative options to fossil fuel imports, particularly by increasing the use of indigenous renewable energy resources.

1.2 RENEWABLES READINESS ASSESSMENT

The RRA methodology developed by the International Renewable Energy Agency (IRENA) is designed to provide a comprehensive assessment of a country's readiness for renewable energy development. After the assessment is completed and concerns clearly identified, the RRA then proposes a series of actions to address the key concerns.

The RMI RRA was requested as part of the 2009 National Energy Policy review. The RRA aims to help enable the RMI to use modern forms of renewable energy to replace or supplement existing conventional energy sources. The multi-stakeholder consultation is part of the RRA process. It brought together representatives from all the energy delivery and energy user groups to discuss the issues and formulate the actions needed to implement and improve the National Energy Policy. A workshop was held in Majuro on 19–21 March 2014 aiming to bring together the principal RMI renewable energy development stakeholders to discuss the key issues identified.

The RRA for the RMI had a number of aims outlined below.

- Improve the understanding of the status of renewable energy development by conducting a comprehensive review of the energy sector.
- Identify and analyse the key gaps in the 2009 National Energy Policy associated with developing and utilising renewable energy resources of the types generally available in the RMI.
- Formulate actions to close the policy gaps while scaling up renewable energy development and deployment.
- Develop a portfolio of actionable initiatives that will exploit the renewable energy development opportunities revealed by examining the renewable energy subsectors and through extensive discussions with multiple stakeholders. The portfolio should be jointly developed by participating stakeholders.

The RRA process was led by the MRD Energy Planning Division in close collaboration with the IRENA RRA team. An issues paper was prepared by the IRENA team to identify the key gaps in energy policy implementation that act as barriers to scaling up renewable energy applications in the RMI. The issues paper also served as a key background document for the discussions that followed.

A number of interviews and follow-up discussions were conducted. They provided an in-depth understanding of the issues discussed at the workshop and explained the different perspectives of the stakeholders. The stakeholders were also asked for further advice on how to address those issues. This process was an important complementary function of the RRA

The RRA study's key findings indicate the country can make great strides in substituting imported fossil fuels with indigenous renewable energy sources.

[2] By the Secretariat of the Pacific Community with the support of the United Nations Economic and Social Commission for Asia and the Pacific and the Forum Secretariat

II. OVERVIEW OF THE ENERGY SECTOR

The RMI has no known fossil fuel reserves though the country is relatively rich in solar and biomass - mainly coconut. Ocean energy sources have potential but have yet to be commercially proven, though development is continuing (IRENA, 2013).

In 2013, 100% of urban households that desired a connection to the grid were connected. This means 89% of households in the RMI has access to electricity, with 26% from off-grid solar and 63% from the grid. Following a rural electrification project due to be completed in 2015, household rural electrification will also reach 100%.[3] The target for non-residential electrification, such as for small rural village health stations and small rural village schools, is 100% by 2020. Only around 30-40 of these small public facilities will lack electricity access once the North-REP (The North Pacific African, Caribbean and Pacific Renewable Energy and Energy Efficiency Project) installations are completed in 2015. This means that overall electrification in the RMI will at that point exceed 99%.

Biomass, mostly coconut fronds, husks and shells, is a significant source of cooking energy. However, liquid petroleum gas (LPG) is now the main cooking fuel on Majuro and is becoming more popular on other islands.

Two electricity utilities operate in the RMI. MEC serves all the islands except for Ebeye in Kwajalein Atoll. Ebeye electricity is provided by KAJUR. Technical standards derived from those used in the US are generally used by all public power systems in the RMI (KAJUR, 2008). In addition, several small grids are run by local governments in the outer islands, and are not chartered as public utilities.

Following near national bankruptcy in 2008, due to the fuel price spike, the government has taken considerable interest in reducing fossil fuel imports by developing cost-effective renewable energy resources. MEC, KAJUR, the College of the Marshall Islands and the University of the South Pacific, all carry out capacity building in support of energy activities.

2.1 PRIMARY ENERGY SUPPLY

Most of the primary energy supply (90%) comes from petroleum, with biomass used for cooking accounting for nearly all the rest. Solar electricity generation is expected to expand rapidly but contributed less than 1% of RMI energy in 2014. Biofuel from coconut oil is also expected to increase in future. At the moment, it makes up a tiny proportion of the national energy balance.

Imported petroleum-based products are gasoline, diesel fuel, dual purpose kerosene (used both as aviation turbine fuel and household kerosene) and LPG. Gasoline and aviation fuel are imported by Mobil. Automotive diesel oil is imported and distributed by MEC, whose large storage facility[4] allows it to import automotive diesel oil at a lower cost than Mobil.[5] MEC is also the sole importer and distributor of LPG, importing 399,391 pounds (180,719 kilogrammes) in 2013.

[3] The target does not include 30 - 40 small schools (mostly single room village pre-schools) and small health centres (tiny single room buildings containing a cot and storage for bandages, antiseptics and pain killers).
[4] A 6.5 million gallon tank facility (24.6 million litres).
[5] MEC sells the diesel fuel to RMI customers, including KAJUR and the Ebeye utility. It uses local vessels chartered to deliver the fuel to Ebeye. MEC is also a major supplier of diesel fuel to fishing fleets in the area, mostly from Pacific Rim countries.

Electricity supply

Electricity is provided mainly by two public sector utilities KAJUR and MEC. KAJUR only serves Ebeye in Kwajalein. MEC operates throughout the rest of the country. Its main grid is on the Majuro atoll, along with a diesel mini-grid on Rongrong islet. Diesel mini-grids on Jaluit and Wotje atolls each serve about 100 homes. As shown in table 1, the Majuro and Ebeye grids have a combined load of 8.8 megawatts (MW), and the small local grids less than 1 MW.

MEC also manages the stand-alone solar installations on all the populated outer islands. Of the grids operational in the RMI, only Majuro has any installed renewable energy capacity. By September 2014, 359 kilowatt-peak (kWp) of solar had been connected to the Majuro grid. Generation from coconut oil is planned, but none is yet on stream.

Table 1: Diesel power grids

Islands	Average load (MW)	Number of households
Majuro	7.0	3 600
Ebeye	1.8	1 200
Wotje	0.08	110
Jaluit	0.09	105
Kili	0.45	110
Others	0.1	
Total capacity (MW)	9.52	5,125

Source: Data from MEC and KAJUR, 2014

MEC was established by charter in 1984 as a government-owned utility. It is responsible for urban and rural power supply, diesel fuel import, storage and bunkering, and rural PV programmes. MEC is the dominant energy supplier in the RMI with a strong role in both policy development and implementation. MEC is overseen by the Joint Utilities Board appointed by the Cabinet, and is chaired by the Minister of Public Works. The board consists of three government and three private sector members.

KAJUR is much smaller than MEC and serves only Ebeye. KAJUR was first owned by the Kwajalein Atoll Development Authority, which was dissolved in 2004. Like MEC, KAJUR is currently supervised by the Joint Utilities Board. The board provides management and technical assistance to both utilities though KAJUR is financially and operationally independent. As Ebeye is the home of many local workers at the US military facility on Kwajalein atoll, the operational losses of KAJUR are met by the US government through grants specifically allocated for Ebeye (US Army Corps of Engineer, 2010; KEMA, 2010). Apart from managing electrical operations, KAJUR also operates Ebeye's water and sewage systems.

Ebeye's grid is very compact, serving only a single islet of 80 acres (32.4 hectares). With around 15,000 inhabitants, it is one of the most densely populated islands in the world. As a result, KAJUR has very short power lines and correspondingly low transmission and distribution losses. It has a relatively level load, and engines that are still efficient. In 2013, the peak load for the Ebeye grid was 2.2 MW. Its total generation was 15,336 megawatt-hours (MWh) and it used 978,376 gallons (3.704 megalitres) of diesel fuel at an average cost of USD 3.99/gallon (USD 1.05/litre). As noted in table 1, the other grids in the RMI are very small, with a combined average load of about 500 kW.

Local governments on several rural atolls, such as Kili, manage mini-grids providing electricity to homes close to local government centres. If requested, MEC will provide technical assistance, at a cost, to support the operation of these diesel mini-grids.

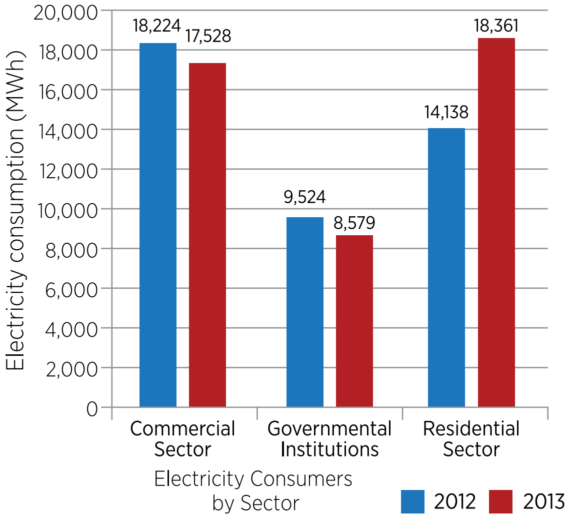
The capital island of Majuro is home to 52% of RMI inhabitants according to the 2011 RMI Census (Economic Policy, Planning and Statistics Office, and Office of the President, 2012). It is composed of numerous small islets connected through causeways, creating a narrow, 30 mile (48 km) long, densely populated strip of low-lying land. The MEC main grid therefore has long transmission and distribution lines extending from its single, centrally located power plant. Those lines are operating at close to capacity and experiencing high transmission and distribution losses.

MEC also uses outdated, heavily de-rated diesel engines to operate close to its available capacity. At present, none of these can be taken off stream for maintenance except at off-peak times. One engine is 60,000 operation hours behind its scheduled service date. Should it break down, rolling blackouts will be necessary at peak load periods. As a result, overall fuel efficiency is not high, and system reliability is also a concern. Although power reliability has improved over the recent years, the system is still operating close to its upper limits, and power outages remain a problem. Periods of rolling blackouts now occur when there are engine problems, and the situation is likely to continue until sufficient capacity can be restored.

A team funded by the Japan International Co-operation Agency (JICA) carried out a detailed study of the Majuro grid with results available from 2015.

In September 2012 - October 2013, the peak load for the main Majuro grid was 8.7 MW. Its generation was 62,437 MWh, of which 228 MWh came from renewable energy (solar) (less than 1%) and the rest from diesel. The utility paid an average of USD 3.28 per gallon (USD 0.87/litre) and used 3.8 million gallons of fuel (14.55 megalitres). At the end of 2013, MEC had 4,598 meters in service, of which 2 819 were prepaid type (mostly residential). Figure 2 shows the estimated sector usage of electricity on Majuro.[6] Unfortunately, only estimates of residential data are available for 2012 and 2013. This is because MEC changed from post-paid to prepaid meters over this time period, and precise kWh data were not available. The apparent increase in residential sales in 2012 - 2013 should, therefore, not be considered an accurate representation of the actual situation.

Figure 2: Electricity consumers by sector on Majuro 2012-2013



Source: Data from MEC, 2014

As shown in table 2, the electricity tariff for early 2014 for residential customers consuming less than 500 kWh per month is USD 0.41/kWh, while those using over 500 kWh per month are charged USD 0.43/kWh. Commercial customers pay USD 0.49/kWh, while government entities are charged USD 0.50/kWh.

Table 2: The 2013 tariff structure

Residential usage 0-500 kWh	USD 0.41/kWh
Residential usage > 500 kWh	USD 0.43/kWh
Commercial usage	USD 0.49/ kWh
Government usage	USD 0.50/kWh

Source: MEC, 2014

These tariffs are the same for all MEC and KAJUR grids. Small grids operated by communities and local governments are not required to charge this national tariff, and their tariffs vary widely. The full cost of electricity delivery is approaching USD 0.50/kWh, so residential tariffs appear to be somewhat below cost. There is no cross-subsidy within the electricity tariff structure, but MEC profits from the sale of diesel fuel are substantial and help offset the electricity sector losses.

On-grid renewable energy sector status

In September 2013, 94% of all electricity generated by grids operated by MEC was from diesel fuel, with solar accounting for about 6%. This ratio continued throughout 2014. KAJUR relies on diesel generation. All renewable energy components on the grid in the RMI were installed after the 2008 fuel price spike that prompted most Pacific island utilities to move quickly to add renewable energy generation sources.

The Majuro distribution system is powered by a single power generation facility with three long, ageing radial transmission lines. MEC has concerns about the effects of unregulated solar energy connection to this relatively fragile grid. As a result, the company has moved cautiously towards adopting grid-connected solar systems that do not include energy storage. So far it has only allowed five grid-connected solar installations without storage. Two 53 kWp and 57 kWp systems are at the College of the Marshall Islands. The others are a 10 kWp system at the fisheries base, a 30 kWp system at the University of the South Pacific campus and a 209 kWp system at Majuro hospital. MEC intends to move cautiously before allowing a major expansion of grid-connected solar generation. This means its staff can gain practical knowledge of how these systems work and their effect on the grid.

[6] MEC changed from post-paid meters to prepaid meters in 2012–2013. During that changeover period, residential data are known to be less accurate than government and commercial sector data, which continue to be generated from standard meters. However, the estimated data are accurate enough to be a good indicator of the relative energy usage among the three sectors.

Although MEC has no significant problems with the 359 kWp of solar PV on the grid, the projects in the pipeline could cause some concern. An 800 kW grid-connected solar installation was proposed by MEC for Majuro funded through a bank loan from the US Export-Import Bank. A 200 kW solar installation for KAJUR on Ebeye is also expected to be funded by a loan. The United Arab Emirates may proceed with its tentative plans to install 500 kWp of on-grid solar at Majuro airport and 200 kWp in Ebeye. If so, the plans for the 800 kW installation for Majuro and the other 200 kW installation at Ebeye may be reconsidered due to concerns about grid instability.

The Ebeye grid is not expected to have a problem with the planned 200 kW of solar to be installed at the existing power plant site. However, to better understand the characteristics of the grid, JICA has been conducted a study of the Majuro grid. This allowed MEC to better predict the effects of more than 1 MW of grid-connected solar.

MEC is actively engaged in developing processes that can increase the renewable energy generation installed by its customers. The reasons for this include its capacity problems and high technical losses. A number of commercial office buildings and residential customers have expressed interest in private, grid-connected solar installations. For example, the US Embassy in Majuro has been seeking MEC approval to add a 7.5 kW rooftop grid-connected solar installation by 2015.

Before opening the grid to a large number of small grid-connected solar installations through net metering or some type of feed-in tariff, MEC has proposed a new computer model. This would help it simulate the effects of adding grid-connected solar in varying amounts at any location. Alongside the JICA survey of the grid, this will provide a technical basis for preparing the MEC policies and interconnection requirements[7] for the PV systems relative to private grid-connected solar power.

With the grid study and model yet to be completed, MEC is encouraging customers to install solar panels with storage batteries. This means they can work off-grid for part or all of their loads. MEC envisages that adding storage to the rooftop solar installations will allow loads to be taken off the grid, thereby reducing peak load and having no effect on grid stability.

There remains an interest in wind power. However, largely as a result of minimal wind resource data and installation experience, the RMI is hesitant to introduce large-scale wind energy systems. The College of the Marshall Islands had planned to install a reef-mounted wind generator for grid connection to complement its rooftop solar. However, it has thus far only put up solar PV installations. One reason for its prudent approach is the unknown effect of wind turbines on marine habitats on the coral reef. These could react to vibrations and low frequency sound that may be transmitted through the footing of the turbines on the reef. The reef ecosystem is an important part of the food supply in Majuro, so a comprehensive environmental impact study is needed.

Off-grid renewable energy

Rural renewable energy installations in the RMI are mostly Solar Home Systems (SHS) as shown in Table 3, in which each household has its own independent solar installation. The SHS typically operates lights, radios, household water pumps and other small appliances off 12 volt batteries charged by the solar panels. In the past decade, these installations have been provided through donors to over 2,000 rural households. Over 1,000 new systems are currently being installed under the EU North-REP project. Most SHS installed recently have 200 Watt-peak (Wp) of solar capacity, sufficient for general lighting and small appliances. Some older installations have a solar capacity of 160 Wp. Namdrik has the oldest operating solar project in the RMI, with just 80 Wp per SHS.

As part of the EU North-REP project, the Namdrik installations were upgraded to 200 Wp in 2014. When the North-REP project is completed, all the outer islands of the RMI will be 100% electrified, of which 37% will be stand-alone solar. The total solar capacity installed on the outer islands is approaching 600 kWp.

The government, through a Memorandum of Understanding with the Ministry of Resources & Development, it has assigned MEC with responsibility for SHS installation and O&M. MEC was initially allowed to set a user fee of USD 12 per month. This allowed full cost recovery including battery replacements and periodic preventive maintenance visits. The fee had to be reduced to USD 5 per month in response to the claims that USD 12 per month is not affordable. This is challenging MEC financial capability for funding the necessary O&M and battery replacements that would soon be required. This is because the first batch of SHS, installed six years ago in more than 1,000 outer island households, may soon experience battery failures. In addition, disposing of spent lead-acid batteries is likely to pose an environmental problem if not properly managed.

[7] The requirements define a minimum set of functions that the system to be installed must provide. This will facilitate the integration of more PV installations.

Table 3: Rural Solar Power Systems - 2014

Location	Number of Installations	Watts	Watts Total
Namdrik	135	200	27 000
Mejit	88/7	160/200	16 480
Wotho	29	230	6 670
Wodmej	42	230	9 660
Ebon	171	160	27 360
Likiep	110	160	17 600
Arno	385	160	61 600
Majuro (Aenkan)	32	160	5 120
Ailinglaplap	450	210	94 500
Aur	80/37	160/200	20 200
Mili	110	160	17 600
Ailuk	90	200	18 000
Lae	47	200	9 400
Lib	29	200	5 800
Maloelap	150	200	30 000
Namu	150	200	30 000
Ujae	71	200	1 420
Jabat	29	200	5 800
Kwajalein-Ebadon	210	200	42 000
Kwajalein-other	84	200	16 800
Jaluit	271	200	54 200
Utrik	4	200	800
Mili	50	200	10 000
TOTAL	2 790		526 590

Source: Data from MEC

In rural schools on Ine, Ebon, Toke, Namdrik, Mejit and Namu, microgrids powered by solar PV systems ranging from 6.17 kWp to 13.26 kWp provide alternating current electric power, as shown in Table 4. Electrification is planned for another ten small schools, each witharound 4 kWp of solar (Energy Planning Division (EPD), 2006). By 2020, it is expected that other 30 small schools and 40 health centres will have solar electrification. This will complete the outer island electrification programme.

However, O&M for mini-grids is daunting for rural electric systems in general. For rural school mini-grid systems, the Ministry of Education pays MEC a per kilowatt-hour fee for electricity supplied, while expecting MEC to maintain the system. The ministry accepts the battery-replacement costs. However, the Service Agreement needs to be revisited and revised. If the Service Agreement is not continued, it would probably result in technical failure especially once the batteries had worn out.

Table 4: Solar for off-grid schools (kW)

Ine, Arno	6.17
Ebon, Ebon	10.71
Toka, Ebon	9.18
Namdrik	13.26
Mejit	9.18
Majkin, Namu	6.17

Source: 2014 data from MEC.
Note: an EU project to add ten more small schools by 2015 with about 4 kW solar power each.

Rural electrification using diesel mini-grids has been challenging. This is partly due to a lack of economically productive activities and partly to the high cost of delivering fuel to the outer islands. To address fuel cost, MEC is interested in following the examples of Tokelau, the Cook Islands and Tuvalu, which have converted outer-island mini-grids to solar power and use existing diesel only for backup. In addition, local municipalities and island governments often operate locally managed mini-grids for public use. Such an approach can reduce generation costs and extend service hours by integrating solar PV capacity into diesel systems.

2.2 RENEWABLE ENERGY SOURCES AND POTENTIAL

Bioenergy

Biomass

Biomass in the RMI mainly consists of coconut husks, shells and fronds with some firewood from mangroves. Biomass still provides a significant part of cooking energy for outer island households. However, it is a limited resource on most atolls, and has been largely replaced by kerosene and LPG for cooking. In general, the biomass resource is not sufficient for power generation by gasification or steam generation on a scale that would be appropriate for utility use.

Biofuel

The RMI is one of the few Pacific island countries that still commercially produces copra and coconut oil for export and local sale. Coconut oil as a biofuel is therefore a significant renewable energy resource in the RMI. Copra, the raw material for making coconut oil, is one of the main income sources for outer island residents. The RMI was a Pacific pioneer in using coconut oil as a biofuel, having carried out trials blending it with diesel fuel for vehicles and using it directly in construction machinery and transport.

Although copra production has varied from a low of 2,653 metric tonnes (t) in 2002 to a high of 7,213 t in 1995, the average annual production of copra for the past 25 years has been 5,020 t. The average for the past five years has been somewhat higher at 5,555 t/year (see table 5).

Solar PV for Jica Freezers
Photo: H. Wade

Table 5: Copra production

Atoll	Annual average (tonne)	
	1985-2010	2005-2010
Ailinglaplap	724	832
Ailuk	94	97
Arno	835	884
Aur	232	238
Ebon	399	429
Erkub	0	1
Jabot	41	59
Jaluit	307	245
Jemo	0	0
Kili	2	11
Kwajalein	20	41
Lae	47	65
Lib	49	73
Likiep	62	94
Majuro	140	164
Maloelap	301	346
Mejit	138	138
Mili	564	628
Namdrik	298	359
Namu	300	355
Rongelap	0	0
Ujae	49	87
Ujelang	0	0
Utirik	75	78
Wotho	29	35
Wotje	317	293
TOTAL	5,020	5,555

Source: Data from Tobolar, 2011

In 1977, the Tobolar Copra Processing Plant was founded as a government-owned copra processing facility. It produced oil, copra cake (a by-product useful for animal feed and fertiliser) and soap as well as selling raw copra on the international market. In 2011, the Ministry of Finance took over operation of the mill to upgrade the facility to produce international quality soap, biofuel quality oil and generally increase coconut oil production.

According to the Tobolar Copra Processing Plant, it takes around 6,000 coconuts to produce a tonne of copra. With a production ratio of about 100 gallons (380 litres) of coconut oil per tonne of copra, 5,555 t of copra can be converted to roughly 556,000 gallons (2.1 mega litres) of coconut oil. In past years, the government had to subsidise Tobolar Copra Processing Plant operations. Copra is the primary income source for outer island families, so this is more a rural than business subsidy.

Little coconut oil is sold as biofuel at the moment because trials have indicated problems associated with its long-term use in the smaller diesel engines employed for transport and construction machinery. These were mostly related to fuel filter clogging and carbon deposits in the engine combustion chambers.

MEC is now upgrading and converting its Engine 3 to operate on a blend of coconut oil and diesel fuel. Operation is due to start by 2015. The engine will initially be fuelled with pure diesel. After around six months, a proportion of coconut oil will be blended into the diesel fuel and gradually increased over time.

A number of barriers affect the further development of coconut oil as a biofuel replacement for diesel in the RMI. These are outlined below.

- Copra supply infrastructure: shipping is irregular, so copra may sit on the outer islands for long periods before being shipped. As a result, mould degrades the copra's quality. Once the copra is delivered to Majuro, the existing mill does not have the high quality filtering and refining equipment needed for biofuel production, so a refining facility needs to be added.

- Poor long-term copra supply outlook: many coconut plantations contain increasing numbers of low production, senile trees, which need to be replaced to yield a consistent, long-term supply.

- Quality control: the quality of copra received at the mill varies widely, making it difficult to maintain a consistent quality of oil for producing biofuel. Small mobile mills on the outer islands that produce the oil from fresh copra may be a way to improve the average quality of oil production. This means the copra does not degrade in storage while awaiting a ship. Shipping oil to the Majuro mill for final refining would also be much less costly than shipping bulky copra.

- Engine technical problems: in general, larger diesel engines, such as those used for power generation or on ships, will work well with coconut oil if engine loading is high. However, many engines have problems with carbon that builds up in the combustion chambers at low loading. As a result, many diesel engine manufacturers will not accept coconut oil in their engine warranty conditions. Some manufacturers will allow coconut oil blended with diesel fuel up to a certain percentage, and a few do allow pure coconut oil as a fuel without warranty problems. In general, diesel generators operating as base load generators (at constant optimal loading) can be used with coconut oil with minimal modification. However, peaking generators with greatly varying loads can have problems if the engines are not specifically designed for coconut oil.

- Copra price: coconut oil and copra export prices have been unstable. That in turn also makes local availability and pricing unstable. For coconut oil to be a viable biofuel, its price must be stable so customers can reasonably expect future costs to be predictable. The cost of coconut oil must also be consistently less than for diesel fuel. Neither of these two conditions have been met in the RMI. Through government regulation and the use of a price averaging fund, these problems could be overcome.

Biogas

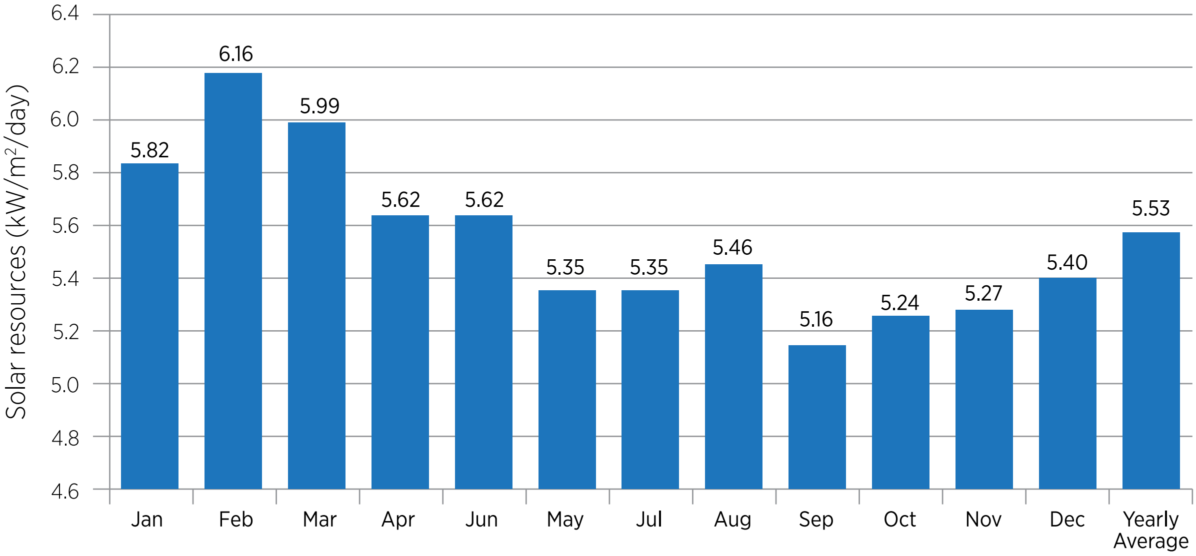
Digester trials in the Pacific Islands to produce biogas in pig and chicken farms have had some success. However, there are no large-scale pig or chicken farms in the RMI. A key barrier is collecting a sufficient amount of feedstock, typically animal manure, to offset fossil fuel use.

In urban areas, biogas opportunities are appearing on the horizon as pressure on municipal sewage waste water treatment increases. The Majuro Water and Sewer Company discharges Majuro's raw sewage into the ocean. Environmental organisations are increasingly putting pressure on the company to operate a proper treatment plant and only allow treated water as outflow. If this were started up, a biogas generation facility as part of the sewage treatment system could provide sufficient electricity to at least cover the energy needs of the sewage plant.

Solar energy

The solar resource is generally very good. Properly designed solar installations have worked well, at least until a lack of maintenance causes degradation or total loss of power. The resource is slightly higher on the atolls at lower latitudes, but even the most northern islands of the RMI still have an excellent solar resource with a relatively constant input over the year. Figure 3 provides solar radiation data obtained from satellite observations made by the US National Aeronautics and Space Administration for the small area of the Pacific that includes the Majuro atoll.

Figure 3: Majuro's average solar resource (kWh/m²/day)



Based on *www.eosweb.larc.nasa.gov*;
Note: the measurements were taken on an optimally tilted surface pointing towards the equator.

Wind energy

Limited data are available on the wind energy potential in the RMI. Survey masts 34 m high were installed in 2012 on Jaluit and Wotje, under the Action for the Development of Marshall Islands Renewable Energies Global Environment Facility project (ADMIRE). This project intended to collect at least two years of wind data for each site at ten minute intervals. Measurements were to include wind speed, wind direction, atmospheric pressure, temperature and solar radiation. However, the Jaluit mast collapsed in 2013 due to corrosion. After that, serious corrosion problems were also found on the mast in Wotje, so that too was taken down. The relatively short periods of data collection are not adequate for a proper resource assessment, though the data available are encouraging.

Meteorological and tidal monitoring stations include continuous wind measurements of over 20 years. However, as they are near surface level, they do not reflect the energy content of the wind at turbine heights. They do, however, contribute to a good understanding of the patterns of variability of the wind over the year, clearly showing that it is a seasonal resource.

Ocean energy

The ocean around the RMI is known to contain substantial thermal and mechanical energy resources. However, there are no well-tested, commercially available wave, ocean current or ocean thermal energy conversion (OTEC) systems. Recent interest in OTEC originated from the need to provide both electricity and fresh water in the Kwajalein military base. In January 2013, the RMI Government officially declared that it will continue to support the development of all forms of alternative and renewable energy technologies, including OTEC. By mid-2014, no commitments had been made for the design or construction of an OTEC plant in the RMI.

Wave energy is modest in equatorial regions, but there is some potential for future energy development when wave energy conversion devices become commercially available.

2.3 ENERGY POLICY AND INSTITUTIONS

Policy background

Though not originally intended as a policy document, a 1995 Asian Development Bank (ADB) outer island electricity study has been used as the basis for the RMI rural electrification policy. That study emphasises the use of local energy sources, commercially proven technologies and the recovery of operating costs from consumers.

In 2009, a National Energy Policy was created and adopted by the government, spurred on by the 2008 fuel price spike that nearly bankrupted the country. It was accompanied by a five year action plan to implement the policy. The policy concentrates on five areas:

- Petroleum and liquid fuels
- Electric power
- Transport and transport energy use
- Energy efficiency
- Renewable energy

In each of these areas, the policy provides four key outputs outlined below.

- Summaries of government policies specific to each energy subsector
- Key barriers to further rational energy use
- Medium-term objectives
- Strategies to achieve the objectives

The policy also includes an associated action plan focusing primarily on 2009 - 2014.

Targets listed by the policy include:

- 100% Urban and 95% rural household electrification by 2015
- 20% Of electrical energy generated in the RMI from renewables by end-2020
- 20% Reduction in imported petroleum use for transport by 2020
- MEC 20% supply side energy loss reduction by 2015 compared to 2009, consistent with sound technical and financial criteria
- Measurable and substantial improvement of energy efficiency by 2020 in at least 50% of households and businesses and 75% of government buildings
- Mandate for locally produced biofuel in diesel-powered government vehicles by 2015

Progress toward reaching renewable energy targets has been encouraging. By 2015, 100% of households desiring electrical service will be connected to either a grid or a stand-alone SHS. The target for generating 20% of electrical energy from renewables is also likely to be reached by 2020 if planned solar and biofuel additions to grid generation are put in place. However, programmes for increased biofuel use in transport and improvements in transport energy efficiency have not yet begun, and progress in residential and government energy efficiency has been slow.

Policy gaps

The RMI requested this RRA as a part of the National Energy Policy review. The aim is to help identify the gaps in the policy and prepare action for areas covered by the policy but yet to be carried out. The stakeholder interviews and the RRA workshop identified a number of areas where a policy is in place but action on that policy still needs to be initiated.

The major gap in the National Energy Policy is its lack of attention to private sector development of renewable energy. In 2009, the cost of developing renewable energy to replace fossil fuel use was seen as too high for significant private sector interest in investment and therefore was not included in the policy. Since the policy adoption in 2009, however, solar panel prices have fallen dramatically. At current PV costs, private investor may have an opportunity for a reasonable return on investment from on-grid solar for the main islands and for solar mini-grids on the outer islands.

To fill that gap, the RRA has recommended the development of attractive financing arrangements for private on-grid and off-grid solar investment. Another recommendation is the establishment of design standards to help level the playing field for private investors. The standards will also help ensure that the equipment installed is of adequate quality and capacity to work reliably in the RMI environment.

The gaps and neglected areas in the 2009 policy are the main focus of this RRA. The actions described in Section 3 of this report address both the lack of attention to private investment and parts of the policy that have not yet been fully implemented. Prospects for renewable energy development are promising for a number of reasons. Firstly, the government has accepted the ADB framework developed for rural electrification through solar energy. Secondly, MEC is willing and able to manage renewable energy initiatives. Thirdly, an agreement exists between MEC and the government to promote renewable energy development throughout the country and carry out solar maintenance on the outer islands. All this means MEC plays the de facto leading role in energy sector implementation and co-ordination, while the MRD Energy Planning Division focuses on energy planning and acts as the energy focal point for government agencies and donors.

Relevant legislation and key institutions

The acts listed below relate to the energy sector either directly or indirectly.

Retail Price Monitoring Act
This provides powers to monitor and regulate retail prices but regulations have never been promulgated, and there is no price control over petroleum fuels.

Unfair Business Act
This could, in principle, be used to regulate electricity and fuel prices but has not been used for this purpose.

Consumer Protection Act
This protects against unfair or deceptive business practices and could be used to regulate some aspects of renewable energy.

Bulletin Boards and Price List Act
This could be used to control fuel prices in outer islands but it is not enforced.

Alternative Energy Fund Act
This established a revolving fund for development, marketing and operation of alternative energy but this fund no longer exists.

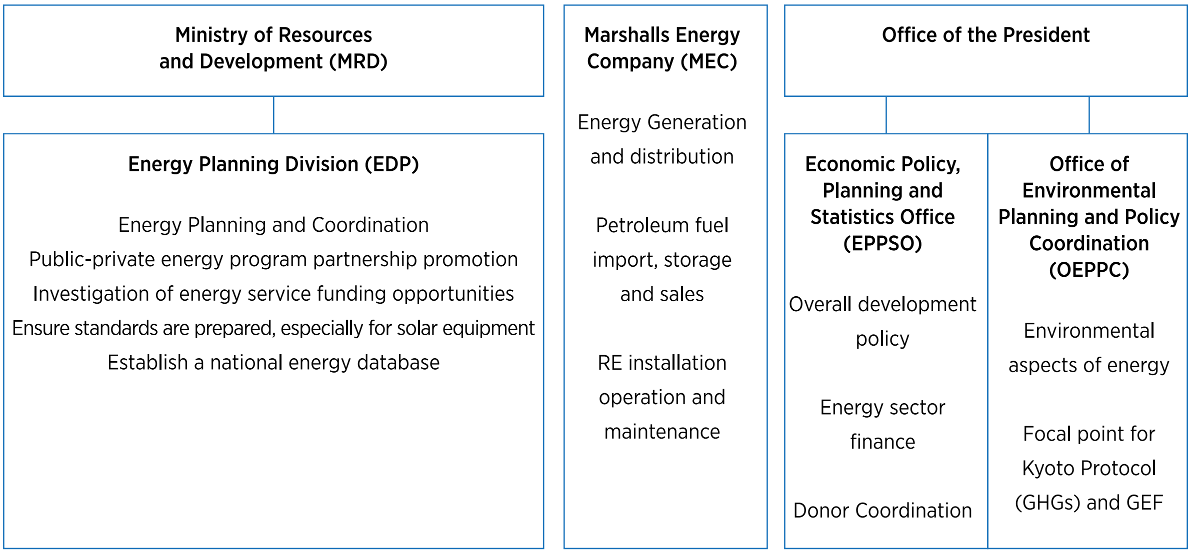
Import Duties Act
This specifies tax rates on all commodity imports.

Environmental Protection Act
This provides powers on land use, pollution control and emissions.

No legislation designates authority or responsibilities to the MRD Energy Planning Division or any other authority to regulate renewable energy systems in the RMI.

Even MEC and KAJUR have no legislated basis. While the MEC Regulations designate MEC as Majuro's sole supplier of electricity, there is no Electric Power Act to define the authority and responsibility of either MEC or KAJUR. They were formed through corporate charters by government granting them the right to generate and sell electricity.

Figure 4: Institutional structure for energy development



Source: ADB, 2010
Note: KAJUR serves the second main urban center of Ebeye; the telecommunications, fisheries, education and health ministries are also involved in solar PV.

The energy development structure shown in figure 4 was established when the 2009 National Energy Policy was adopted. That structure remains in place with the functions of each office as described in the diagram. In addition to this official energy structure, renewable energy projects are often carried out independently and without energy sector co-ordination by a number of government agencies. These are listed below.

1. Ministry of Education (solar projects to electrify rural schools).
2. Ministry of Health (solar projects to electrify rural health centres).
3. College of the Marshall Islands (solar projects to demonstrate solar systems).
4. University of the South Pacific (solar projects to demonstrate solar systems).
5. Marshall Islands National Telecommunications Authority (solar projects to power telecommunications services).

As a result of the lack of co-ordination, these installations are exposed to higher risk of failure. Co-ordination and standardisation of system designs among all government departments would allow the use of a single maintenance facility for each atoll. It would also form a common pool of spare parts, allowing scarce capacity building resources to be used more efficiently.

Human capacity

As with most small Pacific island countries, human capacity development is urgently needed, particularly in technology and business. Two tertiary institutions present on Majuro provide training in these areas. These are the College of the Marshall

Islands and the RMI campus of the University of the South Pacific. The College of the Marshall Islands has the broadest selection of technical courses though they are based more on lectures than laboratory teaching. The University of the South Pacific offers a wide selection of courses related to business, often through distance learning using lecturers based in Fiji.

The College of the Marshall Islands has implemented several programmes to upgrade its technical training to a level useful for renewable energy projects. However, more hands-on technical training is needed that can support ground level projects in the RMI.

Other capacity building activities that have benefited the RMI are described below.

- A regional project run by the US Agency for International Development through the University of the South Pacific in Fiji is expected to provide training for trainers and other support. This will be provided for the College of the Marshall Islands and the University of the South Pacific campuses in the Marshall Islands. The capacity training is expected to support RMI renewable energy implementation.

- The Sustainable Energy Industry Association of the Pacific Islands (SEIAPI) launched its technician certification scheme in May 2012. In 2014, SEIAPI and the Pacific Power Association delivered a regional training course in partnership with the IRENA on the design and installation of grid-connected solar. The course covered installation, commissioning and identifying faults in grid-connected PV systems.

- IRENA and the Secretariat of the Pacific Regional Environment Programme ran a training course for financial institutions in Tonga, Tuvalu and the RMI. This programme enabled financial institutions to develop and implement lending programmes supporting the energy sector. Training was divided into two parts: technical and financial.

Solar powered lighthouse/Shutterstock

III. SCALING UP RENEWABLE ENERGY: CHALLENGES AND RECOMMENDATIONS

3.1 INSTITUTIONAL DEVELOPMENT AND LEGISLATION

Challenges

As with most island countries, the co-ordination of renewable energy development in the RMI needs to be improved. Various ministries are responsible for renewable energy projects with each independently establishing standards and O&M procedures. Several independent renewable energy activities are carried out by the telecommunications, fisheries, health department and education department, as well the MRD Energy Planning Division, MEC and KAJUR.

Different designs are often used for similar projects. Arrangements for maintenance are often not considered at the time of implementation, and training is often not available for the maintenance tasks required by the projects.

The absence of legislation related to the responsibilities and authority of the MRD Energy Planning Division is one of the key root causes of the lack of inter-ministerial co-ordination. A national energy office needs to be established with clear responsibilities and authority mandated by legislation. MEC was also created not by legislation but by government charter, and its authority and responsibilities are poorly defined. MEC needs to have the legislated responsibility and authority. It should be able to develop and enforce national standards and regulations for renewable energy systems supplying electricity to the public either as stand-alone or as grid-connected installations. The MRD Energy Planning Division needs a legislated basis for the government-wide co-ordination of energy activities and the development and implementation of energy policy. Without such enabling legislation, it will be difficult to maintain a stable environment for renewable energy development in the RMI as government administrations change.

Recommendation: Legislative review and institutional improvement

Two types of action are available: (a) review the existing legislative acts that relate to energy (b) establish a working committee for energy co-ordination.

Action 1: Review existing acts relating to energy.

Enact enabling legislation to create a national energy agency and to legislate the responsibility and authority needed to establish and enforce standards for renewable energy systems generating electricity for public use.

There is no legally designated office focusing on energy matters, so renewable energy development is spread across many ministries with little coordination. This results in high risk of project failure due to project designs not appropriate for the environment, and a lack of capacity and finance for maintenance. A review of the existing legislation related to energy should be carried out. That legislation should be amended or new legislation prepared as needed to provide the legal framework necessary to properly support and regulate the development of renewable energy in the RMI.

Action 2: Establish a working committee for energy co-ordination.

An Energy Task Force was formed during the development of the National Energy Policy, but it was not continued after policy document completion. The Energy Task Force consisted of representatives from all ministries with a stake in energy policy development. The committee should be revived and extended to include the private sector. Representatives from ministries with a stake in either on-grid or off-grid renewable energy development would be included. A representative from the development bank and the College of the Marshall Islands would also be included alongside and private sector executives with business or investment interests in renewable energy. The committee's primary purposes would firstly be to co-ordinate renewable energy implementation and secondly to review any national design standards proposed for renewable energy installations. Thirdly, it would propose training programmes to be developed and offered by the College of the Marshall Islands or other educational institutions to support renewable energy development. Finally, it would act as a forum for discussions relating to renewable energy in the RMI.

3.2 GRID-CONNECTED RENEWABLES

Challenges

MEC is under pressure to address its capacity shortage issue while at the same time trying to keep expenditure on imported fuels under control. The successful experience in Pacific islands such as Palau has shown grid-connected solar could help to overcome both challenges, particularly in distributed generation mode. The problem is how to develop a deployment strategy adapted to the RMI local context.

Recommendation: Develop an articulated action plan using a systems approach

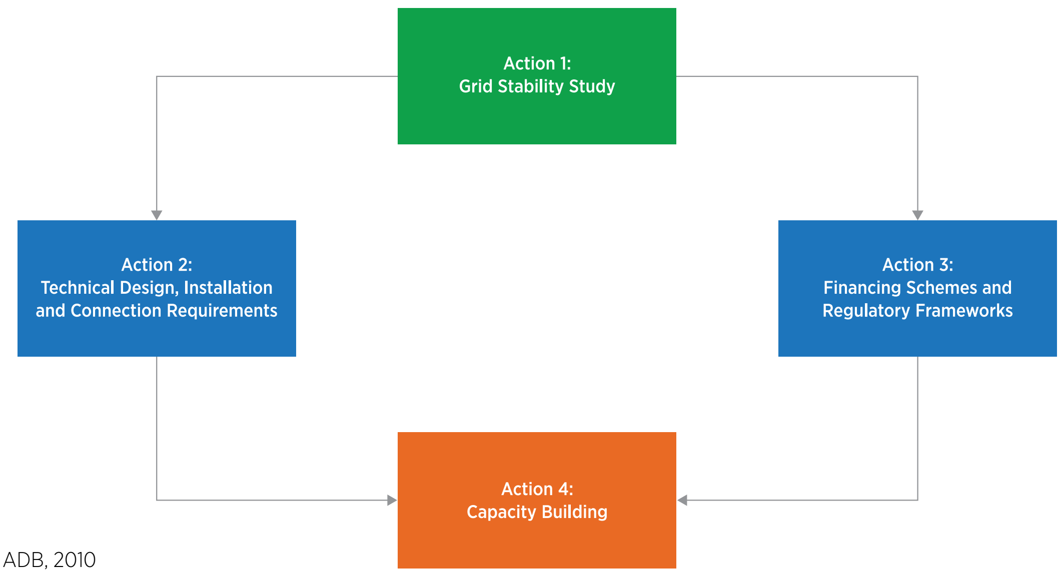
The key issues cannot be successfully addressed without a systems approach and careful planning of the actions that need to be taken. These issues include, for instance, grid stability, a financing scheme, distributed generation system design and installations requirements, and human capacity building. Co-ordination of actions has to be clear from the start.

Action 1: Conduct grid assessment focusing on grid stability

Although JICA is conducting a survey of the MEC grid, its focus is on relatively large-scale solar PV installations operated by professional electricity service providers. MEC is also considering allowing a large number of small-scale systems such as rooftop solar PV with/without battery and wind power generators to be connected to the grid. Power flow and stability analyses are needed. They would provide a better understanding of how connecting variable renewable energy sources affects the grid. This would ensure these small-scale systems are safely accommodated. This analysis can help MEC predict the grid response to solar or wind generation inputs at various points and different penetration levels. Computer modelling will help MEC establish the criteria that installations must meet before being allowed to connect.

However, computer models can address only part of the concern given the apparent capacity deficiency in other respects. It is important, therefore, to assess the current state of the infrastructure and quality of service. This avoids adding the present network operational problems to the issues associated with integrating variable renewable energy. Thus it is proposed that the components outlined below are included.

Figure 5: Articulation of the proposed actions



Source: ADB, 2010

- Diagnostics of present infrastructure.

- Measurement campaign to support the implementation and validations of simulation models. Measurements can also be used to obtain more precise information about the potential of PV and wind power. The effect of solar/wind power output variation on network operation could be better assessed if measurements were available.

- Grid assessment studies providing definitions of the unknowns outlined below.

   a. hosting capacity (at system and distribution level)

   b. expansion requirements and network operational measures

   c. PV/renewable energy deployment plan according to current hosting capacity and recommended measures

   d. technical interconnection requirements (at rooftop and system level)

- Recommendations on technical interconnection requirements to support grid operation. To benefit from economy of scale, requirements should be consistent with regional requirements. Once this study is complete, MEC should be able to design connection requirements that can concentrate private investment on the types of installations best for RMI conditions. Regulatory frameworks and financing schemes can then be designed, particularly where solar PV with battery storage is recommended.

Action 2: Develop and enforce standardised technical design, installation and interconnection requirements

Once the above grid assessment study is completed, basic technical design, installation and interconnection requirements can be developed based on its results. They would consider the generation capacity of a standardised system, geographical distribution and requirements for battery storage if needed. It will be easy to develop and comply with installation and interconnection requirements once technical design has been standardised.

The National Development Bank of Palau created a modular design in Palau for rooftop systems (around 1.7 kWp per module) to establish a standard for residential grid-connected solar generators. This uses components tried and tested for many years in other island countries with a similar environment. After the National Development Bank of Palau set the standards and fixed the design, it provided several weeks of training to local contractors. They learned about installation, grid interconnection and maintenance of the prequalified system. At that time, net metering was not a utility policy, so the designs were vetted by the Palau utility. An agreement between the National Development Bank of Palau and the utility allowed net metering trials for a limited number of homes using the standard design.

The preferable scenario in the RMI would be to create a standardised modular design prequalified for financing by the Marshall Islands Development Bank. Any requirement for a detailed technical review of a proposed installation is thereby eliminated. That way, home owners or solar PV installers will know in advance exactly what will be installed. They will see the same systems installed on other homes, thereby raising their confidence in the programme. Standardised installation and grid interconnection also allows vendors to reduce costs by purchasing components in bulk without worrying whether their design will be approved for installation and grid interconnection. Contractors and maintenance personnel can be trained on the identical system they install and maintain in the field. Standardised systems also reduce investment in spare parts since all installations use the same components. Lastly, they allow training programmes to be easily designed and executed.

The technical benefits of creating a standardised modular design are described below.

- A standardised approach in design, installation and grid interconnection would minimise the hazardous-substance risks faced by utility personnel or installation owners.

- Utilities and the private sector have limited capacity to install, operate, and maintain on-grid solar installations and grid interconnection. This makes it unwise to allow a wide variety of equipment types on the grid. Standardisation could significantly contribute to solving this problem.

- The environmental conditions of the atoll islands are harsh. Only equipment with a record of at least five years of trouble-free performance in a similar island environment should initially be allowed. Standardised technical design could establish a list of prequalified equipment, which can be expanded at a later stage as experience and local capacity improves.

- Permitting only a very limited set of components, at least at the beginning, means training is focused on their installation, grid interconnection and maintenance. This also allows vendors without significant further investment to stay well stocked with spare parts on the islands.

The module size of 1.5 kWp to 1.7 kWp used in Palau may be a good starting point. This is based on previous household surveys and an analysis of the residential energy usage patterns. However, further technical investigations are needed to finalise the module size.

MEC indicates it will require wiring upgrades and energy efficiency measures to be carried out on residential and commercial properties before installing solar generators for grid connection. This is because many RMI homes have substandard wiring and are not energy efficient. The wiring upgrades are intended to increase the safety of the building's wiring. The energy efficiency measures are intended to help customers reduce the size and cost of solar installation by reducing the energy needed for their residence or business.

Action 3: Design workable finance schemes

This need is particularly relevant to solar PV systems with battery storage that would be used by residential users. MEC wishes to reduce the evening peak load on the grid using these systems. This approach to solar generation does not affect grid stability and reduces MEC problems with insufficient generation capacity and high losses from its ageing grid.

However, long-term financing must be made available to make the installations affordable to the home owner. Electricity generated through grid-connected solar PV panels without storage is cheaper than the MEC residential tariff. The levelised cost of electricity by solar PV system with is higher than electricity provided through the grid. Monthly loan payments to generate the kWh from the financed solar installation must be equal or less than the cost to the customer if delivered to the home by MEC. This would encourage investment.

The practice used in Palau could be replicated in the RMI. In 2006, the National Development Bank of Palau initiated a programme to provide subsidised finance for residential grid-connected solar generators. Its intention was to kick start the installation of small-scale, privately owned rooftop solar generators designed to meet most of the electricity needs of a Palau home. The approach was to use grant money to sufficiently leverage low interest finance for grid-connected solar generators to make the installations cost-effective to the customer. That initially represented a subsidy of around 25% - 30% of the solar installation cost. With the continued declining cost of solar PV systems, subsidies of this type might not be needed at all. The Palau programme is still in progress but without the need for the subsidies. This is because solar costs are now so low that generation by solar without storage is lower in cost than that of the diesel fuel used for generation in Palau. The bottom line was to deliver to the customer a viable financing package. The grid-connected solar installation had to generate at a levelised cost of electricity equal to or slightly lower than that of the utility tariff.

A financing scheme along the lines of the grid-connected solar finance programme in Palau now makes very good sense for the RMI. However, it should include battery storage. Using grant funds to lower the cost of storage means installations can compete directly with the MEC tariff. Taking part of the load off the grid would not mean any change to cash outlay for the customer's electricity use. At the same time, it would help solve the many problems associated with dependence on diesel fuel for generation. It would also address the MEC need to reduce the load caused by its capacity problems.

This would require a subsidy sufficient to lower the levelised cost of electricity of a stand-alone residential solar power system with storage to that of the existing tariff. As battery prices fall, the subsidy needed to maintain cost equity with the MEC tariff will also fall. As with the Palau grid-connected solar programme, no subsidy may be needed within a few years (Vanuatu Utilities Regulatory Authority, 2013).

Another example of good practice in Palau is the extended warranties and maintenance in the financing package, which helped ease potential investor concerns about long-term risks. This could be useful in the RMI. If this approach is combined with necessary capacity building for local contractors, it can be very effective.

Modest grant funding to leverage private investment in solar generation is an approach many development partners may find attractive. Locating funds for a trial project of this nature should not be a major obstacle. Once the concept becomes cost-effective without subsidy, the initial project should have developed the local capacity for continuing the programme without further donor community intervention.

Action 4: Design effective capacity building programmes

The capacity of local contractors to install and maintain rooftop solar is lacking, and has been identified as one of the key barriers for solar PV applications in the RMI. Training on the specific technology used for solar rooftop installation is obviously needed.

However, such programmes should be carefully designed and co-ordinated with the actions to develop the standardised technical design and installation requirements. This will not only make the capacity building or training programmes much easier to implement but also roll them out through training for trainers. In the long-term, it will also be necessary to work with the local training institutions, primarily the College of the Marshall Islands and University of the South Pacific. They will continue training people in the installation and maintenance of the standard modular systems used for residential grid-connected solar.

Wherever applicable, it is recommended to take advantage of established regional technical guidelines and existing courses appropriate to the region. This includes, for instance, a regional certification programme for installers developed by SEIAPI. By basing training on the key components of these programmes, it can be easier to develop a programme orientated towards the RMI.

MEC capacity building should also be considered to operate networks with a high share of PV or renewable energy, given that this is a new area for the RMI grid operator. The training programme should be well designed to meet local needs in this respect. In addition, the operational tools should be provided during and after the training.

3.3 OFF-GRID RENEWABLES

Challenges
As with the other Pacific islands, sustainable off-grid system O&M remains a persistent barrier affecting the delivery of reliable and affordable rural energy services. This is particularly true for the outer islands of the RMI.

The challenges identified are multidimensional, thus calling for a solution that could solve the O&M problem from different angles and through different approaches. The specific challenges vary remarkably from one outer island to another due to different local contexts among the outer islands.

MEC is required somehow to receive sufficient continuous funds to cover O&M for the outer island installations while most outer island households have limited and irregular access to financial resources.[8] This makes the challenge all the harder. Some process needs to be established to allow outer island residents to pay through non-cash means or to pay in advance on a prepayment basis when cash becomes available.

Another O&M challenge is to deliver a training programme to local villagers in the hope they can help maintain the systems, thus reducing costs. Most villagers have limited knowledge of English, the common language used for training courses. This means the training programme has to be delivered in the local language to achieve better results. This in turn creates a barrier for MEC or training providers.

Recommendation: Apply a customised approach to develop a solution for sustainable O&M
To apply this approach, the following actions are recommended.

- Conduct a comprehensive survey of factors causing failures in O&M sustainability (particularly for solar PV systems) and develop a remedial plan.

- Create a rural electrification institutional arrangement allowing a customised approach to make it sustainable, and tailor it to each individual outer island.

- Deliver a training programme orientated to the local environment. This provides the know-how that can be understood by local villagers so that they can carry out basic O&M in the long term.

Action 1: Conduct a comprehensive survey of factors causing O&M sustainability issues and develop a remedial plan

The setting in each individual outer island is different, as are the reasons why O&M is not sustained. Funding is an important contributor in most cases, but is not the only one. Other contributing factors are usually unknown. Without a granular understanding of the problems, it is difficult to find a solution. A comprehensive survey is necessary across the outer islands to gain a better and deeper understanding. It could, for example, examine the causes and extent of failures. Detailed knowledge of the status of all outer island installations is required, as well as the reasons for breakdowns and the support needed to bring failed systems back to full service. This will enable proper maintenance and repair when funds do become available.

[8] In most cases, cash income is not received on a fixed schedule so requiring payments on a fixed schedule is not realistic.

Preparations for a small project to be funded by a development partner are therefore recommended. Funding applications should be made to send MEC and/or MRD Energy Planning Division technical staff to all the outer islands to evaluate the extent of residential SHS and public facility system failures. Where an installation has broken down, the survey should explain the causes and include a parts list for its repair.

After determining the cost of repairing failed SHS and public building installations on each island, prepare a remedial project to do so in such a way that they meet the established standards. Remediation should bring all installations up to the standards established for SHS and mini-grids in terms of design, capacity and components. A remedial plan should be integrated into Action 2 in order to implement it effectively in the long term.

Action 2: Develop an institutional arrangement for long-term rural electrification adapted to each individual outer island

Building on the survey results, consultations should take place with both traditional and local government officials, as well as other stakeholders in the community. This will elucidate the different dimensions of the challenge. Brainstorming user payment arrangements sufficient to cover the maintenance cost of the installed SHS needs to engage key local stakeholders right at the outset.

The bottom line, though, is a payment sufficient to cover basic maintenance as well as battery and controller replacements to sustain the operation of the installations. The terms and manner of payment can be customised to allow the different contexts found in each atoll. For example, the arrangements need consider the relative lack of cash on outer islands and the availability of coconuts, seafood and other items that can be converted to cash. In some cases, payments may have to be made at the community rather than household level. Alternatively, a hybrid model combining several approaches may be necessary.

A committee is advised to develop the necessary institutional arrangement. The committee should include representatives from MEC, the national government and local authorities. The committee's task would be to work out institutional systems that can make a long-term financial impact within the social and financial structures on the outer islands. The government should consider different structures on different atolls if it seems appropriate. This includes arranging O&M payments for public building installations managed by the Ministries of Education and Health. This is because they have not made promised payments to MEC for the maintenance of their off-grid solar installations. Another commonly used approach is cross-subsidisation. If other options are not practical, it is worth considering a cross-subsidy to support off-grid solar on outer islands through an increased electricity tariff for Majuro government facilities.

Action 3: Deliver training programmes orientated to the local environment providing know-how that can be understood by local villagers assigned with maintenance

Donor projects typically include training as part of the installation process. However, no ongoing refresher training programmes are run for existing personnel or new recruits. Maintenance quality thus tends to decline over time. The College of the Marshall Islands has begun to integrate renewable energy training into its programmes but will need support to design the courses specifically to meet the needs of the outer island programmes.

The College of the Marshall Islands, the MRD Energy Planning Division and MEC need to work together to develop courses that be sustained in the long term. They would train local people to install and maintain the types of renewable energy equipment being used in the RMI.

Existing technical training is in English only. However, experience in other countries has shown that training in the local language is more effective because technicians in rural villages often have limited knowledge of English. The development of local language capacity building processes for off-grid solar maintenance personnel on outer islands should therefore be considered. These classes should be run periodically on outer islands both as refresher courses for existing village technicians and training for new outer islands. In addition, the project should supply the necessary tools to carry out the off-grid solar maintenance. The training could be provided by MEC or by the College of the Marshall Islands.

Action 4: Develop and enforce design and installation standards for off-grid installations

MEC and the MRD Energy Planning Division should continue to work with SEIAPI and external experts to standardise the designs of both SHS and mini-grid systems to be installed on outer islands. This will achieve greater installation and O&M training effectiveness. This approach would be particularly applicable where alternating current is needed, given that off-grid solar mini-grids are now more cost-effective than diesel mini-grids. However, there is a lack of RMI standard design for solar mini-grids. This deficiency may result in different designs being installed by donors and private parties. That in turn will make it difficult and expensive to prepare training programmes and to stock spare parts.

If standardised design and installation can be provided, projects would be required to follow those standards and guidelines. Installer and O&M personnel training would be greatly simplified. Standard designs and installation can help ensure that equipment by donors is appropriate for use and meets the RMI requirements for consistency and reliability. The standards and guidelines need to be published for private investor use. Differences in the local context, including physical environment, electricity demand and payment terms, should be taken into account when designing these standards and guidelines.

3.4 DIESEL POWERED MINI-GRID CONVERSION TO SOLAR PV SYSTEMS

The cost of operating the outer island diesel generators is very high and continues to rise. The cost of solar generation with battery storage can be less than that of diesel generation and is expected to remain stable or fall in the future. Furthermore, in other Pacific island countries, the replacement of remote diesel generation with solar and storage has increased the reliability of the power. It has also made it economically reasonable to expand to a 24 hour service.

On the outer islands, fuel leakage is also a serious issue for MEC and local governments operating diesel generators. The leaking fuel seeps into the coral and contaminates the fresh water lens for some distance around the fuel storage site as well as damaging reefs. Some even quite small fuel leaks are considered a serious problem for the atoll islands.

Review conversions of outer island diesel generation to solar energy in other Pacific island countries and prepare a similar programme for the RMI.
The first step would be to collect the operational information of the existing diesel powered mini-grids running in the RMI. The next would be to create a standardised modular design for a solar generator that can be used to replace existing diesel generators. This would be based on the experience of Tokelau, Samoa, the Cook Islands and Tuvalu. The basic module design would provide three phase power that can be combined with additional identical modules to meet the specific loads of each of the mini-grids. The cost of generation by solar can be expected to be lower than that of diesel. In addition, this conversion can almost eliminate the need to store supplies of diesel fuel on the outer islands. This both reduces the costs and environmental hazards of such fuel storage.

A project should be developed to convert the small MEC and local government diesel grids operating on the outer islands. Funding could be submitted through the EU Energy Facility or other general energy development fund in the Pacific. The design of the project should be based on the experience of similar action in Samoa (2006), Tokelau (2012), the Cook Islands (ongoing) and Tuvalu (ongoing).

3.5 REPLACING DIESEL WITH COCONUT OIL

In 2015, MEC is planning to start using coconut oil as the primary fuel for one engine at the Majuro power plant. If the trial is successful, coconut oil use will be expanded.

But the supply, quality and price of coconut oil is a concern. The uncertain shipping schedule often results in gradual degradation and mould damage to the copra held in storage awaiting the ship to take it to the Majuro mill. Reduced copra quality results in reduced coconut oil quality, which means it may not be satisfactory as a biofuel. In addition, the cost of shipping copra is increasing due to the rising shipping fuel cost. Local coconut oil prices vary with export prices.

Develop small-scale on-site coconut oil production capacity
To address these challenges, it is worth exploring technological options for extracting coconut oil using small mills on site where the copra is harvested and still fresh.

A coconut oil production trial should be conducted on the outer islands. A small-scale coconut oil production trial on outer islands using portable mills has been considered in the past. It should again be considered for implementation. Oil production on the outer islands should reduce the cost of coconut oil because the oil is substantially cheaper to ship than copra. It should also help improve the average quality of the oil because fresh copra can always be used for its production. As part of the project, the RMI should consider engaging and utilising the knowledge of people from Fiji, Kiribati and Vanuatu with experience of similar activities. Kiribati in particular may be able to provide useful information because it is developing a project for outer island coconut oil production on Abemama and Kiritimati. This will use the type of mill that should be appropriate for the similar conditions in the outer islands of the RMI.

Solar street light
Photo: H. Wade

IV. PROPOSED PROJECT ACTIVITIES

The key challenges and recommended actions formulated were based on consultations with the widest possible range of stakeholders to identify and discuss renewable energy in the RMI. However, the RRA can only provide a snapshot of the situation, and its recommendations are those considered important at the time of its completion. Nevertheless, if these actions were taken effectively, it would improve the RMI's energy status and readiness for increased renewable energy use. This would achieve a sustainable energy future for the RMI.

However, it is necessary to convert the recommended actions into a practical project. Discussions were held during and after the RRA workshop to develop the basic outline of a project structure. Participants assigned specific roles to engaged stakeholders, developed lines of activity, estimated a timeframe and defined key success indicators for monitoring and evaluation. Projects can and should manage and link many of the challenges and recommended actions discussed above. In the annex, project concepts are outlined that include all the recommended actions needed to address the listed issues. It is proposed that the RMI MRD Energy Planning Division review these project concepts. With external support as needed, it should further develop the project concepts into full project proposals that can be submitted to development partners for funding.

Marshall Islands hospital with PV panels
Photo: H. Wade

ACTIVITY 1

Large-scale project to support private investment for on-grid solar, with and without energy storage.

Sector(s)	On-grid solar development
Description	To decrease fossil fuel imports for electricity generation on Majuro and Ebeye, cutting the diesel generation load and raising renewable energy generation is a high priority. The first step is to integrate a 500 kW solar farm and install a rebuilt genset, which will ultimately run on coconut oil biofuel. A new project is needed to encourage private investment in either on-grid solar without storage or off-grid solar. This would further increase the proportion of the Majuro load supported by renewables that integrates enough storage to take some residential and small business loads off the Majuro or Ebeye grid. The project will need to: • Establish standards and design guidelines for on-grid and utility grade off-grid solar installations. • Provide a computer model of the Majuro and Ebeye grids that can predict their dynamic response to the rapid fluctuations of inputs from solar or wind power generation systems through low-voltage feeders. • Develop finance packages for residential and small business solar installations to take loads off the grid. These arrangements should include subsidies sufficient to make energy from a solar installation no more costly per kilowatt-hour than the utility tariff. Finance packages would need to include extended warranties for components and a contract for maintenance appropriate to the system installed. Finance can be directed through the development bank. Alternatively, it could be obtained directly by the utilities. • Provide capacity building for local contractors for the installation and maintenance of solar generators and storage systems.
Actors	MEC, KAJUR, Development Bank of the Marshall Islands, MRD Energy Planning Division, private electrical contractors
Timeframe	36 months
Keys to success	To reduce the perceived risk, private investors must have confidence in the concept, as the project needs to achieve the following: • Strictly enforce design and installation standards consistent with international practice. Provide reliable service under the difficult environmental conditions in the RMI while requiring a minimum of maintenance, spare part stocks and installer and maintenance personnel training. • Promote high-efficiency appliances and lighting as well as home modifications needed for air conditioning, solar heating reduction, and to maximise the benefit from solar installations. Where needed, also include house wiring upgrades. • Provide incentives for early adopters to invite prospective renewable energy investors for visits to see actual home or business installations. • Market renewable energy systems by emphasising the long-term benefits of solar generation, including a fixed electricity price for 20 years or more, in comparison to steadily rising utility costs.

ACTIVITY 2

To provide a sustainable electricity supply to residents on outer islands.

<table>
<tr><th>Sector(s)</th><th>Off-grid electrification</th></tr>
<tr><td>Description</td><td>By 2015, the vast majority of outer island residents and public facilities will have access to electricity through small diesel grids, solar mini-grids or SHS.

However, providing electricity supply from the solar installations on a sustainable basis remains a problem. This is mainly due to an institutional structure that lacks a workable approach to accumulating the funds for maintenance and battery replacements.

A reliable means of accessing O&M funds is an essential aspect of the electrification process to ensure these systems in sustainable operation. Recommended actions to achieve this goal can be included in an outer island standardisation project described below.

• Carry out a survey of all outer island public and private solar installations. Note the components installed, any additional components added by the users (e.g. inverters, phone chargers, DVD players) and the operational status of the installation (e.g. working, partially working, out of order).
• MEC should work with SEIAPI and external experts to standardise the design for outer island solar installations. This is both for household SHS and for solar used in schools and health centres. The standards should also include components known to be reliable in similar environments. They should use installation arrangements providing for proper component ventilation, and maintain batteries at a temperature close to the ambient atmosphere.
• MEC should work with both outer island parliamentarians and outer island traditional leaders to develop a means to collect reasonable fees to cover O&M for SHS and for systems installed on public buildings.
• Once standards and a workable O&M cost recovery scheme has been established, refurbish all outer island installations that are not fully working. This will raise them up to the established configuration standard. When an installation breaks down, repair protocols should also include bringing it in line with the standard configuration.</td></tr>
<tr><td>Actors</td><td>MEC, Ministry of Internal Affairs, outer island governments and national representatives, RMI Cabinet, Ministry of Education, Ministry of Health, MRD Energy Planning Division</td></tr>
<tr><td>Timeframe</td><td>24 months</td></tr>
<tr><td>Keys to success</td><td>Outer island leadership and national government must clearly understand that depriving MEC of access to the O&M funds needed will lead to a breakdown in outer island electrification.

• Effective co-operation, co-ordination and collaboration among stakeholders.
• Outer island households and public facilities need to place a high enough priority on electricity supply to accept a significant part of the cost of sustaining that service.</td></tr>
</table>

ACTIVITY 3

Convert outer island diesel grids to solar PV electricity generation.

Sector(s)	On-grid solar electrification
Description	As shown in Samoa and Tokelau, solar mini-grids can now generate electricity on outer islands at a lower cost and higher level of reliability than that from diesel. A project to convert the MEC diesel mini-grids on Jaluit, Wotje and Rongrong is appropriate, as is conversion of locally managed public diesel mini-grids on other outer islands. Specific activities include obtaining development partner funding for the purposes outlined below. • Establish a standard, modular design for RMI solar mini-grids that is easy to scale up to meet the generation requirements of any outer island mini-grid. The New Zealand - Ministry of Foreign Affairs and Trade (NZ-MFAT) model is the recommended basis for design. • Conduct feasibility studies for each outer island grid to be converted. This will include details needed to develop specific designs for each grid and its tender specifications. • Support the College of the Marshall Islands and/or University of the South Pacific to create and provide courses in installation and O&M for the standard modular mini-grids. • Procure and install solar generators using the existing diesel generators for backup.
Actors	Development partners. The EU may be a good partner as would be the United Arab Emirates. SEIAPI, MEC, Ministry of Internal Affairs, outer island governments, College of the Marshall Islands and University of the South Pacific.
Timeframe	60 months
Keys to success	• Support by development partners both for technical assistance and for installation. • A simple, modular standard design that fits the stringent environmental requirements of the outer islands and can be expanded to fit all mini-grid sizes needed.

ACTIVITY 4

Coconut oil production shifted from Majuro to the outer islands, lowering costs and improving oil quality.

Sector(s)	Biofuel production
Description	A project was recently proposed to try out the concept of using a small mill to make coconut oil on the outer islands. This is an alternative to relying on intermittent shipping to transport copra to the Majuro mill. Unfortunately, it was never completed. The project concept looks good and replicates pilots in Kiribati, Vanuatu and Fiji. It should be reinstated, but all aspects of the project need to be agreed between all stakeholders before making funding applications. Key activities are outlined below. • Negotiate the location and operating process of the project before seeking funding so that these decisions do not cause implementation delays. • Consult with Kiribati, Vanuatu and Fiji to learn about their experience of this concept so as not to repeat their mistakes in the RMI. Find the expertise needed for the small mill specifications, and provide the necessary training to operate and maintain the mill. The oil is expected to be used by MEC in Majuro, so that final refining can take place there, thus simplifying outer island operations. • Develop a formal project document and locate a development partner to provide funding. • Trial the concept for at least two years and if it proves satisfactory, expand the project to include other islands.
Actors	Tobolar, Energy Planning Division, Ministry of Internal Affairs, leadership of the outer islands selected
Timeframe	24 months
Keys to success	• Selection of a simple yet resilient mill with components capable of providing high enough quality oil to be used by MEC as a biofuel once refined on Majuro. • Sufficient training and support materials (spare parts and tools) available to properly maintain the mill and produce the quality of oil needed. • Co-operation from local coconut growers, copra cutters and local leadership to supply and run the mill.

ACTIVITY 5

Review the 2009 National Energy Policy and enabling legislation.

Sector(s)	Policy and legislation
Description	The 2009 National Energy Policy included a review every five years. That review is currently in progress. Additional inputs from outside the MRD Energy Planning Division are needed. • To include all major stakeholders, it is recommended that the Energy Task Force formed to help create the original energy policy is reactivated. It should include members from all ministries and agencies involved with activities related to energy. This includes but is not limited to MRD, Ministry of Education, Ministry of Health, NTA, MEC, Tobolar, Ministry of Internal Affairs, Ministry of Finance and Majuro Water and Sewer Company. • With the assistance of the Energy Task Force, review the National Energy Policy and the MRD Energy Planning Division. Update it as appropriate and then seek confirmation of the changes by the Energy Task Force. • Review legislation relating to energy and amendments. Decide whether new legislation or amendments are needed to encourage and accommodate the addition of private renewable energy generation on the grid. If necessary work with the Government Law Office to draft the necessary amendments to the act. • With the assistance of the Energy Task Force and the Government Law Office, prepare legislation that establishes a formal RMI Energy Office and provides for its staffing and budget.
Actors	MRD, Ministry of Education, Ministry of Health, National Telecommunications Authority, MEC, KAJUR, Tobolar, Ministry of Internal Affairs, Ministry of Finance, Majuro Water and Sewer Company
Timeframe	8 months
Keys to success	• Co-operation and full engagement by all parties. • The members of the Nitijela should be kept informed of the actions proposed and the reasons for including proposed legislation.

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ANNEX

RRA workshop participants by discussion group

POLICY AND LEGISLATION	
OFF-GRID ELECTRICITY	OEPPC
Divine Waiti	Nitijela
Rina Keju	MOFA
Bernard Adiniwin	Office of the Attorney General
Riyad Mucadam	Island Eco
Sultan Korean	BOMI
Dolores de Brum-Kattil	ADMIRE
Angeline C. Heine	MRD Energy Planning Division

ON-GRID ELECTRICITY	
Steve Wakefield	MEC
Tom Vance	Moana Marine
David Utter	Islands Radio
Paul Relang	MALGov
Emil de Brum	Island Energy Savings
Damian Jetnil	MTC

OFF-GRID ELECTRICITY	
Michael Trevor	College of the Marshall Islands
William Reiher	College of the Marshall Islands
Mison Levai	Tobolar
Nilda Saludes	Tobolar
Juren Jatios	MEC
Brian Dunn	New Energy
Tamara Greenstone-Alefaio	University of the South Pacific/KIO Club
Joe Talley	AKMA (Arno Koba Maron Association)
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