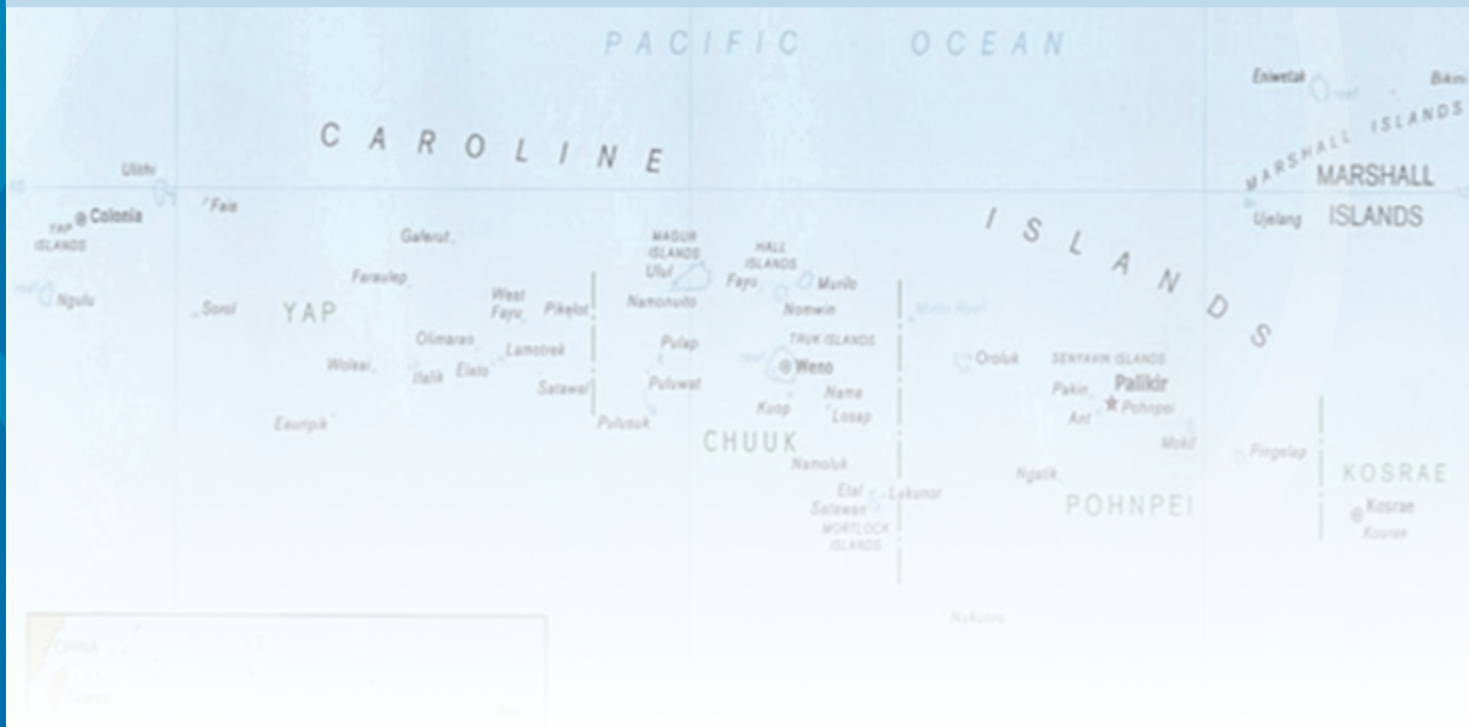
Report

IRENA
International Renewable Energy Agency

Pacific Lighthouses

Renewable energy opportunities and challenges in the Pacific Islands region

Federated States of Micronesia



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.
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August 2013

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Note on currency:
The United States Dollar (USD) is used in the Federated States of Micronesia.

Preface

In the Abu Dhabi Communiqué on accelerating renewable energy uptake for the Pacific Islands (of 13 January 2012), leaders from the Pacific Island Countries and Territories (PICTs) called on the International Renewable Energy Agency (IRENA) to "...map the Renewable Energy Readiness of the Pacific Islands Countries and Territories to ascertain the status of renewable energy opportunities and identify pathways to close gaps" and to integrate all IRENA activities in the region "...into a coherent roadmap for the Pacific Islands". In response, IRENA has carried out a wide range of activities of specific relevance and application to the PICTs as well as other Small Island Developing States (SIDS). This work has now been integrated into the IRENA report: ***Pacific Lighthouses: Renewable Energy Roadmapping for Islands***.

The report consists of an overview roadmap framework and 15 island-specific studies on the respective energy situations, and the challenges and opportunities for renewable energy deployment, around the region. These studies are available for the Cook Islands, the Federated States of Micronesia, the Republic of Fiji, Kiribati, the Republic of the Marshall Islands, the Republic of Nauru, Niue, the Republic of Palau, Papua New Guinea, Samoa, the Solomon Islands, the Kingdom of Tonga, Tokelau, Tuvalu and the Republic of Vanuatu. The IRENA Pacific Lighthouses report draws on those studies, as well as an additional study on a diesel-renewable energy hybrid power system, intended as a transition measure to a renewables-based energy future for the PICTs, which is also part of the series.

IRENA, in collaboration with its members and other key development partners, will continue to support the development national roadmaps and strategies aimed at enhanced deployment of renewables in the Pacific and other island states and territories.

Acronyms

ADB	Asian Development Bank
COFA	Compact of Free Association
CPUC	Chuuk Public Utility Corporation
DC	Direct Current
DoEA	Department of Economic Affairs
EDF	European Development Fund
EU	European Union
FSM	Federated States of Micronesia
GDP	Gross Domestic Product
kL	kilolitres (thousands of litres)
km; km²	kilometre; square kilometres
KUA	Kosrae Utility Agency
kW	kilowatts (thousands of Watts)
kWh	kilowatt hours (thousands of Watt hours)
MW	Megawatts (millions of Watts)
O&M	Operation and Maintenance
PV	Solar Photovoltaics
RET	Renewable Energy Technology
SOPAC	South Pacific Applied Geoscience Commission
SPC	Secretariat of the Pacific Community
TTPI	Trust Territory of the Pacific Islands
USD	United States dollar
USDOE	United States Department of Energy
Wp	Watts-peak (Solar Photovoltaics)
YSPSC	Yap State Public Service Corporation

1. Country context

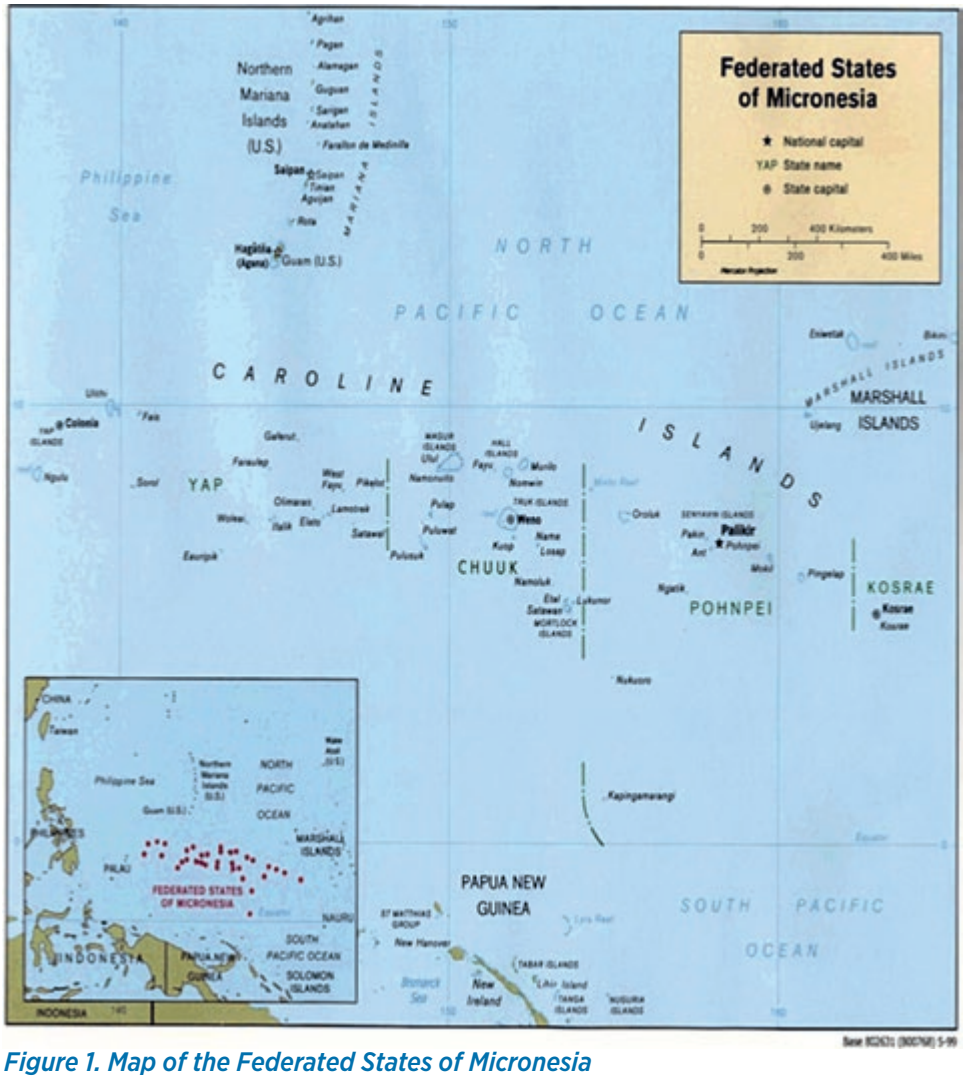

Figure 1. Map of the Federated States of Micronesia

Source http://www.lib.utexas.edu/maps

The boundaries and names shown on this map do not imply official acceptance or endorsement by the International Renewable Energy Agency.

Physical description. The 607 islands of the Federated States of Micronesia (FSM), north-northeast of Papua New Guinea, extend east to west over 2 414 kilometres (km) and north to south over 965 km. The land area is 702 square kilometres (km^2) with an exclusive economic zone exceeding 2.59 million km^2 distributed over four states: Chuuk, Kosrae, Pohnpei and Yap. The islands vary geologically from high and mountainous to low coral atolls, with the majority being low-lying and resource-poor.

Population. The most recent census was conducted in 2010. It recorded a population of 102 624, down from the 107 008 recorded in the 2000 census, largely due to emigration to the United States. Chuuk is the most

populous state with 47.4%, of total inhabitants, while Pohnpei has 35.1%, Yap 11.1%, and Kosrae 6.4%. The census, while not distinguishing between urban and rural areas, suggests that Chuuk and Kosrae have the densest population clusters: Chuuk because of the relatively high percentage of people living on Weno, the state's capital island; and Kosrae because it consists of only one island with one main village.

Environment. The climate of the FSM is tropical, with heavy rainfall all year round. Rainfall is high on the volcanic islands (Kosrae, Pohnpei and Chuuk), sometimes exceeding 10 000 millimetres (mm) per year in Pohnpei. Strong north-east trade winds prevail from December through April with periods of weaker winds from May to November. Storms and typhoons are generally more severe in the west, while Kosrae, the most easterly state, is hardly affected. In April 2004, Typhoon Sudal hit Yap State with winds in excess of 210 kilometres per hour (km/h) in one of the state's worst disasters in recorded history. About 90% of structures, including power lines, were damaged or destroyed. The cost to the power utility to repair damaged power infrastructure ran into millions of USD.

The FSM is party to various treaties and conventions related to environmental protection including the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol, both of which have energy implications.

Economic overview. Fishing and subsistence farming are the main economic activities of the FSM, followed by tourism and some light manufacturing. Economic development has been highly variable and extremely dependent on funding from the Compact of Free Association (COFA) from the U.S., which provides financial support to the FSM to 2014 and a trust fund thereafter. The different states of the FSM enjoy considerable autonomy, including in economic policy. Pohnpei, with 35% of the population, accounts for around 45% of GDP whereas Chuuk, with 47% of the population, has only 30% of GDP as shown in Table 1. The 2010 GDP for the FSM was USD 297.45 million, according to estimates by the World Bank.

The economic performance the FSM has varied considerably by state, partly reflecting differences in policies and responses to external developments. Pohnpei and Yap grew the most rapidly at 2% per annum from 1987–2003. Kosrae and Chuuk each grew by about 0.6% per year.

Table 1. GDP and population

State	GDP	Share of population
Kosrae	8%	7%
Pohnpei	45%	35%
Chuuk	30%	47%
Yap	17%	11%

Source: FSM Energy Policy, 2010a.

2. Energy landscape

Institutional and regulatory arrangements for energy

State utilities. There is no single independent energy sector regulator. Each of the four island states has its own state-owned power utility authority – Chuuk Public Utility Corporation (CPUC) for the Chuuk State, Pohnpei Utilities Corporation (PUC) for Pohnpei State, Yap State Public Service Corporation (YSPSC) for Yap State and Kosrae Utility Authority (KUA) for Kosrae State. Each utility has its own tariff structure and is regulated at the state level only.

The Division of Energy. The Division of Energy operates under the FSM Department of Resources and Development. The responsibilities of the Division include policy development for an energy sector in the country, promotion of energy efficiency and the development of renewable and indigenous sources of energy, coordination with the state governments on sustainable use of fuel energy and working with regional and international counterparts to seek funding and technical assistance to support energy development in the country. The Division of Energy is the implementing centre of the FSM National Energy Policy.

National Energy Policy. In 1999, the Department of Economic Affairs prepared a draft National Energy Policy, but it was never accepted. A revised energy policy, prepared in 2010 with support from the European Union (EU) and the Asian Development Bank (ADB), was adopted at the Second Regular Session of the Seventeenth Congress of the Federated States of Micronesia in 2011. The overall strategic goals of the policy and its state action plans are:

- improve coordination and program management;
- provide a safe, reliable and affordable supply of conventional energy;
- increase share of renewable energy (more than 30% in 2020); and
- conserve energy consumption and improve energy efficiency (50% efficiency improvement in 2020)

Each of the four states is expected to prepare its own action plans for meeting the goals of the National Energy Policy.

There is no national electricity or petroleum legislation (other than for the creation of the FSM Petroleum Corporation) and each state has its own statutes relating to energy. In addition to state laws establishing the four power utilities and the national law creating the FSM Petroleum Corporation, there are state and national environmental laws that could affect energy investments, although typically there are no specific environmental requirements for energy projects except for pollution control and waste management.

Energy supply and demand.

Petroleum. The FSM is highly dependent on imported petroleum fuels. Approximately 86% of gross energy supply is from petroleum and 14% from biomass for cooking. Refined petroleum products are supplied by the government-owned FSM Petroleum Corporation (PetroCorp) based in Pohnpei. There is no control of fuel prices except for state use in Kosrae. Although requested data on volumes of imported petroleum fuels were not readily available from the country, Table 2 shows data provided by the Secretariat of the Pacific Community (SPC) on the FSM's total imports by fuel type.

Only preliminary population information is available from the 2010 census at the time of writing but the 2000 national census reported that over 50% of all households used wood as their main cooking fuel, ranging from 8% in Kosrae to 71% in Chuuk. This suggests that perhaps 12 000 tonnes of oil equivalent (toe) of biomass was used in 2000 for energy and, since most of that use was on the outer islands, it is unlikely to have changed much o date.

Electricity generation and demand. Each state owns and controls its power utility. Historically, COFA funds have been the main source of funding the utilities for both capital replacement and expansion, although ADB now has major utility-directed projects in FSM. There is no national utility for the FSM and there are no national standards, utility laws or regulation. Table 3 shows the percentage of the population with electricity access in 2009 according to the FSM National Energy Policy document.

The Kosrae, Pohnpei and Yap utilities operate semi-autonomously, but rely on state governments to cover

Table 2. Total petroleum imports for all FSM states, 2005–2010.

Fuel	2005	2006	2007	2008	2009	2010
Diesel fuel (kL)	21 343	26 639	30 567	26 426	34 885	26 087
Gasoline (kL)	17 498	17 191	18 576	16 772	23 771	14 524
Jet Fuel (kL)	8 004	4 190	4 315	4 436	5 799	4 145

Source: Provided through communication by SPC.
Where kL is kilo litres.

Table 3. Percentage of population with electricity access (2009)

State	Kosrae	Pohnpei	Chuuk	Yap
Percentage electrified	98%	87%	46%	70%

Source: FSM Energy Policy, 2010a.

any deficits. In Chuuk, the Chuuk Public Utility Corporation (CPUC) has been subsidised since October 2010 through a COFA grant with no direct state intervention (although the COFA grant is from a state allocation). Collections since 2010 have been good, since 98% of meters are pre-paid and the utility has resolved many non-payment issues. Post-paid (on account) payments are up to date – non-payment after two weeks results in disconnection – and people can now make their payments reliably. There is a high level of arrears from previous years, but the CPUC is making progress with collection rates. In general, the Yap and Kosrae utilities provide reliable power. In the past, Chuuk has had frequent power outages and poor power quality. Continuous power generation returned in December 2011, and overall power reliability has since then. Pohnpei has experienced capacity problems and sometimes resorts to rolling blackouts. All utilities have state-wide mandates but provide services primarily to the state's main island or islands. Table 4 shows electricity production by states for the years 2007 to 2011.

The Pohnpei Utilities Corporation is the largest power utility in FSM, with six Caterpillar diesel generators

Table 4. Electricity production in the States of FSM (2007 to 2011)

State	Item	Unit	2007	2008	2009	2010	2011
Pohnpei	Production	kWh	37 644 600	36 149 600	38 186 200	38 919 700	-
	Fuel	litres	9 481 071	9 782 666	10 273 424	10 720 900	-
Kosrae	Sales	kWh	5 027 225	5 075 045	5 169 356	5 511 304	-
	Fuel	litres	1 822 385	1 619 715	2 426 015	2 289 074	-
Yap	Sales	kWh	10 567 458	10 138 648	10 491 206	10 170 106	9 986 558
	Fuel	litres	3 627 285	3 583 965	3 508 035	3 399 648	-
Chuuk	Production	kWh	11 298 000	9 385 000	11 226 000	9 497 000	7 701 000
	Sales	kWh	-	-	-	-	5 103 786
	Fuel	litres	3 274	2 619	3 290	3 123	2 298

Source: Pohnpei Utility Corporation (PUC), Kosrae Utility Agency (KUA), Yap State Public Service Corporation (YSPSC), CPUC.
Where kWh is kilowatt-hours.

having a combined effective (de-rated) capacity of 4.9 megawatts (MW) and four newer Daihatsu units with a total effective capacity of 10 MW. The 2 MW Nanpil hydro plant is not currently operational. The Pohnpei power distribution system reaches nearly all inhabited areas of the main island.

The Yap State Public Service Corporation serves Yap Island and has four operational generators rated at 7.6 MW in total. The network reaches 98% of Yap Island's population and about 60% of the state's households.

The Chuuk Public Utilities Corporation serves the main island of Weno with 3.6 MW of effective capacity from two generators. An overhaul is underway on a third generator to bring capacity up to 5.4 MW. The peak load is 2 MW and the base load 1.9 MW. Because of the small current margin of capacity over peak load, the two operating generators must be in constant service, or risk outages which have been frequent in the past.

The Kosrae Utilities Authority has an effective capacity of 5.4 MW, a peak load of 1.2 MW and base load of just 0.7 MW. The vast majority of Kosrae's households (98%) are electrified through the grid. Overall, 46% of FSM's households are electrified through a state utility, ranging from Kosrae's near-complete coverage to the low of 19% in Chuuk.

Electricity tariffs. The electricity tariffs in FSM vary from state to state as shown in Table 5.

Table 5. Electricity tariffs in the FSM (2013)

State	Tariff
Chuuk	**Residential:** USD 0.5026 per kWh **Commercial:** USD 0.5326 per kWh **Government:** USD 0.5526 per kWh
Kosrae	**Residential:** < 100 kWh = USD 0.428 per kWh 101–1 000 kWh = USD 0.468 per kWh 1 001–10 000 kWh = USD 0.478 per kWh 10 001–100 000 kWh = USD 0.471 per kWh >100 000 kWh. = USD 0.411 per kWh **Commercial:** < 100 kWh = USD 0.468 per kWh 101–1 000 kWh = USD 0.478 per kWh 1 001–10 000 kWh = USD 0.488 per kWh 10 001–100 000 kWh = USD 0.478 per kWh >100 000 kWh. = USD 0.438 per kWh **Government:** < 100 kWh = USD 0.528 per kWh 101–1 000 kWh = USD 0.528 per kWh 1 001–10 000 kWh = USD 0.542 per kWh 10 001–100 000 kWh = USD 0.528 per kWh >100 000 kWh. = USD 0.488 per kWh **Industry:** < 100 kWh = USD 0.528 per kWh 101–1 000 kWh = USD 0.528 per kWh 1 001–10 000 kWh = USD 0.533 per kWh 10 001–100 000 kWh = USD 0.523 per kWh >100 000 kWh. = USD 0.448 per kWh
Pohnpei	**Residential:** USD 0.14 per kWh Service charge USD 4.0 per month **Large power users:** USD 0.12 per kWh Charges USD 19.0 per month **Industrial:** USD 0.12 per kWh (<100 000 kWh per month); USD 0.08 per kWh (>100 000 kWh/ per month); Charges USD 33.10 per month
Yaap	**Residential:** < 50 kWh = USD 0.3712 per kWh 51–250 kWh = USD 0.4242 per kWh > 250 kWh = USD 0.4507 per kWh Outer regions = USD1.0949 per kWh **Commercial:** < 1 000 kWh = USD 0.4507 per kWh > 1 000 kWh = USD 0.5303 per kWh Outer regions = USD1.1948 per kWh **Government:** USD 0.7683 per kWh Outer regions = USD1.6275 per kWh

3. Renewable energy opportunities

Biomass. Large areas of the native forests on the mountainous islands have been destroyed by timber extraction and agricultural expansion. Environmental issues and logistics make the harvest of indigenous forests for energy unlikely, so any biomass resource that can be made available must come from existing economic tree crops, primarily coconut. The FSM's coconut resource would be the best crop to use for biofuel production, and although there has been no significant copra production for years, production of around 6 500 tonnes per year appears possible. However, to achieve that level it would be necessary to renovate plantations, improve production efficiency and increase payments to copra producers.

Biogas. No resource assessment is available, but some urban waste and possibly some farm waste could make small-scale development possible. Chuuk is planning to upgrade its sewage treatment facility, which could be a biogas source although it would probably only provide enough power to meet the needs of the facility itself. Upgraded landfills are also possible sources. The use of biogas digesters has been piloted at boarding schools using waste from associated piggeries.

Solar energy. The FSM has a good to very good solar resource with average insolation of around 5.5 kilowatt per square metre per day (kW/m^2/day) on horizontal surfaces, a level sufficient for cost-effective photovoltaic and solar water-heating use.

Wind power. A limited wind resource assessment has been carried out in Yap and sufficiently high wind areas have been located on the main island that may allow cost effective power generation. Detailed assessments are planned for 2013 at two high-wind sites, one close to Colonia, Yap, and the other at Tonowas, in Chuuk. The resource in these areas is seasonal and, based on weather measurements, appears modest, but there may be areas of sufficient wind to support a cost-effective installation.

Hydropower. Pohnpei has an estimated 4–5 MW of developable hydro potential on the Seniphen River and the Lehnmasi River. Output would be seasonal, but could result in large fuel cost-savings. Kosrae has a site on the Malem River, capable of about 35 kilowatts (kW), but land tenure issues have prevented its development.

Wave energy. A moderate resource is probably present, although buoy-based wave assessments in the region by the South Pacific Applied Geoscience Commission (SOPAC) in the 1980s and 1990s did not include detailed resource assessments for the FSM.

Ocean thermal energy conversion (OTEC). Thermal gradient surveys of the North Pacific carried out in the 1970s by the United States and more recently by SOPAC suggest that a large resource is likely to be present. However, this cannot be developed with current technologies at a cost compatible with the small-scale needs of the FSM.

Geothermal energy. There is no known developable resource.

4. Experiences with renewable energy technologies

Many small-scale "demonstrations" of various renewable energy technologies were carried out in the FSM during the TTPI years, mostly during the 1970s and 1980s. However most were not sustained for very long and none have survived as operating facilities.

Solar Photovoltaics. A cholera epidemic in 1982, probably caused by poor water sanitation, led Chuuk State to provide more than 200 small solar pumps to residents for pumping ground water. The units were well-received, and spare parts for the pumps were still being purchased 20 years after their original installation.

In Pohnpei, state trials of solar energy for village electrification were carried out in Mwoakilloa in the late 1980s. Though the project was not sustained, the experience led to the development of improved technical and institutional arrangements for a total of nearly 500 installations in Mwoakilloa, Pingelap, Sapwuhafik and other Pohnpei State outer islands. Table 6 shows the solar home installations made in Pohnpei state between 1986 and 2000. Yap state also has had village electrification projects using solar power. The most recent are a French-funded project for 50 Satawal homes and the solar mini-grid electrification of two Ulithi Atoll islets – Asor and Fadrai – by the EU in 2006. Some private solar installations also exist, but no survey has been carried out to determine their characteristics or number.

The EU electrified schools and health centres with off-grid solar installations in Pohnpei and Chuuk in 2005–2006, with alternating current (AC) power using sealed Outback Power Inverters that have so far worked satisfactorily for six years. In Kosrae, 51.26 kWp

Table 6. Solar home systems installed in Pohnpei, 1986–2000

Year	Location	No.	Wp	Equip Type	Volts	Tariff	O&M	Status	Remarks
1986	Main Island	2	78	Two 15 watt fluorescent lights	12 volts DC	Buy unit to own @ USD 511/unit	Owner and Energy Office	None in service	Systems beyond repair
Early 1990s	Mwoakilloa	47	100	Four 15 watt lights & one freezer	24 volt DC	USD 15.00 per month No Fee Collection anymore	Energy Office, island trained technicians	5% operating	60% of panels OK. Batteries controllers and other components need replacement
1999	Sapwuahfik	105	75	Two 15 watt lights	12 volt DC	USD 5.00 per month No Fee Collection anymore	Energy Office, island trained technicians	25% operating	60% of panels OK. Batteries controllers and other components need replacement
2000	Parem	50	100	Two 15 watt lights	12 volt DC	USD 5.00 per month No Fee Collection anymore	Energy Office, island trained technicians	10% operating	60% of panels OK. Batteries controllers and other components need replacement
	Lenger	17							

Source: 2012, SPC, Review of Outer Islands Electrification Programmes in the FSM.

Where Wp is watts-peak; Equip is Equipment; DC is direct current; O&M is operation and maintenance.

of grid-connected solar was installed under the same EU project. Table 7 shows the solar installations made under that EU project; Table 8 shows Compact-funded solar installed in Chuuk; and Tables 9 and 10 further EU-funded solar projects planned under the European Development Fund (EDF) energy facilities.

Yap has completed a feasibility study that indicates that 300 kWp of grid-connected solar is feasible to be installed under ADB funding. The installations will be all mounted on government buildings and will be well-distributed geographically to keep the overall variation in solar output caused by cloud passages to a minimum.

Two major projects are in the pipeline. On Yap, the EU Energy Facility II will electrify 10 outer islands with solar home systems for homes and provide stand-alone micro-grid systems for most public facilities such as schools and health centres. Those outer islands in Yap that are already electrified through diesel power will be addressed by the EU-funded 10th European Development Fund (EDF-10), North Pacific Renewable Energy and Energy Efficiency Project (North-REP). This includes Mogmog, Woleleai, and Falalop islands, where solar PV will largely replace diesel generation, with the diesel sets kept as a backup. The North-REP project will also expand the grid-connected system capacity for Kosrae and provide off-grid systems for a school along with some home lighting kits in Walung village. Chuuk will receive electrification for 16 schools, 17 health centres plus some 3 000 solar lanterns with associated charging stations for general use by residents.

Solar thermal. Solar water heating has been used for hotels, hospitals and guesthouses for many years. An increasing number of private homes in the urban areas of

Table 7. Solar Photovoltaics (PV) installed under EU EDF-9, 2006-2007

State	Island	Type	Capacity
Yap	Asor	Village Power PV mini-grid	19.5 kWp
	Fadrai	Village Power PV mini-grid	28.08 kWp
Chuuk	Satawan	High School	6.6 kWp
	Mock	Public Facilities – PV Micro-grid	6.7 kWp
	Udot	High School	3.4 kWp
	Onoun	Public Facilities – PV Micro-grid	10.5 kWp
Pohnpei	Kapingamarangi	School	5.8 kWp
		Dispensary and Municipal Office	4 kWp
	Nukuoro	Dispensary	3 kWp
		School	4.6 kWp
	Sapwaufik	School, Municipal Office	8.4 kWp
		Dispensary	3 kWp
	Mwaokollao	School	6.1 kWp
		Dispensary	2.5 kWp
	Pingelap	School	6.2 kWp
		Dispensary	2.5 kWp
Kosrae	Airport	Grid-connected solar	7.8 kWp
	State Building	Grid-connected solar	11.7 kWp
	State Public Health	Grid-connected solar	16.38 kWp
	KUA Car Park	Grid-connected solar	4.68 kwp
	Legislature Chamber	Grid-connected solar	11.7 kWp

Source: FSM Draft Energy Policy 2010a, and KUA.

Table 8. COFA-funded PV for Chuuk

Atoll-Island	kWp
Truk Lagoon / Romum -Winisi	1.1
Truk Lagoon / Sapore – Fefan	1.1
Truk Lagoon / Parum – Nukanap	1.1
Truk Lagoon / Fefen – Ununno	1.1
Truk Lagoon / Fonoton – Sapota	1.1

Source: SPC, 2012, Review of Outer Islands Electrification Programmes in the FSM.

the FSM are using imported solar water heaters but the percentage of homes with installations is still quite low.

Wind power. Although wind energy has already been used for water pumping in the FSM, using the multi-bladed windmills common in the USA central plains, there have been only small-scale demonstrations of electricity generation by wind power and they have not been considered technically or economically successful. However, Yap has recently completed a feasibility study that recommends using ADB funding to integrate 1.5 MW of wind generation into its grid. Only two turbines probably will be initially installed, with further

Table 9, EDF-10 (North-REP) PV Installations

State	Atoll/islands/village	Type of system	Number
Kosrae	Walung – households	PICO Lighting Systems – 2 lights	42
		PICO Lighting Systems – 3 lights	12
		PICO Lighting Systems – 4 lights	4
	Walung – school	PV Stand-alone System – 6 kWp	1
Chuuk	Truk Lagoon / Fefen – High School & Dispensary	PV mini-grid – 14 kWp	1
	Truk Lagoon / Fefen – Elementary School	PV stand-alone system – 8 kWp	1
	Truk Lagoon / Uman – Elementary School	PV stand-alone system – 6 kWp	1
	Truk Lagoon / Fanapanges – El. School & Disp.	PV stand-alone system – 7 kWp	1
	Truk Lagoon / Fonoton – El. School & Dispensary	PV stand-alone system – 7 kWp	1
	Truk Lagoon / Tol – El. School (Central Wonip)	PV stand-alone system – 6 kWp	1
	Truk Lagoon / Tol – El. School (Munien)	PV stand-alone system – 4 kWp	1
	Lekinioch / Jr. High School and dispensary	PV mini-grid – 11 kWp	1
	Oneop / Elementary School	PV stand-alone system – 6 kWp	1
	Truk Lagoon / Fefen – Sapore	Solar lanterns	800
	Truk Lagoon / Fefen – Kukku	Solar lanterns	300
	Truk Lagoon / Uman – Sapota	Solar lanterns	500
	Truk Lagoon / Fanapanges	Solar lanterns	300
	Truk Lagoon / Fonoton	Solar lanterns	300
	Truk Lagoon / Tol – Central Wonip	Solar lanterns	300
	Truk Lagoon / Tol – Munien	Solar lanterns	150
	Lekinioch	Solar lanterns	500
	Oneop	Solar lanterns	250
Yap	Ulithi-Falalop / High-School	PV Mini-grid / 62.7 kWp	1
	Ulithi-MogMog (island grid)	PV Mini-grid / 34.4 kWp	1
	Woleai – Falalop	PV-Diesel hybrid / 41 kWp	1
	Fais	PV Micro-grids / 20 kWp (2) – 25 kWp	3
	Satawal	PV Micro-grids / 20 kWp (3) – 15 kWp	4

Source: SPC, 2012. Review of Outer Islands Electrification Programmes in the FSM.

turbines added when the benefits of the project have been demonstrated.

Biofuels and biomass. Biomass combustion remains a major energy source for rural cooking, but no significant development of biomass or biofuels for commercial energy has taken place even though the potential for biofuel use appears good, especially on the outer island electrification where most of the coconut resource is located. Placing modular oil mills on each island, as is being done in Fiji, appears to be a better approach than shipping copra to a central mill on the main island and then shipping coconut oil back to outer islands to be used as fuel. However, a number of institutional issues will need to be resolved before this approach can be expected to work well.

Hydropower. During the years of Japanese administration (1918–1945), several small hydro installations were developed but were not maintained after World War II and provided little energy in the post-war years. Increasing demand for electricity and increasing costs of production have now led to renewed interest in hydro development. In 1988 the Nanpil run-of-river hydropower system in Pohnpei was commissioned at the site of an earlier pre-war Japanese installation. A real capacity of 1.8 MW was possible but stream flows are widely variable and the installation could not be considered as able to provide firm capacity for the power system. The installation was rebuilt in the 1990s but is not currently working due to mechanical problems.

Ocean energy. In 2013 Kosrae hopes to connect 1.5 MW of wave power capacity to its grid using the Wavesurfer™ technology from Ocean Energy Industries. If it goes ahead, the Kosrae Utility Agency will form a joint venture, Kosrae Ocean Energy, with Ocean Energy Industries to provide private sector financing for the operation of the installation.

Hydropower. The EU-funded (EDF-10) North-REP project will rehabilitate the Nanpil hydro facility in Pohnpei that feeds the Pohnpei grid.

Biogas. Several small-scale trial units have been installed with the help of China (2008) and are being monitored. One private household uses pig waste in a digester to make cooking gas.

Table 10. PV installations for Yap under the EU EF-II

Atoll-Island	Pop.	Type of system	No.
Ngulu	26	Solar Home Systems – 500 Wp	5
		PV for public facilities – 2.5 kWp	1
Woleai _ Falalus	146	Solar Home Systems – 500 Wp	20
		PV for public facilities – 2.5 kWp	2
Woleai _ Siliap	94	Solar Home Systems – 500 Wp	20
		PV for public facilities – 2.5 kWp	2
Woleai _ Tagailap	119	Solar Home Systems – 500 Wp	20
		PV for public facilities – 2.5 kWp	2
Woleai _ Wattagai	122	Solar Home Systems – 500 Wp	25
		PV for public facilities – 2.5 kWp	2
Euripik	113	Solar Home Systems – 500 Wp	21
		PV for public facilities – 2.5 kWp	2
Faraulap – Falalap	141	Solar Home Systems – 500 Wp	25
		PV for public facilities – 2.5 kWp	2
Faraulap – Pigue	80	Solar Home Systems – 500 Wp	20
		PV for public facilities – 2.5 kWp	1
Elato	96	Solar Home Systems – 500 Wp	20
		PVfor public facilities – 2.5 kWp	2
Ifalik	561	Solar Home Systems – 500 Wp	90
		PV for public facilities – 2.5 kWp	2
Lamotrek	339	Solar Home Systems – 500 Wp	70
		PV for public facilities – 2.5 kWp	2
		Total Solar Home Systems	**336**
		Total Stand-Alone Systems for Public Facilities	**20**

Source: EFII paper and YSPSC.

5. Challenges for renewable energy deployment

The challenges for renewable energy deployment are known to include:

- Subsidised electricity tariffs making conventional power appear less costly than renewable alternatives.
- Poor collection of electricity utility charges in some states making it difficult to collect charges for renewable energy used for electricity production.
- No incentives for renewable energy technology development at state or national level.
- Weak energy policies and insufficient legislation to encourage renewable energy use.
- Lack of national energy officers, planners and regulators in state and national government.
- No coordination of energy matters, authority is spread over several ministries.
- Lack of institutional arrangements suitable for renewable energy operations.
- Poor understanding of opportunities and obstacles to renewable energy development.
- Individual states being small and lacking the skills for large-scale project design and implementation.
- Small dispersed populations, with many outer islands that are expensive to access.
- Low level of public awareness regarding energy issues and options.
- Limited renewable energy technology and energy efficiency technology training capacity.
- Land tenure issues.
- Vulnerability to cyclone damage (except Kosrae).

IRENA can suggest pathways to overcome these challenges through its Global Renewable Energy Islands Network (GREIN) and believes that regional and national roadmaps should reflect these pathways. IRENA will continue to work with existing regional and national stakeholders to achieve the transition to renewable energy for a secure and sustainable energy supply.

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In the preparation of this report, primary sources were used as much as possible. Some information was obtained through written questionnaires, some through interviews and some through email correspondence. Where primary sources were not available, the following secondary and tertiary sources were used.

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