IRENA
International Renewable Energy Agency

A Path to Prosperity:

RENEWABLE ENERGY FOR ISLANDS

Second Edition

Prepared on the occasion of the Island Energy Transitions conference, held in Fort-de-France, Martinique, 22-24 June 2015

A PATH TO PROSPERITY: RENEWABLE ENERGY FOR ISLANDS

A Path to Prosperity: Renewable Energy for Islands presents a compilation of case studies from small island developing states (SIDS) and development partners. These demonstrate real-life project viability, highlight innovative solutions and showcase successful partnerships, which together are advancing the deployment of renewable energy in SIDS. The first edition of *A Path to Prosperity: Renewable Energy for Islands* was released at the Third International Conference on Small Island Developing States, held in Samoa in 2014. The second edition expands on the database of projects and introduces a selection of tools which may be of assistance to SIDS in their renewable energy transition.

A Path to Prosperity: Renewable Energy for Islands was made possible through the engagement and contributions of the governments of Antigua & Barbuda, Bahamas, Cabo Verde, Fiji, France, Germany, Jamaica, New Zealand, St. Vincent and the Grenadines, Samoa, Tokelau, Vanuatu, the United Arab Emirates and the United States of America, as well as Aguas de Ponta Preta, the Asian Development Bank, the Caribbean Development Bank, the ECOWAS Commission for Renewable Energy and Energy Efficiency, Fondation Energies pour le Monde, the International Renewable Energy Agency (IRENA), the United Nations Development Programme and the World Bank. Country information was obtained from the CIA World Factbook. Highlighted tools stem from IRENA island-related programmatic work spanning the last five years.

A Path to Prosperity: Renewable Energy for Islands was prepared in support of the Martinique conference, *Island Energy Transitions*, taking place in Fort-de-France on 22-24 June 2015. Under the umbrella of the SIDS Lighthouses Initiative, the Martinique conference will gather stakeholders to consider resources, technology, markets, financing and other aspects of renewable energy development on islands.

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SIDS
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LIGHTHOUSES

The 21st Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC), or COP21, to be held in Paris in December 2015, will be a key milestone in the international effort to curb global warming. Small Island Developing States (SIDS) can act as lighthouses by transforming their costly oil-based power generation towards renewable energy, addressing at the same time affordability and climate change.

SIDS LIGHTHOUSES INITIATIVE

The extraordinary momentum created in 2014 by the International Year for Small Island Developing States, the Third International Conference on Small Island Developing States and the UN Secretary General's Climate Summit has set the focus of the international community on the imperative of sustainable development for SIDS. Within this context, there is a central role for renewable energy. SIDS and partners are taking decisive steps to accelerate renewable energy deployment in support of sustainable development for all SIDS. During the Renewable Energy Forum that took place in Samoa on 30 August 2014, leaders and experts highlighted the importance of renewable energy for supporting the sustainable development of SIDS and highlighted the key areas that need to be addressed in order to advance renewable energy in SIDS.

While energy use and greenhouse gas emissions from islands represent only a small share globally, SIDS provide a unique opportunity to demonstrate successful transitions to very high shares of renewable energy. In addition, the relatively small size of SIDS means that renewable energy transitions can be implemented in a shorter period of time and thus quickly provide valuable insights to assist with renewable energy transitions in other remote areas and larger energy systems worldwide.

The SIDS Lighthouses Initiative (in brief: Lighthouses) supports the strategic deployment of renewable energy in SIDS, brings clarity to policy makers regarding the required steps, and enables targeted action. As a joint effort of SIDS and development partners, this framework for action is assisting in transforming SIDS energy systems through the establishment of the enabling conditions for a renewable energy-based future.

Lighthouses has five main objectives:

- Develop and implement a structured approach to island power sector transitions to high shares of renewable energy through a set of guidelines, tools and support mechanisms, thus enabling more efficient use of resources
- Accelerate renewable energy transitions through identification of needs and gaps, and learning from experiences on other islands
- Strengthen knowledge base and building of institutional capacity that can handle a rapid and profound transition
- Facilitate development of enabling frameworks for investment
- Identify funding opportunities and facilitate matchmaking between project developers and funding organisations

The SIDS Lighthouses Initiative was officially launched on 23 September 2014 at the UN Climate Summit in New York City. During an initial five-year timeframe, the Initiative focuses on the electrical power sector and aims to achieve the following quantitative targets:

- Mobilise USD 500 million in funding for renewable energy transition in SIDS

- Deploy 100 MW of new solar PV
- Deploy 20 MW of new wind power
- Deploy significant quantities of small hydropower and geothermal energy and a number of marine technology projects
- Ensure all SIDS develop renewable energy roadmaps

STATUS OF THE INITIATIVE

During the Samoa Conference on 30 August 2014 as well as the Climate Summit in New York on 23 September 2014, renewable energy was highlighted as a crucial part of sustainable development and as a solution for climate change. At the Summit, the SIDS Lighthouses Initiative was featured as an area for collaborative action, receiving strong support from SIDS, development partners and private sector stakeholders. The Initiative has grown from 32 partners to 45 at present, including Aruba, Antigua and Barbuda, Bahamas, Barbados, Belize, Cabo Verde, Comoros, Cook Islands, European Union, Fiji, France, Germany, Grenada, Guyana, Italy, Japan, Kiribati, Maldives, Marshall Islands, Mauritius, Nauru, New Zealand, Norway, Palau, Samoa, São Tomé and Príncipe, St. Vincent and the Grenadines, Seychelles, Federated States of Micronesia, Solomon Islands, Tonga, Trinidad and Tobago, Tuvalu, Vanuatu, United Arab Emirates, United States of America, and Carbon War Room, Clinton Climate Initiative, ENEL, Indian Ocean Commission, IRENA, Rocky Mountain Institute, SE4ALL, UNDP, the World Bank Group. Interest from new partners to join is growing.

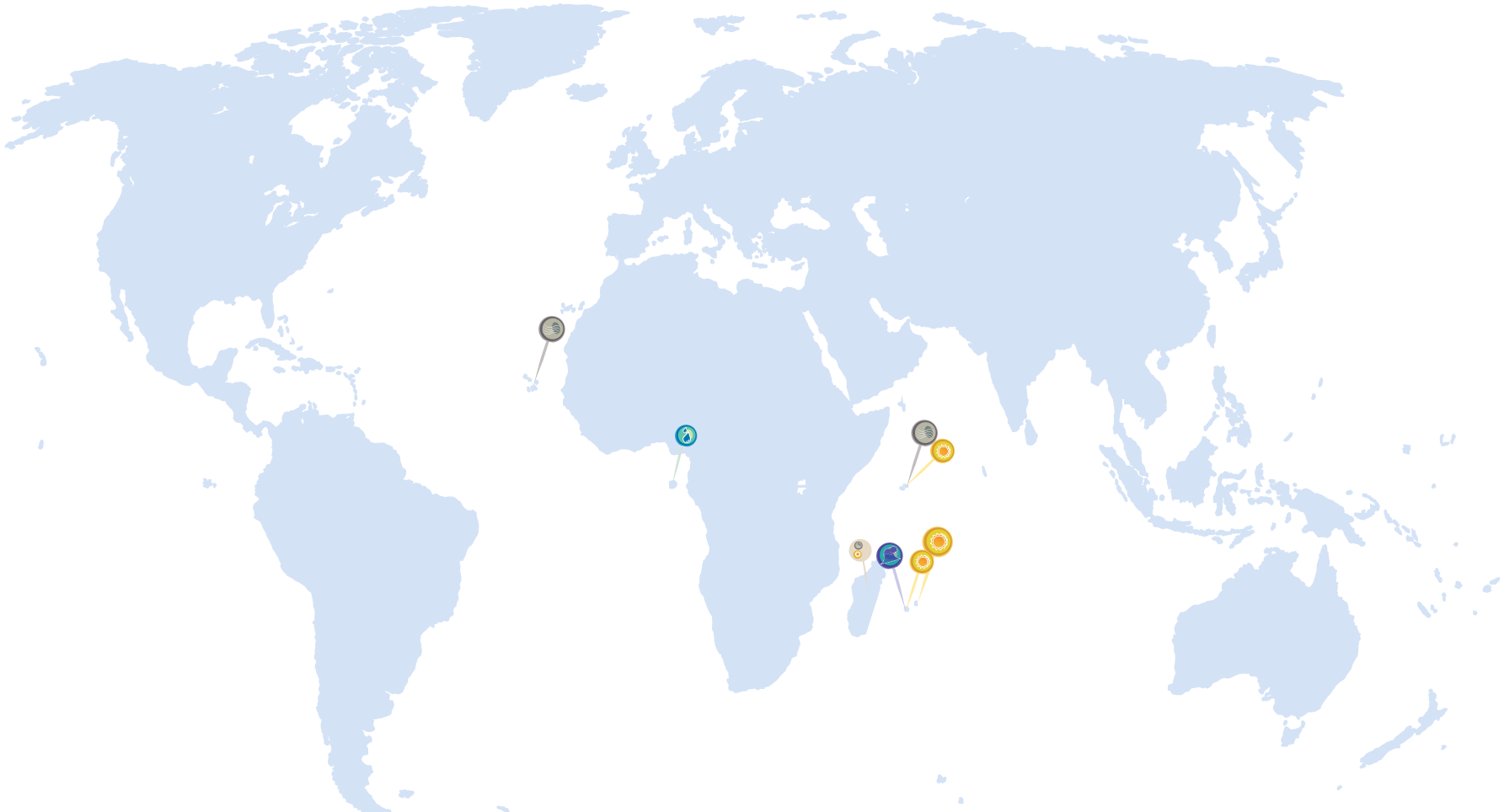
CONTINUING IMPLEMENTATION

Despite recent targeted action, many islands face continued barriers during the different stages of project development. For example, increased island investment has meant that many islands are in a situation of project overload, creating a need for islands to focus resources on electricity system design and integration before pursuing new projects. Lighthouses helps islands assess and address these issues to enable stronger, sustainable development and smart integration of renewables.

Lighthouses works with partners to apply all operational steps and develop a comprehensive overview of SIDS power sector knowledge, best practice and transformation issues. With partner support, this overview will bridge the gap between studies and projects on the ground through innovative deployment mechanisms.

Under the umbrella of the SIDS Lighthouses Initiative, *A Path to Prosperity: Renewable Energy for Islands* provides real-life examples of renewable energy projects, key insights and lessons learned to stakeholders. Based on feedback received, information on selected tools which may be of assistance to SIDS in their transition to renewable energy has also been provided.

Contributions to the project database and profiled tools are welcome.



Atlantic, Indian Ocean, Mediterranean and South China Sea

Cabeolica Wind Project, **Cabo Verde**

Sustainable Energy Services for Isolated Communities Through Renewable Energy Powered Micro-Grids in Santo Antão (SESAM-ER), **Cabo Verde**

Decentralised Rural Electrification in Southern Madagascar (Resouth), **Madagascar**

Renewable Energy and Energy Efficiency in Buildings and Industry, **Mauritius**

Agrinergie, **Réunion**

OTEC in French Overseas Territories, **Réunion**

Technical Assistance for Power Sector Efficiency Improvement in São Tomé and Príncipe, **São Tomé and Príncipe**

Port Victoria Wind Farm, **Seychelles**

Cabeolica Wind Project

Cabo Verde archipelago
Date started: 2006
Date completed: 2011

Republic of Cabo Verde
Area: 4 033 sq km
Coastline: 965 km
Population: 538 535 (July 2014 est.)
GDP: USD 3,389 billion (2014 est.)

The Cabo Verde archipelago is one of the best sites for wind power generation since it is located in the northeast trade winds belt. Wind power was first deployed here in 1994. The government set a target to generate 50% of its energy from renewable energy sources by 2020 and ultimately, 100%. This was due to:

- The islands' heavy reliance on expensive and imported diesel (which is not environmentally friendly).
- The high price of transporting fuel.
- The unreliable electricity supply.

The Cabeolica project was part of this strategy. It was a joint effort financed by the European Investment Bank, the African Development Bank, the African Finance Corporation, Finnfund and InfraCo Africa.

The Private Infrastructure Development Group provided a USD 170 000 grant to fund wind pattern and technical engineering studies during the development phase of the project.

Main features

Scale: Up to 25.5 MW of power generated by 30 turbines

Project budget (USD): 78 million

Funding source: Public-private partnership

- The Cabeolica Wind Project involves 30 turbines in four wind farms on Boa Vista, Sao Vicente, Sal and Santiago islands.
- The farm on Santiago Island, the site of the largest of the four wind farms, was the first put into operation in September 2011.
- It was developed, commissioned and deployed by InfraCo Africa, a multi-government funded, privately managed company. The project is now managed by Cabeolica SA established in 2009 by the Government of Cabo Verde, Electra (the government owned utility) and InfraCo Africa, the lead project developer.

Impact

- The Cabeolica Wind Project won the 2011 Africa Energy Renewable Energy Project of the Year Award. It is the first infrastructure public-private partnership (PPP) in Cabo Verde and the first PPP in the renewable power sector in Sub-Saharan Africa.
- The wind farms are expected to generate approximately 25% of the country's energy, thereby diversifying the energy mix and protecting the electricity sector from oil price volatility.
- The power generated is cheaper, cleaner and more reliable, helping to decrease the number of outages and support economic growth.
- As a result of the project, an additional 50 000 citizens were connected to the national electricity grid.
- Power generation costs are expected to be approximately 20% less than before. Oil imports are expected to be greatly reduced by up to 20 000 tonnes.

Project insights

- The project design and financing can be replicated elsewhere, particularly in other Sub-Saharan regions at scales suitable to the relevant countries.

Sustainable Energy Services for Isolated Communities Through Renewable Energy-Powered Micro-Grids in Santo Antão (SESAM-ER)

Porto Novo City, Santo Antão, Cabo Verde
Date started: March 2008
Date completed: February 2012

Republic of Cabo Verde
Area: 4 033 sq km
Coastline: 965 km
Population: 538 535 (July 2014 est.)
GDP: USD 3,389 billion (2014 est.)

CABO VERDE

Monte Trigo is a fishing village of about 270 residents, located in the south of Santo Antão, with no adequate road access or connection to the national grid. The community only had limited access to electricity from a diesel generator which was difficult to maintain. The lack of fuel hampers its development, making this fishing community one of the most vulnerable in Porto Novo. The isolation, lack of reliable transportation infrastructure and the high poverty rate contribute to this vulnerability. Generation costs were even higher than the national tariff of USD 0.45, which is one of the highest in West Africa. The project was deemed important to showcase electrification possibilities through means other than grid extension.

Main features

Renewable energy source: Solar power

Technology and Scale: Number of panels: 290 (210 panels of 130 Wp and 80 panels of 150 Wp)

Project budget (USD): 498 115

Funding source:

Owner: Municipality of Porto Novo (public)

Implementation and operation: APP - Águas de Ponta Preta, lda (private)

Co-financing: 75% European Union (Energy Facility) and 25% Municipality of Porto Novo

- The micro solar photovoltaic power plant supplies 39,3 kWp for 24

hours a day to 75 houses and institutions.

- Excess energy produced in the photovoltaic power plant is used by fishermen for refrigeration purposes.

Impact

- Monte Trigo is the only 100% green village in Cabo Verde. The diesel generator previously used has barely been used since the completion of the project in 2012.
- Operating costs decreased from 2 009 532 CVE (20 095 USD) to 534 672 CVE (5 347 USD). Costs include those for fuel and staff.
- Between February 2012 and February 2015:
  - 91 899 kWh of power generated;
  - approximately 26 787 litres of fuel saved;
  - about 80 tons of CO_2 emissions avoided.

Project insights

- Large distances separating villages from urban areas are a disincentive to investment in energy transportation and grid extension to these areas.
- Monte Trigo receives regular visitors from the rest of the country and West Africa interested in the potential of mini-grids for rural electrification.
- Experiences from Monte Trigo are now being replicated in a new project started in 2015. The project aims to create a regulatory framework for mini-grids and to institute tariff setting at the national level.

Decentralised Rural Electrification in Southern Madagascar (Resouth)

Ambondro and Analapatsy, Southern Madagascar
Date started: 2008
Date completed: 2012

Republic of Madagascar
Area: 587 041 sq km
Coastline: 4 828 km
Population: 23 201 926 (July 2014 est.)
GDP: USD 33.64 billion (2014 est.)

MADAGASCAR

In 2011, the rural electrification rate in Madagascar was just 5%. With limited access to modern energy sources, rural communities have relied on traditional sources which are expensive and harmful to the environment. To provide electricity to communities located far from the national grid, where the ability to pay for energy is limited, decentralised solutions using renewable energy are attractive options. As a result, the Fondation Energie pour le Monde (Fondem) carried out a study in Southern Madagascar. The two villages of Ambondro and Analaptsy were selected as sites for the implementation of pilot projects.

Main features

Renewable Energy Source: Wind and solar

Scale:

Ambondro: 2 wind turbines connected to a local grid distribution of over 3.5 km.
Total power: 2 x 6 kW
Total battery storage capacity: 5280Ah@C120

Analapatsy: 78 individual solar photovoltaic systems with a power range between 40 and 240 Wp
Total power: 5 kW

Project budget (USD): The costs below cover the supply and installation of the electrical equipment:

Ambondro: 320,000
Analapatsy: 150,000

Funding source:

Multilateral: European Commission

Public: French Environment and Energy Management Agency (ADEME); French Ministry of Ecology, Sustainable Development and Energy; Madagascar's Ministry of Energy

Private: Electricité de France; the company Total; private donations

- As the first stage of regional rural electrification plans, the Resouth project was launched in 2008 by Fondem in close collaboration with local partners: the Madagascar Ministry of Energy, local and regional authorities, and local NGOs as a path to increased local economic development.

- Solar energy was deployed at Analapatsy and a central wind turbine at Ambondro. These choices were made based mainly on local energy resources and needs, population density, and the presence of suppliers in close proximity to the sites.
- Timetables for energy consumption, appropriate pricing, the management of the system by local operators and relations with the competent authorities needed to be established.
- During project implementation, local technical and consulting firms were hired.

Impact

- Today, approximately 200 end-users and more than 1,200 people benefit directly from electricity access provided by the Resouth programme. As a result, 5 000 inhabitants of the two communities benefit from the improved quality of social and economic services.
- About 20 micro-businesses benefitted from access to electricity.
- The project diversifies energy supply and reduces the use of diesel and traditional biomass.
- Two solar generators were manufactured and donated by the French constructor Soitec, and were installed in Ambondro after the completion of the project to increase the available electricity when there is little wind and allow the connection of more end-users. The total power generated by these 2 solar generators is of 2.3 kWp.
- A network of actors has been established within the island through increased awareness, training and partnerships for decentralised electrification using renewable energy.

Project insights

- In an attempt to reduce costs and improve efficiency, the scale of projects needs to be expanded. This can be achieved by developing similar projects to suit local conditions in villages within a specific geographical area.
- A similar project is now being implemented by Fondem in Boreale. It aims to electrify 7 communities through solar energy before 2016.

Renewable Energy and Energy Efficiency in Buildings and Industry

Mauritius
Date started: 2008
Date completed: 2014

Republic of Mauritius
Area: 2 040 sq km
Coastline: 177 km
Population: 1 331 155 (July 2014 est.)
GDP: USD 20.95 billion (2013 est.)

The cost of importing fossil fuels for energy generation in Mauritius is significant. Renewable energy sources are not yet widely used and energy consumption in buildings and industry is often inefficient. The building sector alone accounts for about 78 % of total national carbon emissions. Efforts to promote renewable energy and energy efficiency through a market approach are under way. To date, significant measures have been taken to reduce barriers to the adoption of rooftop photovoltaic (PV) systems and improve energy efficiency in residential and commercial buildings. A similar approach is being pursued within the country's industrial sector. This project aims to sustainably transform and decarbonise Mauritius' energy future via a suite of policies and incentives in the areas of renewable energy and energy efficiency.

Main features

Scale: 3.8 MW installed capacity

Project budget (USD):

- GEF Grant implemented by UNDP: 912 411
- SIDS DOCK: 1 000 000
- Ministry of Energy & Public Utilities (in-kind): 400 000

Funding source: Public/Multilateral

MAURITIUS

The project aims to:

- Build institutional and human resource capacity at the policy level and to promote renewable energy and energy efficiency through de-risking policy instruments and financial incentive schemes.
- Promote local businesses in the industrial sector, such as textiles and food industry processing, by improving their energy efficiency.
- Pilot public and market-based instruments to shift investments from fossil fuels to more climate-friendly alternatives.
- Develop a Feed-in Tariff (FiT) scheme for small-scale energy systems smaller than 50 kW.

Impact

- The annual cost savings potential from energy efficiency measures in industrial sectors is expected to total USD 3 million.
- The project has supported the development and formal enactment of the 2012 Energy Efficiency Act which created a functional energy efficiency market.
- A new Energy Efficiency Code will complement the new Energy Efficiency Act, providing a comprehensive framework for buildings' energy management in Mauritius.
- Most participants are using the Code of Good Practice to guide their energy management decisions. Energy audits in various enterprises have revealed savings of up to 30% over the past six months.

- The FiT scheme for small-scale energy systems (smaller than 50 kW) has attracted over 400 applications for residential and commercial systems and over 80 applications from public, educational, non-governmental and religious organisations.

Project insights

- The newly developed clean energy policies and activities have made Mauritius a regional leader in the adoption of a clean energy, low-carbon pathway.
- Based on these experiences, a FiT scheme for PV systems over 50 kW will be promoted.
- Regulatory changes have stimulated demand and supply for energy-saving services and technologies in the building, industrial and appliance sectors. Some owners of non-residential buildings and industrial plants have voluntarily undertaken energy retrofits.
- The Ministry of Industry, Commerce & Consumer Protection is currently developing a software tool for the auditing of energy-intensive industries and has published an industrial energy audit guidebook and code of good practice for energy management in industries.

Agrinergie 5

Saint-Joseph, La Réunion
Date started: 2009
Date completed: In operation since 2011

Area: 2 511 sq km
Population: 840 974 (Jan 2013)
GDP: USD 21 billion (2012)

Réunion has set the ambitious target of becoming a net zero energy island by 2025. This is a particularly challenging goal due to the island's high population density. In light of this, Akuo Energy launched a solar and agricultural project, called Agrinergie 5, in a sugar cane cultivation zone in Saint-Joseph. This project involves the use of solar panels installed on the rooftops of hurricane-proof greenhouses.

Main features

Renewable energy source: Solar

Technology and scale: 1 400 kW

Project budget (USD): 8 million

Funding source: Private

- The solar farm consists of 1.3 ha of hurricane-resistant greenhouses and 1.4 MWp of PV capacity.
- Several tunnels of greenhouses facilitate the control of humidity and temperature for crops. The monocrystalline technology PV panels chosen were the most powerful on the market.
- The total annual production is more than 2 000 MWh of electricity.
- For the past 3 years, this innovative project has successfully produced electricity as well as organic vegetables sold to the local market and served in local canteens.

Impact

- The farm supplies more than 1 000 people with clean energy and supports the Saint-Joseph grid.
- The project created 40 jobs over the space of six months of construction.

Project insights

- Akuo has constructed five other solar greenhouses where crops such as tomatoes, watermelons, red peppers, eggplants and passion fruit are cultivated. Some of these plants were previously disappearing from Réunion. Precious flowers such as Lilies, Anthuriums and Orchids are grown in the greenhouses where experimentation with new cultures and old vegetable varieties is also carried out.
- The project shows that solar panels can be integrated into an agricultural area without competing for land use.

OTEC in French Overseas Territories

St-Pierre, La Réunion
Date started: 2010
Date completed: 2011

Area: 2 511 sq km
Population: 840 974 (Jan 2013)
GDP: USD 21 billion (2012)

Islands such as Réunion, which rely on fossil fuel imports for power generation, need to develop alternative solutions for their power needs. Aiming for a carbon neutral economy and a reduced dependence on fossil fuels, the local authorities have created partnerships with major industrial actors such as the DCNS, a naval defence company, to facilitate renewable energy deployment. Since 2009, the Réunion Island University, the Réunion Island Local Authorities and the DCNS have worked towards the deployment of ocean thermal energy conversion (OTEC) technology in tropical regions by constructing the first full scale industrial non-experimental OTEC plant in Réunion.

Main features

Technology and scale: The exchangers are approximately 1/100th of the size of a full scale plant.

Project budget (USD): 8 million over a five-year period.

Funding source: Public and private investments.

- Each year, the island's authorities and the DCNS jointly fund the PAT ETM Research and Development (R&D) project in order to test major components of future OTEC power plants being developed by the DCNS.
- The costs of the research program are divided roughly into three parts: research and engineering staff, operational costs and sub-contracted maintenance. Maintenance is provided almost entirely by local companies.

RÉUNION

- University staff and DCNS engineers run trials on the prototype technological heat exchangers for research purposes. The results enable the recalibration of the mathematical models used to design full scale OTEC heat exchangers.
- Different types of heat exchangers are tested in conjunction with a pseudo turbine.

Impact

- The PAT encourages local companies to increase their skill sets and train their staff in anticipation of the construction of more complex OTEC plants. It has become a recognised reference point in the international OTEC field.
- Building on the successful experience of the reduced scale pilot in Réunion, Akuo Energy and the DCNS are implementing the first full-scale offshore pilot OTEC plant in the world in Martinique. Martinique is an island with growing energy needs and is strongly dependent on fossil resources to produce base load power (94% from thermal plants). OTEC will provide a renewable, carbon-free and constant source of power and will make Martinique more self-sufficient in terms of energy consumption. The development of this new energy sector will also generate a significant number of jobs locally. The NEMO (New Energy for Martinique and Overseas) is planned to be operational in 2018 and will be capable of supplying electricity for 35 000 homes in Martinique. As an offshore floating plant, it also has very limited visual and landscape impacts and generates no sound pollution and no greenhouse gas emissions.

- Although the focus of OTEC is typically on the production of electricity, the energy produced has the potential to be used for desalinisation, aquaculture, hydrogen production and air-conditioning, all of which could add to its economic viability and further reduce dependence on fossil fuels. It is designed for usage in large tropical archipelagoes.

Project insights

- The project has provided further understanding of how heat exchangers perform in conditions of low pressure and limited temperature differential.
- The scientific and technical insights gained from the PAT help reduce the development costs of future OTEC power plants.

Technical Assistance for Power Sector Efficiency Improvement in São Tomé and Príncipe

São Tomé and Príncipe
Date started: September 2013 (initial proposal)
Date completed: January 2015

Democratic Republic of São Tomé and Príncipe
Area: 964 sq km
Coastline: 209 km
Population: 190 428 (July 2014 est.)
GDP: USD 612 million (2014 est.)

The energy sector in São Tomé and Príncipe faces critical challenges and has been identified as a major hindrance to the country's economic growth. Challenges relate to the need to reduce generation, transmission and non-technical losses; improve the financial sustainability of the electricity sector; and strengthen the public utility Empresa de Agua e Electricidade (EMAE). Resolving these power system issues are required for variable renewables such as solar photovoltaics to be connected to the grid.

The *Technical Assistance for Power Sector Efficiency Improvement in São Tomé and Príncipe* project aims to tackle these issues by improving the efficiency of the energy sector. Studies for the rehabilitation and capacity upgrade of the El Contador hydro power plant will also be done.

Main features

Renewable Energy Source: Hydro energy and grid improvements to enable other grid connected renewables

Technology and Scale: 4MW of hydro power

Project budget (USD): 300 000

Funding source:

Multilateral: SIDS-DOCK funding managed by the Energy Sector Management Assistance Programme (ESMAP) and the World Bank and executed by the World Bank in collaboration with the Empresa de Agua e Electricidade (EMAE).

- To reduce the large amount of technical failures, a load flow analysis was performed. The analysis identified overloaded equipment and additional protection requirements to isolate faults and improve reliability. The study included a catalogue of the installed protective devices and identified further protection needs and options for improvement. It evaluated the need to increase the voltage level in some transmission and distribution lines and outlined associated costs.
- State of the art technologies and methods to expand rather than simply replace installed capacity were considered.
- The project proposed a series of interventions to reduce unmetered consumption in a sustainable manner.
- The project also covered a feasibility study for the rehabilitation of El Contador power plant, including the evaluation of a capacity expansion from 2 to 4MW. The plant has been in operation since 1967.
- Both of the final reports have been presented to EMAE, the Ministry of Energy and other representatives of the Government of São Tomé and Príncipe.

Impact

- The replacement of meters at identified locations has been recommended in order to reduce technical and commercial losses. The report also recommends the implementation of a supervisory control and data acquisition (SCADA) system.
- The second report on the El Contador hydropower plant shows the technical and economic viability of the plant upgrade. This upgrade would significantly improve the electricity supply in São Tomé and Príncipe. Without the rehabilitation of the plant, São Tomé will lose an important asset available to meet peak demand.
- As a result of this project, the World Bank is preparing an infrastructure project to finance and implement the recommendations of both reports.

Project insights

- Improvements in metering and billing tools and processes, in addition to measures to avoid illegal connections, not only contribute to the reduction of non-technical losses, but also help to reduce technical losses, as consumers tend to decrease consumption as their ability to pay declines. This reduces peak load and electrical equipment overloading.
- Additional technical assistance is on-going in order to explore the potential reconstruction of small hydro power plants on colonial plantations and in other locations.

Port Victoria Wind Farm

Mahé, Seychelles
Date started: April 2013
Date completed: May 2014

Republic of Seychelles
Area: 455 sq km
Coastline: 491 km
Population: 91 650 (July 2014 est.)
GDP: USD 2.404 billion (2013 est.)

The Seychelles, located in the western Indian Ocean, has been nearly 100% dependent on diesel imports for power, resulting in high prices, low energy security and constraints on growth and development. Based on this, the government set a renewable energy target of 15% by 2030. As part of the close cooperation between the Seychelles and the UAE, Masdar identified and executed the country's first large-scale sustainable supply solution, the Port Victoria Wind Farm project, which aims to alleviate the economic impact of diesel imports in the Seychelles and to normalise the use of renewable energy.

Main features

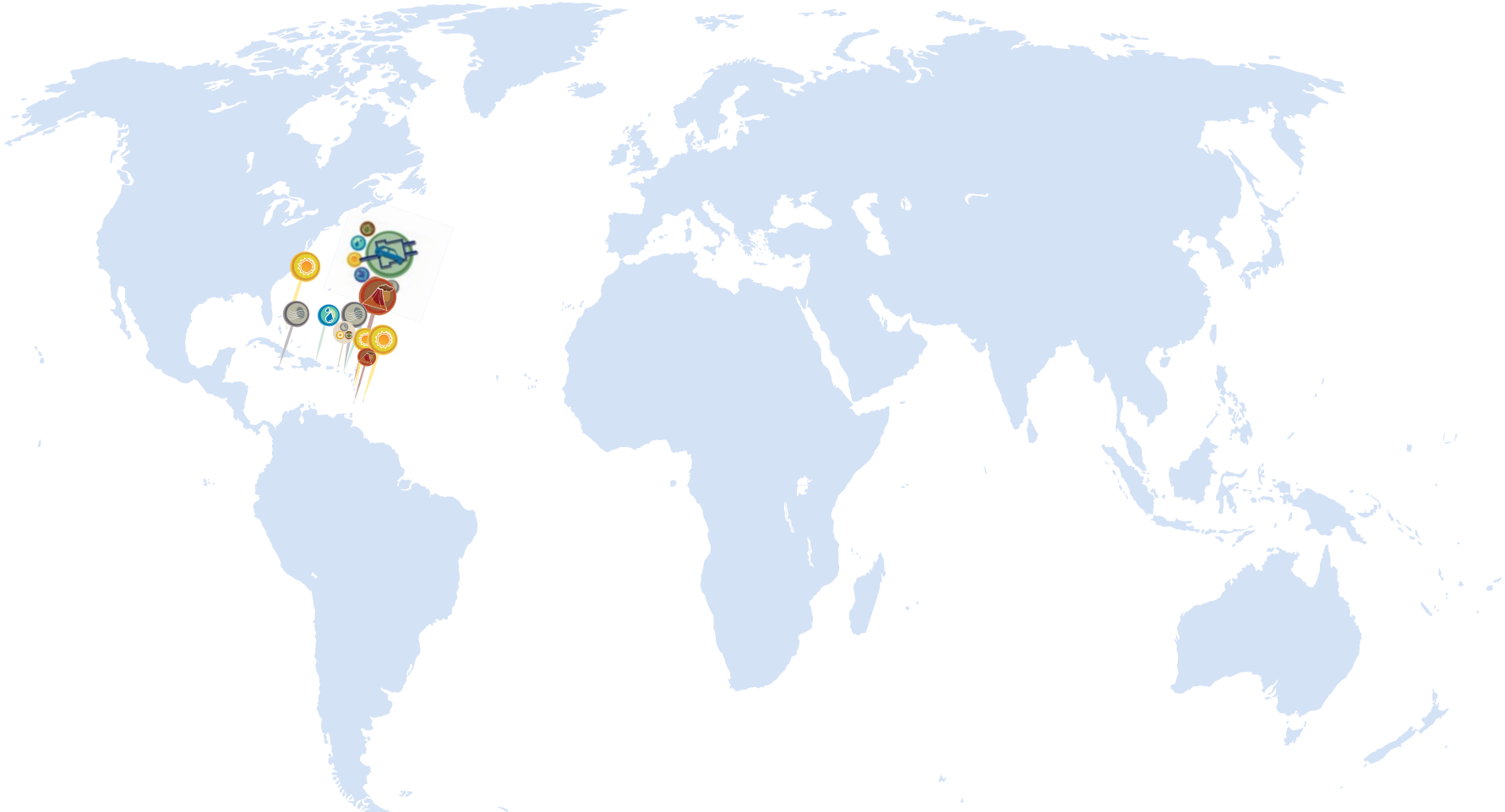
- The project was enabled by strong government support for implementation and land acquisition, matched with grant-funding from the UAE.
- The project's large size meant that careful study of grid stability was necessary, given the implications for project design.
- 8 x 750 kW wind turbines were built on two existing reclaimed islands with high wind potential, opposite the harbour of the capital, Victoria, on Mahé island.
- 3 km of submarine cables connect the wind turbines.

Impact

- The plant satisfies 8% of annual electricity demand on the island, representing a major leap forward for the country's energy diversification.
- An estimated 5845 tons of CO_2 emissions per annum are also avoided.

Project insights

- The Port Victoria Wind Farm project demonstrates the feasibility of large-scale wind energy deployment in SIDS and the Indian Ocean in particular.
- Resource assessment is critical for larger-scale projects, where the economics depend more heavily on the resource itself – as opposed to smaller-scale projects, where spending on associated infrastructure such as roads is often a determining factor.
- The project demonstrates the value of grid stability studies to ensuring appropriate plant design.



Caribbean

Implementation of Sustainable Solar Energy, **Bahamas**
Turtle Beach Resort Solar Water Heating Project, **Barbados**
Geothermal Development in Dominica, **Dominica**
Renewable Energy Based Rural Electrification Programme, **Dominican Republic**
Désirade Electric Vehicles, **Guadeloupe**
Petite Place Wind Farm, **Guadeloupe**
Wigton Windfarm Phase I & II, **Jamaica**
Study of Martinique's Photovoltaic Performance, **Martinique**
Geothermal Development Project, **St. Vincent and the Grenadines**
USVI Energy Transition, **United States Virgin Islands**

Implementation of Sustainable Solar Energy

The Bahamas
Date started: 2012
Date completed: Project is in monitoring phase

Commonwealth of The Bahamas
Area: 13 880 sq km
Coastline: 3 542 km
Population: 321 834 (July 2014 est.)
GDP: USD 11.4 billion (2013 est.)

Electricity generation in the Bahamas is almost entirely reliant on thermal plants powered by petroleum fossil fuels. The volatility in oil prices coupled with an increasing national demand for energy has generated a huge financial burden for the Bahamas, impacting the competitiveness of the tourism industry, restricting economic growth and increasing inflation. In response, the Bahamian Government has started to incorporate renewable energy and energy efficiency programmes into national plans. This is expected to lead to a decline in fossil fuel imports, significant savings, increased energy security and a decrease in carbon emissions. The Implementation of Sustainable Solar Energy project is an example of such a programme.

There are several sustainable energy projects which are currently active within the country. The successful execution of these projects will assist in lowering the cost of electricity as well as meeting the national goal of increasing dependency on renewables to 30% by 2030. In 2012, the government, with the assistance of the Inter-American Development Bank (IDB) and the Global Environment Facility (GEF), implemented this solar energy pilot project. The project was designed to ultimately remove barriers to renewable energy technology, facilitate the collection of data, boost entrepreneurial activity, develop new job streams and allow the public to benefit from lower electricity bills. In total, the project involved the installation of 134 solar water heaters and 33 photovoltaic solar systems in homes throughout the Bahamas. The Bahamas Government has also eliminated tariffs on inverters for solar panels. The IDB and GEF pilot projects will be the initial registrants of the Renewable Energy Self Generation (RESG) programme which will be launched in 2015.

Main features

Technology and Scale: Solar PV: 2 kWp

Solar water heaters: 60 – 80 gallons

Project budget (USD): 1 million

Funding source: Public/multilateral

Impact

- Initial data gathered from the project indicates a steady drop in the consumption of electricity by participants.
- Fossil fuel imports and transportation costs within the archipelago are expected to decline.
- Guidance relevant to renewable energy is being introduced into the building code.

- Existing acts and regulations are being created and amended to regulate the renewable energy industry in the future.
- Regulations which enable individuals to connect to the grid and take part in a net metering programme are in place. As a result, it is expected that participants will benefit from further electricity cost reductions.

Project insights

- Laws and policies should be amended prior to the deployment of renewable energy technologies to ensure that the industry can be appropriately regulated.
- All relevant agencies should be a part of the deployment process to guarantee the relevant sectors are well informed and costly delays are reduced.
- Public awareness and education related to renewable energy is essential for the encouragement of its use by the public.

Turtle Beach Resort Solar Water Heating Project

Dover, southern coast of Barbados
Date started: 1997
Date completed: 1997

Barbados
Area: 430 sq km
Coastline: 97 km
Population: 289 680 (July 2014 est.)
GDP: USD 7.004 billion (2013 est.)

Prior to 1997, water in the Turtle Beach Resort was heated by systems powered with diesel-generated electricity. The resort consists of 167 suites and several facilities, including restaurants, bars and a fitness centre that require a significant amount of hot water on a daily basis. However, electricity in Barbados is relatively expensive due to the high cost of fossil fuel imports (about USD 0.278 per kWh in 2013). Furthermore, the price is extremely volatile due to the Fuel Clause Adjustment mechanism, through which the Public Utilities Board allows utility companies to adjust the electricity tariff as the international price of fossil fuels rises and falls. This can have a particularly significant impact on resorts, given their high reliance on the provision of hot water for laundry, cooking and air conditioning.

In 1997, the management of Turtle Beach Resort decided to invest in a solar water heating system, which would help to minimise costs and provide a reliable energy source. Barbados is a leader in the western hemisphere when considering the number of solar water heater installations per capita. Approximately 50% of homes in Barbados are equipped with these heaters. They are also extensively used in the commercial sector - particularly in hotels.

Main features

Scale: 372 040 kWh per year

Project budget (USD): Total capital cost: 200 000

Annual maintenance cost: 6 250

Funding source: Private

- A total capacity of 7 800 gallons can be heated up to 55-60 °C. This is sufficient for 40 gallons of water per room, totaling 6 680 gallons and 1 120 gallons for ancillary services, such as catering.
- The total amount of energy produced every day by the system is about 1 048 kWh.

Impact

- Between 1997 and 2013, total savings from reduced electricity consumption as a result of the solar water heating system amounted to USD 1.5 million. Over the same period, the cost of maintaining the system was about USD 100 000.
- Between 1997 and 2013, the system prevented about 655 tons of CO_2 emissions or about 41 tons every year.

Project insights

- The tourism industry can profit by exploring alternatives to conventional electricity for the provision of amenities – for example, solar water heating solutions. Investing in solar water heating technology makes economic sense for hotels on islands, particularly when electricity prices are high.
- The capital investment and maintenance costs of a solar water heating system are lower than the resulting, long-term savings.
- If the same project were implemented in 2013, assuming an average electricity price of about USD 0.38 per kWh for the average household, the avoided electrical costs would be USD 91 177 every year, and the investment cost could be paid back within a year.

Geothermal Development in Dominica

Dominica
Date started: 2012
Date of completion: 2014

Commonwealth of Dominica
Area: 751 sq km
Coastline: 148 km
Population: 73 449 (July 2014 est.)
GDP: USD 1.015 billion (2013 est.)

Dominica has high but largely unrealised geothermal resources which could produce electricity at a lower cost and transition Dominica from its current dependence on imported fuels into a regional energy hub. The Government of the Commonwealth of Dominica (GoCD), with the assistance of development partners such as the Agence Française de Développement, the European Union and the International Finance Corportation, has completed the drilling of three geothermal exploration wells in the Wotten Waven / Laudat field, where a 10-15 MW geothermal power plant could meet domestic demand. The GoCD is also actively assessing potential for further geothermal development to generate power for exports via sub-sea cables to neighbouring islands.

Main features

Scale: 10-15 MW

Project budget (USD): 295 000 (leverage of 30-40m investment)

Funding source: Multilateral

- The project funded a gap analysis to assist the GoCD in gauging the progress, identification of shortcomings and preparation of the Wotten Waven/Laudat geothermal field.
- The following five areas were assessed:

  i. geothermal resource assessment and technical viability of the project

DOMINICA

ii. integration of the project into the electricity market

iii. finance and risk

iv. policy, regulatory and institutional implications

v. environmental and social safeguards

Impact

- Based on the gap analysis, technical assistance was provided to support geothermal development. This included the upgrading of the project feasibility study to be more closely aligned with industry standards, a peer review of drilling operations, guidance on the deal structure, and financial and tariff analyses.

- Further advisory support is being provided to upgrade the environmental and social work for the project and explore potential World Bank financing for development of the first phase of the operation.

Project insights

- In the Caribbean, the World Bank has begun replication of the geothermal project in Saint Lucia and Grenada.

- There is a need to mobilise public sector and donor support and to create the right incentives for private sector investment. This is particularly relevant for SIDS where opportunities for market expansion are limited.

Renewable Energy-Based Rural Electrifications Programme

Dominican Republic
Date started: 2008
Date of completion: 2014

Dominican Republic
Area: 48 670 sq km
Coastline: 1 288 km
Population: 10 349 741 (July 2014 est.)
GDP: USD 101 billion (2013 est.)

The World Bank estimates that approximately 400,000 people live without electricity, relying instead on kerosene lamps or pine kindling for lighting at night. While oil for kerosene lamps is expensive, pine kindling often causes health hazards, such as long-term neurological and kidney damage.

Since 2008, 13 communities excluded from the national power grid have been supported through renewable energy projects led by UNDP's Rural Electrification Programme. The programme, was supported by the Government of the Dominican Republic and local NGOs, with funding from the European Union and builds on more than 18 years of UNDP experience working with government and development partners to promote renewable energy in rural communities.

This programme is part of the Sustainable Energy for All initiative promoted by the United Nations.

Main features

Scale: 23 small micro hydropower plants

Project budget (USD): 3 203 000

Funding source: Public/communities/multilateral

DOMINICAN REPUBLIC

- The Rural Electrification Programme promotes access to renewable energy in rural communities and supports the development of community enterprises to strengthen collaboration between communities and local governments to better manage electricity.
- The programme supports small enterprise income generation and integrates energy production, environmental protection, social needs, institutional capacity building, and local community cooperatives.
- The programme organises villagers into work teams to participate in the construction of the micro hydropower plants, promoting a strong sense of ownership.

Impact

- Since 2008, 23 small micro hydropower plants have been installed to provide sustainable energy to more than 3 000 families across the country. By 2014, the new power supply had helped more than 40% of participating communities develop small enterprises.
- Sustainable energy considerations have been incorporated into future plans and management policies in 70% of municipalities where new plants are located.
- The programme helps families save earnings. For example, households in the village of La Cabirma spend on average 30% less on energy needs.

Project insights

- The government and local municipalities recognise that further progress will depend on the management of micro watersheds. Many towns have set up surveillance brigades to ensure that communities contribute to the maintenance of water levels needed for the smooth running of the hydropower plants.
- There is a need for governments and municipalities to incorporate sustainable energy considerations into their future natural resources management policies.
- The cooperation of local commercial enterprises has been crucial for the viable and sustainable development of micro hydropower plants. It also contributes to the strengthened sense of ownership of the project by its beneficiaries.

Désirade Electric Vehicles

La Désirade, Guadeloupe
Date started: 2014
Date of completion: 2015

Area: 1 628 sq km
Population: 405 739 (Jan 2013 est.)
GDP: USD 10.3 billion (2012)

The Désirade Electric Vehicles project is located on the small island of La Désirade, an ideal location for the use of electric vehicles (EVs) since it is just 6 km in length. The project will involve the construction of autonomous EV charging stations for 6 EVs. The charging stations, powered by solar power, introduce clean technology into the fuel mix.

Main features

Renewable energy source: Electric vehicle solar charging station

Technology and scale: 14 kWp photovoltaic – 6 vehicles

Project budget (USD): 320 000

Funding source: Private

- Energy is produced by a 14 kWp solar shelter. The charging station has the capacity to refuel 6 EVs with 16 kWh each, equivalent to 100 to 150 km per day.
- The EVs will be used for rental activity and will be charged during the night by a 50 kWh battery which stores electricity not used during the day.
- The main difficulty has been in finding ready-made components which could make the system simpler and more replicable.

Impact

- The charging station can produce 19 000 kWh of electricity per year, equivalent to 120 000 km or 50 km/day per EV.
- The battery powering the charging station is designed to be changed every 5 years, the usual duration of rented vehicles.
- Construction will be carried out by local companies, creating local jobs.

Project insights

- This project will contribute to the understanding of the appropriate systems and organisations for the effective deployment of EVs in small islands.
- Insights into the optimum size of each system component will also be gained.
- Based on a life-cycle analysis, this project aims to promote the deployment of clean EVs. As most of the electricity in the French overseas territories is produced from coal and/or oil, it is important to find solutions for charging EVs apart from simply connecting them to the grid. This will avoid indirect CO_2 emissions and extra costs for public authorities, since electricity is subsidised.

Petite Place Wind Farm

Capesterre de Marie-Galante, Guadeloupe
Date started: 2014
Date of completion: 2015

Area: 1 628 sq km
Population: 405 739 (Jan 2013)
GDP: USD 10.3 billion (2012)

The Petite Place Wind Farm project is the first wind project with energy storage in Guadeloupe. The project is located at the top of a gentle slope and faces the prevailing wind on the east coast of Marie-Galante island.

In Guadeloupe, renewable energy power producers are sometimes disconnected from the island's grid when the wind and solar energy supply rises to more than 30% of consumer demand. A wind tariff was established to prevent this by providing power producers with a forecast a day ahead of time. If the power producer is able to comply with the forecast, it will not be disconnected.

Main features

Technology and scale: 9 wind turbines: 2.475 MW

Project budget (USD): 11.9 million

Funding source: Private

- The project will revamp a 15 year old 1.5 MW wind farm.
- The wind farm has nine 275 kW wind turbines, each 50 m in hub height and with a lithium-ion 500 kWh battery.
- A wind power forecast tool will provide a power forecast at 30 minute intervals for the current and following day.

- A supervisory control and data aquisition (SCADA) system will monitor system storage to compensate for forecast error and will provide grid frequency and voltage system support.
- Turbines are able to be lowered to ground level to prevent hurricane damage.
- All information is exchanged on the internet to ensure automatic operation and remote control.
- There has been some difficulty in finding an optimum battery size in compliance with tariff specifications while minimising costs.

Impact

- The farm will produce 6 400 MWh per year over 20 years, preventing 5 085 tons of CO_2 per year.
- The electricity produced is equivalent to the consumption level in Capesterre, a town of 3 600 residents.
- The battery is designed to be changed only once during the life of the project.
- Construction will be done by local companies, creating local jobs.

Project insights

- With current technology, energy storage has an impact on price, however, it offers valuable opportunities for improving the integration of renewable energy into the grid. This supports wind farm grid capabilities, thereby increasing wind power potential.

Wigton Windfarm Phases I & II

Wigton, Rose Hill, Manchester, Jamaica
Date started: Wigton I – September 2003
Wigton II – March 2010
Date completed: Wigton I – April 2004
Wigton II – December 2010

Jamaica
Area: 10 991 sq km
Coastline: 1 022 km
Population: 2 930 050 (July 2014 est.)
GDP: USD 25.13 billion (2013 est.)

Jamaica is over 90% reliant on imported fossil fuels, leading the government to set renewable energy targets of 12.5% by 2015, and 20% by 2030. In order to implement these mandates for energy diversification, the Petroleum Corporation of Jamaica conducted studies on wind energy during the period 1995 to 1998 at various locations across the island. The wind company, Wigton Windfarm Limited, a subsidiary of the Petroleum Corporation of Jamaica, was formed in April 2000 to assist in meeting these targets.

Main features

Scale: Wigton I: 20.7 MW

Wigton II: 38 MW

Project budget (USD): Capital Cost Wigton I: 26 Million

Capital Cost Wigton II: 47.5 Million

Funding source: Multilateral

- The main activities included feasibility studies; government and regulatory approvals; topographical and geotechnical surveying; construction design; permitting; power purchase agreement negotiations; land usage arrangements; government procurement processes for supplier contracting; environmental, health and safety monitoring; transportation; construction; testing; commissioning; operations and maintenance.

JAMAICA

- The electricity sector's generation market was liberalised in 2001, creating the legal framework for independent power producers to sell electricity to the national grid.

Impact

- The energy supplied from Wigton will strengthen the grid in this region and assist in meeting the country's projected increase in demand for electricity in an environmentally responsible manner.
- Local contracting firms and local labour were utilised, where possible. The Wigton II Project employed 120 local workers and 26 overseas workers. One permanent electrical engineer was added to Wigton staff in June 2011 and two local engineers were hired, thereby strengthening wind energy technical capacity in Jamaica.
- The Wigton II project promotes renewable energy training and technology transfer. Partnerships are being strengthened with local universities. The first workshop was held in the new Wigton Resource Centre on February 1, 2011, with participants from utility companies, universities and the private sector in attendance. A renewable energy certificate course was held in July 2011 and again in July 2013 in collaboration with the University of the West Indies. The Wigton Resource Centre is being further developed to house a renewable energy lab to offer practical training sessions to energy practitioners, students and enthusiasts.
- Wigton Windfarm Limited has supported the adjacent Rose Hill Primary School on various initiatives, providing re-roofing after hurricane Ivan; constructing a new, modern bathroom complex; improving lighting and repairing the pressurised water pumping system. The neighbouring New Broughton School also received a contribution towards a literacy centre and the nearby Cross Keys Health Centre a contribution towards a concrete water tank.

Project insights

- All contracts should be fully negotiated prior to the payment of deposits.
- Technology specific energy rates may be suitable for driving renewable energy uptake. For example, for the 2012 call for 115 MW of renewable energy proposals which stipulated technology specific rate caps, there were over 800 MW of renewable energy proposed.

Study of Martinique's Photovoltaic Performance

Southern Martinique
Date started: 2009
Date completed: 2014

Area: 1 128 sq km
Population: 386 486 (Jan. 2013)
GDP: USD 10.7 billion (2012)

The Government of Martinique is conducting an environmental study to support its regional plan for climate, air quality and energy. The plan defines ambitious targets, particularly regarding photovoltaic (PV) energy production. The main objective is to increase the share of renewable energy from 7% today to 50% in 2020. Technical and economic insights are needed to attain such progress. The PV Performances study will improve the understanding of such systems under realistic conditions and through this, contribute to increased renewable energy deployment on the island.

Main features

Technology: 5 types of technologies were studied: monocristallin, polycristallin, CIS, amorphous and triple junction amorphous silicon solar modules.

Scale: 376 000 kWh per year.

Project budget (USD): 761 716

Funding source: Public

Partners: The Martinique Energy Agency (AME) and the French National Institute for Solar Energy (CEA/INES).

Funders: The Martinique Regional Council, the European Regional Development Fund, the Martinique mixed union for electrification (SMEM), and the French Agency for Environment and Energy Management (ADEME).

- Two grid-connected PV systems (226 kWp and 15 kWp) were constructed to study the characteristics of PV systems on these two scales.
- Five testing systems were installed in different climatic zones in Martinique.
- The monitoring systems include module temperature sensors, pyranometers, direct current, voltage analysers and grid analysers, outdoor ambient temperature sensors and an acquisition unit.

This facilitates:

- The comparison of the levels of PV technology performance available in Martinique.
- An analysis of the PV potential in each climatic zone studied.
- The measurement of the effects of on-roof integration technology.
- An evaluation of soiling effects.

Impact

This study will facilitate the revitalisation of the PV sector by providing:

- Ways to increase the levels of renewable energy which can be used within the grid without using a more expensive storage solution.
- Guidelines for choosing the PV technology most suitable to one's needs.
- A better understanding of the economics, technology and maintenance of a PV project in a tropical climate.
- Methods to propose more adequate feed-in-tariffs.

Project insights

- This study will assist in the implementation of solar resource prediction tools.
- The testing methods and results are replicable in other islands.
- Databases will be shared for use in other research projects and testing models.
- The findings will contribute to the evolution of renewable energy legislation.

St. Vincent and the Grenadines Geothermal Development Project

La Soufriere, northern St. Vincent
Date started: 2013
Date completed: Under development

St. Vincent and the Grenadines
Area: 389 sq km
Coastline: 84 km
Population: 102 918 (July 2014 est.)
GDP: USD 1.198 billion (2014 est.)

St. Vincent and the Grenadines is highly dependent on diesel for its growing energy demands. The 2014 cost of electricity, at USD 0.42/kWh, is one of the highest in the region. As a result, the exploration of indigenous sources of energy has become a priority for the Government. The St. Vincent and the Grenadines geothermal project, viewed as a 'game changer' in the energy sector, became the preferred option, given the limited alternatives for providing base load power, and the islands' full exploitation of hydro energy. Additionally, St. Vincent and the Grenadines seeks to demonstrate climate leadership by reducing its generation of carbon emissions.

IRENA and the Abu Dhabi Fund for Development (ADFD) have allocated USD 15 million in concessional loans to the project, with interest rates between 1% and 2% per year over a 20 year loan period, including a 5 year grace period. The IRENA/ADFD Project Facility provides up to USD 350 million in concessional loans to projects in developing countries recommended by IRENA. Over seven cycles, funds are allocated and the equivalent or more of the amounts allocated is leveraged from other sources. Selected project proposals demonstrate the potential for innovation and replicability in other settings, thereby enhancing renewable energy deployment worldwide.

Main features

Technology and Scale: 10 - 15 MW, geothermal power plant

Project budget (USD): 90 million

Funding source:

Multilateral: Emera Caribbean, Reykjavik Geothermal, Government of St. Vincent and the Grenadines, IRENA/ADFD Project Facility and other project debt.

- The partnership between RG and Emera Caribbean has evaluated the possibility of using geothermal energy from La Soufrière volcano for electricity generation.
- Geophysical exploration revealed conditions comparable to those of productive geothermal fields worldwide. A preliminary geophysical model indicates possible temperatures in excess of 240˚C.
- The project's business model allows St. Vincent and the Grenadines to access international technical expertise and financial resources. It will be developed under an independent power producer (IPP) framework, the first in St. Vincent and the Grenadines and one of the first in the Caribbean Community (CARICOM), with a power purchase agreement (PPA) between the IPP and the national utility, St. Vincent Electricity Services Limited (VINLEC).
- The Government controls 100% of stakeholder interest in the utility and the Electricity Supply Act prevents the transmission of electricity unless a licence is issued by the Government. This means there is specific interest on the part of the Government to ensure the project delivers at a technically appropriate and cost-effective level and generates high socio-economic benefits.

Impact

- Successful project implementation will lead to lower and more stable energy prices and a reduced reliance on imported fossil fuels. Import bills should decline by about USD 15.6 million and about 75% of the country's energy needs could be met by renewables. There is also a potential for expansion to meet increasing national and external demands.
- A range of local jobs will be created during the developmental, constructional, and operational phases of the project.
- Access to cleaner, more affordable energy will attract more international investors, as the cost of doing business declines.

Project insights

- Test drilling can account for up to 15% of the overall capital cost of a geothermal project and is usually required when the risk of project failure is high.
- Countries with high national debts and limited fiscal resources will require grants and concessional loans at earlier phases since geothermal development comes with such high and risky capital costs. As a result, the ability to replicate this model depends on the ability to attract donor funding.

USVI Energy Transition

United States Virgin Islands (USVI)
Date started: 2009
Date of completion: 2025

United States Virgin Islands
Area: 1 910 sq km
Coastline: 188 km
Population: 104 170 (July 2014 est.)
GDP: USD 1.577 billion (2004 est.)

With increases in the price of imported fossil fuels at the turn of the 21st century, electricity rates reached unsustainable levels in the United States Virgin Islands. As a result, the USVI legislature passed a law in 2009 that required 30% of the Virgin Islands Water and Power Authority's peak demand to be supplied by renewable sources by 2025. Shortly after this peak electricity system requirement was set, the USVI set an overall goal of reducing fossil fuel use by 60% by 2025.

In 2012, the Water and Power Authority (WAPA) prepared its Energy Production Action Plan (based in part on analysis from the Energy Development in Island Nations project) to transition from a dependence on imported fossil fuels. The energy transition will involve cleaner fossil fuels, a substantial amount of renewable energy generation and the installation of energy efficiency measures in homes, businesses and power plants.

Main features

Technology and scale: To date 17 MW solar PV installed or permitted; solar water heating; fuel conversion and heat recovery; reducing line losses; new energy efficiency business unit.

Project budget (USD): N/A

Funding source: A government led initiative that resulted in both public and private sector investments.

US VIRGIN ISLANDS

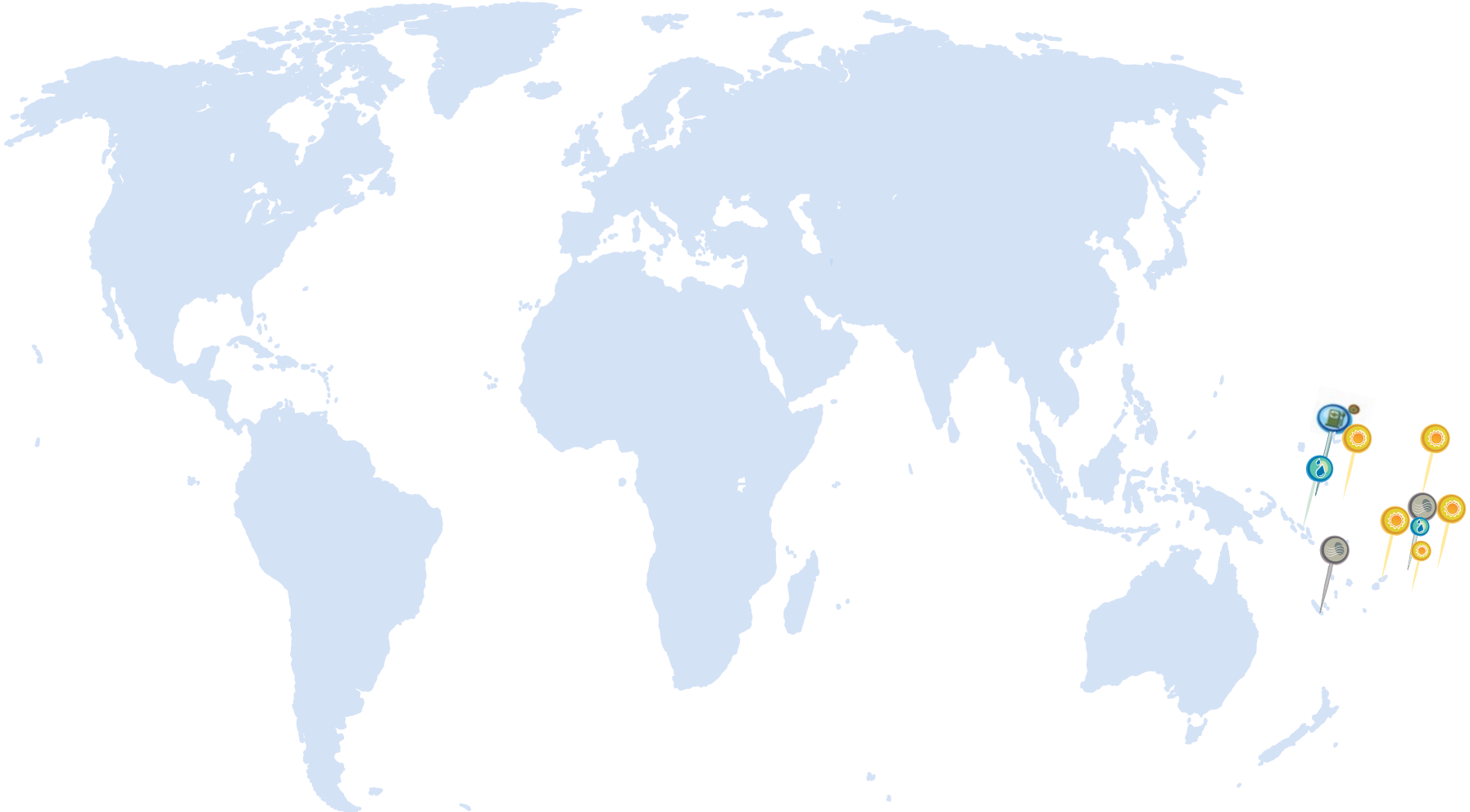
- In 2012, WAPA issued a Request for Proposals and negotiated offers to obtain long-term power purchase agreements from solar PV facilities that would account for approximately 15% of peak load at an average cost of USD 0.15 — USD 0.17/kWh. Two projects totaling 9 MW capacity are under construction, and one is expected to begin operation in November 2014.
- The net metering programme has resulted in many small solar PV installations with over 8 MW of distributed solar energy permitted throughout the USVI and 4.4 MW on St. Croix alone.
- Nearly 1,000 light emitting diode (LED) streetlights were installed.
- A feed-in-tariff was passed by the legislature in 2014 and is currently being designed.
- WAPA signed an Engineering, Procurement and Construction agreement in 2013 to convert its fuel supply from diesel to cleaner-burning, less expensive propane. Based on current plans, project cost will be repaid over seven years with an option to repay in five.

Impact

- The diversification of the USVI's fuel sources to include different renewables, cleaner fossil fuels, and improve efficiency will lower rates and create a more resilient energy system.
- In 2011, a 450 kW PV facility at Cyril E. King Airport was installed, providing a highly visible demonstration of the USVI's commitment to its energy transition and saving the Port Authority nearly USD 1 000 a day.
- Solar water heater requirements improve energy use in new buildings and maximise the usage of internal space.
- St. Croix's heat recovery steam generator installed in 2010 continues to save utility customers at least USD 1.5-2 million per month in fuel costs. Once installed, additional heat recovery units that have been approved will increase these savings.
- Line losses have been reduced by nearly 17%.
- Work so far has supported dozens of construction jobs.

Project insights

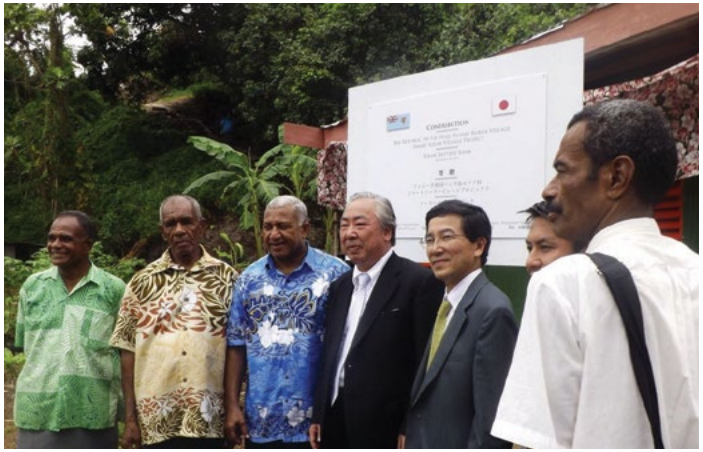
- Efficiency in generation and transmission can be low hanging fruit to reduce fuel consumption without any changes to load.
- With the appropriate analysis, community input, and political will, it is possible to attract private sector investment, install renewable energy and reduce electricity costs.



Pacific

Rukua Mini-Grid Solar Project, **Fiji**
InterContentinal Bora Bora Resort & Thalasso Spa, **French Polynesia**
Prony I, II, III and Mont Mau, **New Caledonia**
Samoa Wind Farm, **Samoa**
Alaoa Hydropower Rehabilitation, **Samoa**
Coconut Oil Diesel Replacement Trial, **Solomon Islands**
Tokelau Renewable Energy Project, **Tokelau**
La'a Lahi Solar Field, **Tonga**
Tuvalu Photovoltaic Electricity Network Integration Project, **Tuvalu**
Talise Micro-Hydroelectric Project, **Vanuatu**

Rukua Mini-Grid Solar Project



Rukua Village, Beqa Island, Central coast of Fiji
Date started: 2013
Date of completion: 2013

Republic of Fiji
Area: 18 274 sq km
Coastline: 1 129 km
Population: 903 207 (July 2014 est.)
GDP: USD 4.45 billion (2013 est.)

Rukua is a village settlement on the island of Beqa, an island south of the main island of Viti Levu. The island depended heavily on diesel generator systems (usually 3-4 hours daily), and benzene and kerosene lamps for its basic electricity needs. Over the years, the villagers have incurred significant fuel costs linked to price increases and the high cost of transportation from the main land of Viti Levu. The village of approximately 77 households (280 people) was in dire need of an alternative form of energy.

Main features

Scale: About 200 kWh per day or 20 000 kWh per year

Project budget (USD):

- Total capital cost: 400 000
- Annual maintenance cost (Amortised): 4 000

Funding source: Public-private-donor-community partnership

- The diesel generator used by the villagers for many years was replaced by a 20 kWp mini-grid. The previous system used approximately 200 L of fossil fuel (diesel, pre-mix, benzene, kerosene) per day or 73 000 L of fuel per annum.
- The project was funded by the Inter Action Corporation (IAC), facilitated by the Japanese Government and coordinated by the Fiji Government through the Department of Energy (DoE), which provided

local components such as house wiring, underground reticulation systems, battery houses, transportation and logistical assistance, as well as technical personnel from the Rural Electrification Unit.

- The solar panels and power system installation was done by a team of solar and electrical engineers from the IAC and technical staff from the DoE.

Impact

- The project has developed essential infrastructure for electricity generation and distribution, and demonstrated that a pre-paid metered system can be fully operationalised and maintained by the local community.
- The project is managed by a village committee which has employed salespersons and operations staff. Villagers received training on managing small businesses.
- The villagers no longer face the financial burden of buying expensive fossil fuels for their electricity needs. The project provides clean and affordable electricity to the Rukua community at a reduced cost.
- Between December 2013 and June 2014, the total avoided cost of fossil fuel use was about USD 43 000 and in the same period the revenue generated through tariff collection was about USD 1 800. Over this period, the cost of maintenance has been minimal and given the stream of revenue to date, the project will be able to self-fund maintenance costs within 5 to 7 years.
- Between December 2013 and June 2014, the solar energy system had prevented approximately 95 tons of CO_2 emissions and is projected to reduce CO_2 emissions by approximately 192 tons annually.

Project insights

- This was a successful demonstration of a public-private-donor-community partnership which highlights the benefits of renewable energy and its advantages for a small island economy.
- With technological advancements and continuing reductions in solar system equipment prices, in many cases, it is cost-effective in the long term to shift towards solar energy utilisation.
- Similar investments in solar energy power systems are suitable for some remote islands where grid extension is not economically viable.

InterContinental Bora Bora Resort & Thalasso Spa

Bora Bora, Polynesia
Date started: 1998
Date of completion: 2006

Overseas Lands of French Polynesia
Area: 4 167 sq km
Coastline: 2 525 km
Population: 280 026 (July 2014 est.)
GDP: USD 5.65 billion (2006 est.)

The InterContinental Bora Bora Resort and Thalasso Spa is located on the eastern coast of Bora Bora, French Polynesia. Expensive oil imports and high electricity prices of about USD 0.48 per kWh, one of the most expensive in the world, constrained the hotel's profitability. With 83 large villas, conventional air conditioning systems, using imported fossil fuels, would have been expensive and would have released high levels of greenhouse gases. As an alternative, a seawater air conditioning system (to replace conventional air conditioning systems) was installed.

Main features

Scale: 450 tons or 1.6 MW of air conditioning

Project budget (USD): Capital investment: 7.9 million

Funding source: Private

- This is the first hotel in which a sea water air conditioning system has been installed and operated.
- A 2 300 m long pipeline extracts seawater at a temperature of about 5°C, from a depth of about 930 m and transfers it to sea level using capillary pressure.
- At sea level, the water temperature increases to about 7°C and is pumped to a thermal exchanger made of corrosion-resistant titanium and located 50 m from the shore.

- The exchanger cools a separate freshwater circuit which distributes it to the hotel's villas, restaurants, kitchens, spa, staff residences and other areas where air conditioning and refrigeration is required.
- Seawater at a temperature of 12–13°C is re-funneled to the ocean at a depth which does not harm ocean ecosystems.
- The Government of French Polynesia provided assistance in the form of a 35% tax credit to the hotel owner to encourage renewable energy deployment.
- The return on investment (ROI) period is a relatively short 7.4 years or 5 years when taking the tax credit into account.

Impact

- Estimated savings are equivalent to approximately 1 million kW per year or 200 gallons of oil per year.
- The hotel saves about USD 720 000 (a 40% decrease) every year as a result of decreased energy usage.
- About 2 500 tons of carbon emissions are prevented every year since no greenhouse gases are released.
- There has been a 90% reduction in electricity consumption in comparison to non-seawater air conditioning systems (SWAC).
- Maintenance costs are reduced by the use of a corrosion-resistant heat exchanger.

Project insights

- Due to high initial costs, this project is more feasible in locations with high energy costs. However, the sale of excess cooling generated could increase project feasibility.
- Despite high initial investment costs, the relatively short ROI period means this is a positive business and environmental model for large hotels located close to the sea.
- The SWAC model is best suited to locations close to deep waters and close to the shore as location may impact project costs.
- For tropical islands where air conditioning is used daily, government tax credits can be useful incentives for private sector investment in seawater air conditioning systems.
- Retrofitting of this model could be complicated and expensive, making it more applicable to new constructions rather than existing hotels.

Prony I, II, III and Mont Mau

New Caledonia
Date started: 2004
Date of completion: 2007

Territory of New Caledonia and Dependencies
Area: 18 575 sq km
Coastline: 2 254 km
Population: 267 840 (July 2014 est.)
GDP: USD 9.28 billion (2008 est.)

The Prony and Mont Mau wind farms were constructed in the Mont-Dore district in southern New Caledonia in response to environmental concerns and a need to reduce the territory's heavy dependence on fossil fuels to generate its electricity. New Caledonia previously relied on fossil fuels for 97% of its electricity generation. These wind farms are a good example of successful renewable energy development in SIDS.

There was a favourable legal framework and strong political will from the government for the promotion of renewables. In particular, an attractive feed-in tariff facilitated this project.

Main features

Technology and scale: Wind: 16.45 MW

Funding source: Private

- Hilly terrain and narrow, winding roads present a challenge for the transportation of heavy material and equipment in New Caledonia. The lightweight, tilting design of the wind turbines enabled easier construction of the wind farms - particularly in hard to reach locations.
- Sixty-six wind turbines were constructed.
- Maintenance of the turbines is performed at ground level, without the need for cranes.

- Twelve years into the operation of the first phase of the project, the turbines have had to withstand several hurricanes. All original turbines are still in operation, due to the tilting feature that allows them to remain securely attached to the ground during a hurricane.

Impact

- The Prony and Mont Mau wind farms generate 31 422 MWh of clean electricity per year, covering the electricity needs of the Mont-Dore city.
- 5 470 tons of diesel were saved per year, which is equivalent to 38 750 tons of diesel since the commissioning of the first phase in 2004.
- The success of this project led to additional wind farm installations in New Caledonia and on Lifou Island.
- There are currently 21 technicians employed full time in New Caledonia to operate the wind farms and provide regional support to other wind farms in operation in the Pacific region (Fiji, Vanuatu, New Zealand, Australia and Japan).

Project insights

- Investments in renewable energy provide opportunities for cooperation and capacity building between local technicians.
- Robustly designed equipment enabled the team to address challenges specific to New Caledonia, including logistics, hurricanes and high corrosion environments.
- Communication with island electrical utilities was important for the management of the impact of renewables on the grid, and for the stability and quality of electricity supply in off-grid applications.

Samoa Wind Farm

Upolu, Samoa
Date started: April 2014
Date of completion: September 2014

Independent State of Samoa
Area: 2 831 sq km
Coastline: 403 km
Population: 196 628 (July 2014 est.)
GDP: USD 1.145 billion (2013 est.)

The Samoa Wind Farm project aims to further diversify efforts to reduce diesel import dependency and to improve resilience against cyclones. Located on the eastern shore of the capital island of Upolu, where 75% of the national population reside, the turbines are Samoa's first use of wind technology and can be taken down prior to severe weather. The project is funded by the UAE-Pacific Partnership Fund, which provides USD 50 million in untied grants to increase renewable energy deployment in Pacific islands.

Main features

Scale: 1 619 MWh per annum (550 kWp)

Funding source: Public

- The project comprises 2 Vergnet GEV MP-C wind turbines (hub height of 55 metres with blades of 16 metres), each rated at 275 kW, for a total of 550 kW, with associated substation, grid connection and control systems.
- The turbine towers pivot at the base, allowing the entire turbine to be lowered and locked down within 45 minutes, in cases of impending severe weather.
- The site is located approximately 2 km inland from the eastern coastline near the village of Vailoa at an altitude of around 70 m above sea level. The 22 kW high voltage grid will be extended via underground cable to the wind project substation.

- The project was enabled by strong government commitment, including multiple community consultation sessions.

- Close coordination between the Ministry of Finance and the Electric Power Corporation (EPC) utility has also expedited project completion. The project complements other initiatives to increase the penetration of renewable energy, particularly PV and hydro, while improving the control of the grid to cope with the variability of some renewable energy sources.
- The project additionally benefitted from the facilitation of the International Renewable Energy Agency (IRENA), and initial guidance from the South Pacific Regional Environment Programme (SPREP), New Zealand, AusAid, ADB and World Bank.
- The project grant provided for the feasibility study and covers operation and maintenance of the plant for the first 2 years. At the end of that period, the EPC becomes the sole operator.

Impact

- The plant meets 2% of annual electricity demand on the island.
- Total savings from decreased diesel fuel consumption as a result of the project are estimated at 540 000 L per annum.
- The project prevents an estimated 1 352 tons of CO_2 emissions per annum.

Project insights

- Wind power can play a much larger role in the Pacific energy mix and can increase countries' options for mitigating diesel dependency. It also complements the generation patterns of other technologies, particularly solar energy which, unlike wind, is available only during the day.
- The project is one of the first wind projects in SIDS to be cyclone-proof and indicates the potential of the technology to support climate resilient objectives.
- For small-scale wind farms, minimising the cost of required infrastructure (roads, transmission and communications) will often have a greater impact on project feasibility than the wind resource itself. Similarly, elevated locations may have better wind resources, but will often not be economically feasible given infrastructure costs needed to exploit them.
- Introduction of similar technology can be facilitated by educational outreach to the key government and regulatory stakeholders. Community consultation can also facilitate land access.

Alaoa Hydropower Rehabilitation

Samoa
Date started: 2010
Date of completion: 2012

Independent State of Samoa
Area: 2 831 sq km
Coastline: 403 km
Population: 196 628 (July 2014 est.)
GDP: USD 1.145 billion (2013 est.)

The Alaoa hydropower station is located on the main island of Upolu, Samoa, adjacent to the national capital, Apia. The plant was installed over 50 years ago and although adequately maintained, required a major overhaul to improve generation capacity and reliability. Periodic plant shutdowns and growing demand meant that the national power utility (Electric Power Corporation) was increasingly dependent on costly diesel generation to meet the power shortfall.

Main features

Technology and scale: 1.2 MW

Project budget (USD): 1.8 million

Funding source: Public/multilateral

- The rehabilitation of the Alaoa hydropower station was supported through the Asian Development Bank's financed project 'Samoa Power Expansion Project' implemented by the Electric Power Corporation.
- The project was co-financed by the Government of Japan and the Government of Australia.
- The project consisted of a generator, turbine, switchgear and transformer refurbishment; as well as the installation of a new turbine generator control panel with a supervisory control and data acquisition (SCADA) control system.

SAMOA

Impact

- Hydropower generation has resulted in improved energy security through the diversification of energy sources.
- Plant refurbishment has reduced the usage of diesel for power generation. This is reducing diesel importation and benefiting Samoa's economy.

Project insights

- The project site is prone to flooding during the rainy season. In December 2012, Cyclone Evan generated heavy rainfall in the catchment area which led to landslides and affected civil and hydraulic structures. Fortunately, the powerhouse, mechanical and electrical systems were not damaged. Based on this experience, regular drills, staff training, proactive maintenance and physical inspection of all infrastructure assets and hydraulic structures at hydropower sites should become routine, particularly before the rainy season.

Coconut Oil Diesel Replacement Trial

Auki, Malaita Province, Solomon Islands
Date started: 2011
Date of completion: 2012

Solomon Islands
Area: 28 896 sq km
Coastline: 5 313 km
Population: 609,883 (July 2014 est.)
GDP: USD 1.145 billion (2013 est.)

SOLOMON ISLANDS

The Coconut Oil Diesel Replacement trial project is located in the provincial capital of Malaita in the Solomon Islands. The current cost of power generation in Malaita is high as the grid is 100% diesel based. Power tariffs in the Solomon Islands are among the highest in the Pacific at USD 0.86 per kWh for domestic consumers and USD 0.92 per kWh for commercial or industrial consumers (2013). High generation costs are due primarily to the transportation cost of small batches of diesel by boat from the capital to the provincial centre.

The local copra industry is also struggling due to the high costs of transporting copra or coconut oil from the provincial centre to the nation's capital, where it is consolidated for international transshipment. Utilising locally produced coconut oil as a diesel replacement offers an opportunity for reduced fuel costs and increased economic activity.

Main features

Technology and scale: 340 kW biodiesel dual fuel generator

Project budget (USD): Supported under the 3.6 million Asian Development Bank regional technical assistance project: Promoting Access to Renewable Energy in the Pacific

Funding source: Public/multilateral

- Under the technical assistance project, Promoting Access to Renewable Energy in the Pacific, the Asian Development Bank supported the Solomon Islands Electricity Authority (SIEA) in conducting a trial for blending coconut oil with diesel for the purposes of power generation.

- A new 340 kW generator and a coconut oil conditioning unit were installed at the SIEA outstation at Auki on the island of Malaita. The generator runs on a blend of locally sourced coconut oil and imported diesel fuel. Coconut oil blends of up to 50% were successfully trialed. After the trials, the engine was stripped and inspected and it was confirmed that there was no damage resulting from the use of coconut oil as a fuel source.
- There was strong support from the provincial government, since the project provided the potential to reinvigorate one of the main local agricultural products through an increased demand for coconut oil.
- There were some difficulties concerning the establishment of reliable supply chains due to the limited number of local suppliers.
- Subsequent to the successful trial, SIEA issued a tender for supply of coconut oil for diesel replacement at 3 outstations and has now entered a contract with 2 local suppliers in order to introduce competition into the supply chain.
- Coconut oil is now being supplied reliably to SIEA outstations for power generation at a cost below that of diesel.

Impact

- Coconut oil (CNO) supply contracts were established with a local CNO mill, which in turn purchased additional copra from local suppliers. This increased demand and economic activity.
- The supply contract has created a steady source of income to the local mill, where expansion is now planned. SIEA have established a locally produced alternative fuel supply for power generation, at a lower cost than that of diesel.
- Utilisation of coconut oil as a fuel supply has increased energy security for the provincial power grids.
- Local fuel production has increased employment in the area.

Project insights

- The project has demonstrated that coconut oil can successfully be used as a diesel replacement.
- Promoting local enterprise leads to job creation and gives suppliers access to new market potential since coconut production costs are below that of diesel.
- The use of coconut oil has a range of potential environmental benefits including a decrease in greenhouse gas emissions.
- The demonstration project should be monitored closely and used for greater advocacy to raise the potential benefits of CNO as a biofuel.

Tokelau Renewable Energy Project

Fakaofo, Nukunonu and Atafu atolls, Tokelau
Date started: 2010
Date of completion: December 2013

Tokelau
Area: 12 sq km
Coastline: 101 km
Population: 1 337 (July 2014 est.)
GDP: USD 1.5 million (1993 est.)

The Tokelau Renewable Energy Project (TREP) was led by the Government of Tokelau and supported and co-funded by the New Zealand Ministry of Foreign Affairs and Trade. This project involved the construction of a photovoltaic/diesel hybrid system on each atoll in Tokelau. Previously, the atolls used diesel generators to provide electricity on a centralised distribution network. The new solar power systems were designed to provide at least 90% of the islands' electricity needs from solar power and are expected to save approximately USD 760 000 per year in diesel costs.

Main features

Technology and scale:

- PV/Diesel Hybrid
- PV capacity: 930 kWp (Fakaofo: 365 kWp; Nukunonu: 265 kWp; Atafu: 300 kWp).

Project budget (USD): 6.93 million

Funding source: Public

- Prior to the TREP systems being installed, diesel generators supplied the three atolls with power.
- A PV/diesel hybrid system was chosen to help Tokelau meet its 2004 National Energy Policy and Strategic Action Plan goal of achieving energy independence.

- The PV systems were designed to provide 90% of each island's annual electricity needs through solar power with the balance of electricity being provided by the diesel generators during extended periods of cloudy conditions.

- In recognition of the positive social, economic and environmental impacts, the TREP won the New Zealand Innovators' Clean-tech and Sustainability Award and the Energy Efficiency and Conservation Authority Renewable Energy Award.

Impact

The TREP has assisted Tokelau in improving energy security by reducing its dependence on imported diesel for electricity generation:

- It has cut annual CO_2 emissions by more than 1 300 tonnes.
- Diesel fuel savings are estimated to be around USD 760 000 per year and may increase over the 25 year life of the project as the price of diesel rises.
- Maintenance costs are estimated to have been reduced by half, from approximately USD 85 000 to USD 42 000 per year.
- High power consumption devices are now able to be used simultaneously, due to the higher capacity of the battery inverters.
- The delivery of the TREP has provided local training and capacity building:
  i. Operation and maintenance training was provided to utility technicians.
  ii. Construction of the PV foundations and the battery buildings on Nukunonu and Atafu were completed by the villages' men's groups.
- The TREP has helped reduce the risk of accidental fuel spills in Tokelau's fragile reef environment.

Project insights

- The PV systems installed in Tokelau were designed in line with the New Zealand Ministry of Foreign Affairs and Trade's Renewable Energy Mini-grid Common Design Principles which set guidelines for the design of off-grid and hybrid PV systems in the Pacific. These guidelines were written to provide donor organisations and Pacific electrical utilities with a consistent approach to design that is tailored to the remote tropical marine conditions of the Pacific Islands. The guidelines will contribute to the replicability of the TREP.

La'a Lahi (big sun) Solar Field

Vava'u, Tonga
Date started: December 2012
Date of completion: November 2013

Kingdom of Tonga
Area: 747 sq km
Coastline: 419 km
Population: 106 440 (July 2014 est.)
GDP: USD 846 million (2013 est.)

As an emerging tourism hub with 17 000 residents, Vava'u needed to reduce its importation of highly expensive diesel and did so with the help of the Tonga Energy Road Map (TERM). The TERM Implementing Unit and Masdar launched an extensive solar energy project, aiming to maximise fuel savings. The project was funded by the UAE-Pacific Partnership Fund which provides USD 50 million in untied grants to increase renewable energy generation projects in the Pacific Islands.

Main features

Scale: 866 MWh per annum (512 kWp)

Funding source: Public

- The La'a Lahi (big sun) solar field project can supply up to 67% of power from the existing conventional, diesel-based micro-grid at solar peak hours.
- Advanced control technologies are used to maximise solar power production while minimising possible disturbances to the grid in terms of stability or the need for grid infrastructure upgrades. Solar input into the grid is automatically capped when production by diesel generators cannot be decreased.
- The mounting structure of the solar panels consists of aluminium in order to minimise corrosion from the marine environment.
- Performance monitoring is facilitated by automatic data reporting in Tonga and at Masdar.

Impact

- Total savings from decreased diesel fuel consumption as a result of the project are estimated at 289 000 L per annum.
- The plant satisfies 17% of Vava'u's annual electricity demand.
- The project is credited with reducing electricity tariffs across Tonga by 1%.
- Avoided CO_2 emissions are estimated at 724 tons per annum.
- Local job development during plant construction was equivalent to USD 400 000.

Project insights

- The project's unprecedented level of penetration (up to 67%) and nearly full year of performance data, shows the rapid growth of renewable energy technology in Tonga. In recent years, the maximum accepted level of instantaneous renewable energy penetration averaged only 20-30%. This reinforces the business case for further renewable energy deployment to reduce national fuel import needs.

Tuvalu Photovoltaic Electricity Network Integration Project

Vaitupu, Tuvalu
Date started: November 2009
Date of completion: December 2009

Tuvalu
Area: 26 sq km
Coastline: 24 km
Population: 10 782 (July 2014 est.)
GDP: USD 40 million (2013 est.)

The Tuvalu Photovoltaic Electricity Network Integration Project is located on the rural islands of Vaitupu and provides electricity to the public secondary school. Prior to this solar PV project, the school was powered by diesel generators with consumption levels of 120L/18 hours of operation each day. The cost of fuel is relatively high, with an average fuel price of USD1.27/litre in 2009. The cost of electricity is USD 0.52 per kWh and has not changed since 2009. The school relies heavily on electricity for purposes such as lighting and cooling.

The success of the project has garnered donor support for the replication of this system in other islands in Tuvalu and is contributing to Tuvalu's ability to reach its energy target of 100% renewable energy by 2020.

Motufoua Secondary School houses more than 600 boarding students and staff. The Government of Tuvalu decided to improve electricity access at the school and reduce diesel consumption.

Main features

Technology and scale: 46 kWp

Project budget (USD): 800 000

Funding source: Multilateral

- The project was funded by the government of Italy and Austria and managed by the International Union for Conservation of Nature (IUCN) through the Tuvalu Electricity Corporation (TEC).
- It is a solar PV mini-grid with batteries and has a total capacity of 46 kWp.

Impact

- The school now has 24 hours of power supply.
- The system was able to generate a total of 100 740 kWh per year and reduce diesel consumption to 26 510 L a year.
- Between 2009, when the project was commissioned, and 2014 the total maintenance cost was approximately USD 4 650.

Project insights

- High electricity tariffs coupled with the small scale of the school made it unprofitable for the Tuvalu Electricity Corporation to provide a continuous power supply. This supported the business case for investing in solar PV technology. The capital investment and maintenance costs of the system are also lower than those associated with supplying the school with diesel fuel.
- Even on a relatively small scale, a dependence on expensive diesel can be efficiently reduced while ensuring a reliable power supply.
- Project success has attracted more funding for its replication on seven of the rural islands of Tuvalu and is helping Tuvalu reach 100% renewable energy use by 2020.

Talise Micro-Hydroelectric Project

Central west of Maewo Island, Penama Province, Vanuatu
Date started: 2011
Date of completion: 2014

Republic of Vanuatu
Area: 12 189 sq km
Coastline: 2 528 km
Population: 266 937 (July 2014 est.)
GDP: USD 1.27 billion (2013 est.)

Like most Pacific Islands, Vanuatu does not have fossil fuel resources. The economy therefore relies heavily on imported petroleum products and has felt the impact of recent volatile oil prices. Rural electrification remains a challenge, partly due to the high cost of energy sourcing from diesel generation. This has resulted in approximately 27% of the total population having access to electricity, which is largely concentrated in urban centres. As a result, the Government set out to develop its renewable energy resources to improve the rate of rural electrification while using environmentally friendly methods. The Government proposed the development of the micro-hydro Talise River project to meet the electricity needs of the villages of Talise, Nasawa, and Narovorovo in the Central West of Maewo. The villages have approximately 1 300 residents and a total of 361 households, public buildings, and commercial establishments.

Main features

Scale: 75 kW micro-hydro power (MHP) capacity

Project budget (USD): 300 000

Funding source: Public

- A feasibility study in 2002 determined that the best option for the electrification of the area was hydropower. The Talise River was considered most suitable for this development given its orientation, flow, location and land ownership issues. The river has a 106m decline

VANUATU

between its source and the location of the power station. It spans a distance of 1.5 km.

- The Talise electrification proposal was funded by the Italian and Austrian Government through the International Union for the Conservation of Nature (IUCN). It is projected that funding for the second stage of the project (including transmission, distribution and maintenance) will be approximately USD 700 000.
- A community based management approach was chosen, utilising locally owned workshops, locally found materials, skills and knowledge, where possible.
- The project promotes small rural business operations to enable revenue generation for the communities and ensures that the hydropower project generates its own revenue and is able to fund its own future grid expansion and rural economic development without further government or donor partner assistance.

Impact

- Cost savings from reduced payment for fuel, generators and lamps will boost savings which can be used for purposes such as education and health care.
- With a population growth of 4%, the provision of electricity in the area has the potential to enable rapid economic growth and could make this a main economic centre for the province, advancing the national Government's vision of the decentralisation of services.
- The project is also expected to result in a reduction of greenhouse gas emissions of approximately 829g of CO_2 per kWh.
- Schools will benefit from electricity and, as a result of better conditions and resources, education standards will be improved.
- Safety for women in the villages will be improved as they will be able to walk freely within the community.

Project insights

- Due to the remoteness of the site, the Department of Energy in Port Vila proposed a community based management structure for the ongoing operation and maintenance of the system. A minimum transition period of one year will be given, in which the department will provide sufficient training, management structure development, capacity building, establishment of a fee collection system and monitoring for the communities. This model will be useful for similar remotely located projects.
- Community awareness programmes for potential income generation opportunities and financial literacy will be regularly provided by the Department of Energy. This will support further economic activity in the area and the maintenance and probable extension of the grid to neighbouring areas.

IRENA Tools

Lighthouses Initiative Quickscans
Renewables Readiness Assessments
Island Roadmaps
Project Navigator
Grid Integration Assessments

Lighthouses Initiative Quickscans

The Lighthouses Initiative (LHI) Quickscan is designed as the preliminary step used to evaluate the readiness of a SIDS to deploy renewable energy within the power sector. The Quickscan is a useful tool as it provides insightful results within a short period of time. It is also a key tool for communicating the most important needs of SIDS. This information can be shared within the LHI community and beyond.

The Quickscan process is centered around a questionnaire covering seven areas critical for the successful deployment of renewable energy. IRENA engages the designated focal point from the SIDS government through interviews to complete this Quickscan questionnaire.

The key needs identified in the Quickscan allow SIDS governments and development partners to prioritise the areas of support that will have the largest impact on accelerating renewable energy deployment. The main areas covered by the Quickscan questionnaire include:

1. Institutional framework

- The level of political support within the country for the deployment of renewables.
- The effectiveness of government plans and targets in supporting renewable energy deployment.

2. Knowledge base

- The availability and quality of national resource assessments on renewables.
- The availability and quality of energy balances and other data on the current performance of grid and off-grid assets.
- The presence of regularly updated demand growth forecasts.
- The level of engagement and information sharing between important stakeholders and agencies in the renewables space.
- The availability of experience within the country in the fields of design, installation and procurement of renewable energy technologies.

3. Planning

- The readiness of infrastructure and organisations to support the planning process for renewable energy projects needed to achieve large scale deployment.
- The existence of assessments to support the integration of variable renewable energy into the grid.

4. Financing

- The sufficiency of funding from public and private sources to meet official renewable energy deployment targets.
- The presence of clear rules and procedures to stimulate local and foreign investment in renewables.

5. Deployment

- The presence of a reliable supply chain and infrastructure, such as ports and roads, necessary for project implementation.
- The effectiveness of procedures for grid inspection and connection.
- The existence of plans and budgets to effectively manage funding for projects.

6. Capacity building

- The accessibility of training and educational programmes on renewable energy.
- The capacity to install, operate and maintain power grids and other equipment needed for the deployment of high shares of variable renewable energy.
- The capacity to develop bankable project proposals.

7. Cooperation

- The level of engagement of regional and international organisations in the deployment process and the presence of frameworks to support such engagement.
- The existence of a government office with expertise in the renewable energy field to support project coordination.

Quickscan progress

Quickscans have been developed for the Bahamas, Fiji, Kiribati, Mauritius, Samoa, Tonga and Tuvalu with 8 more ongoing in Antigua & Barbuda, Cook Islands, Federated States of Micronesia, Marshall Islands, Nauru, Palau, the Solomon Islands, and Vanuatu. IRENA aims to carry out Quickscans in all SIDS partners of the LHI by the 21st session of the Conference of the Parties to the UNFCCC (COP 21) in December 2015.

If you wish to engage in the Quickscan process, please contact Mr. Emanuele Taibi: ETaibi@irena.org

Renewables Readiness Assessments

The RRA is a country-initiated, country-led process that identifies the actions needed to enable the rapid deployment of renewables. It takes place ideally after the Quickscan.

The RRA consists of four main phases:

- Initiation and demonstration of intent
- Country assessment and action plan
- RRA country validation and finalisation
- Follow-up

Various stakeholders are engaged during each of these phases to ensure that the process achieves the intended purposes of compiling relevant information, establishing networks and promoting renewable energy deployment. This multi-stakeholder consultation brings together key actors in the renewable energy space to discuss common challenges and to jointly devise actions to tackle them with resources from the international community.

Impact and insights

Within this context, RRAs have improved cooperation at the national and regional levels through engagement in 24 countries since 2011. The islands that have engaged in the RRA process include Fiji, Grenada, Kiribati, the Republic of the Marshall Islands (RMI) and Vanuatu. IRENA has also initiated RRAs in Antigua and Barbuda and in the Bahamas. Drawing upon the expertise within these countries and within IRENA, a portfolio of recommendations is proposed to the government.

RRAs have made an immediate impact in islands. Some of these include:

- After the RRA workshop completed in Fiji, a new method for the calculation of tariffs for independent power producers (IPPs) was adopted, making the tariff more attractive to investors.
- As a result of the RRA workshop in Vanuatu, the Utilities Regulatory Authority of Vanuatu decided to develop regulatory guidelines for IPPs and Power Purchase Agreements.
- The RRA for the RMI included an action plan for grid-connected renewables and a plan for the mini-grids powered by diesel to be powered by solar photovoltaic systems.

An RRA report also presents potential investors with renewable energy development opportunities in the respective country related to the potential for renewable energy resource development, national energy contexts, legal and regulatory frameworks in place and institutional and administrative structures that potential investors would need to navigate to develop renewable energy projects.

If you wish to engage in the RRA process, please contact Mr. Gorbuz Gonul: GGonul@irena.org

Island Roadmaps

Island roadmaps are used to assist governments in creating a comprehensive plan for renewable energy by considering country targets and elaborating on their implications regarding costs and the policy and regulatory changes needed to achieve optimal levels of deployment.

IRENA's island roadmaps are a country-requested and country-led process involving in-depth analysis and extensive consultation with governments and key stakeholders to develop a comprehensive plan for renewable energy deployment. The IRENA island roadmap is ideally completed after the Quickscan and the Renewables Readiness Assessment. The analysis done covers the full range of cost-effective renewable energy options and supporting technologies. Key milestones are outlined and recommendations on policies to support the transition are provided. National renewable energy targets, energy security issues, pollution limits and any other country-specific objectives are taken into consideration during the process. The stakeholders involved are selected by the government and usually include representatives from the utility and from the ministry covering renewable energy.

In the case of Cyprus, the renewable energy roadmap completed by IRENA consisted of three sections which complemented each other:

1. Cyprus energy balance and demand forecasts

This involved an analysis of energy use data from 2012 and provisional data from 2013. Based on this information, demand forecasts up to 2040 were made. This information was used in the creation of the roadmap's electricity supply model described below.

2. Electricity supply model

This was the focus of the roadmap, as requested within the Expression of Interest sent by the government to IRENA. The Energy Supply Model for Cyprus (ESMC), a long-term energy planning model of the power system in Cyprus, was created to understand the potential effects of important policy decisions on the power generation mix. A long-term energy modelling platform, the Model for Energy Supply Strategy Alternatives and their General Environmental Impact (MESSAGE), was used to create the ESMC. Using the ESMC, six scenarios were developed to meet electricity demand at minimum cost within varying constraints between 2013 and 2030.

3. Technical studies investigating variable renewable energy (VRE) generation

IRENA's insights were requested to enable the government to make decisions regarding the best methods to be used to accommodate large shares of solar and wind energy into the electricity mix of the country. The studies focused on supporting this integration while maintaining a stable electricity grid. It involved:

1. VRE production forecasting
2. State-of-the-art technology supporting VRE integration

The main findings of the Cyprus roadmap included:

1. Electricity can already be generated at a lower price through renewable energy technologies including solar photovoltaics (PV) and wind. As a result, by 2030, between 25% and 40% of the island's electricity could be generated from renewable energy. Solar PV is predicted to be the main source, with predicted shares between 15% and 17% by 2030.
2. Utility-scale solar PV is the cheapest generation option available.
3. In 2013, electricity generation costs were about EUR 130/MWh. By 2030, costs could decline to about EUR 83-92/MWh due to renewable energy and natural gas use.
4. By 2030, between 11,000 and 22,000 jobs could be created in Cyprus as a result of renewable energy deployment.

Some measures recommended to minimise electricity generation costs while allowing for renewables to be deployed as per the optimal pathway and to their full economic potential included the following:

1. Renewables deployment can be best encouraged by an electricity market that allows full participation of renewable energy generators and correctly values renewable energy with time of day pricing.
2. Grid code requirements for renewables should be minimised with an emphasis on essential safety and security. Market measures should be used as the primary means of driving and controlling the deployment of renewable energy.
3. A transition from a net-metering to net-billing scheme could support higher shares of renewable energy. Renewable energy fed into the grid should be sold at market price or at a feed-in tariff below market generation cost.
4. A feed-in tariff should be maintained until an effective market for renewables is operational.

IRENA has also completed roadmaps for Nauru, Mauritius and the Republic of Maldives. Roadmaps for Kiribati and Barbados are being developed. Support is also being provided to GIZ through a joint project for the implementation of roadmaps in Cabo Verde and Vanuatu.

A roadmap baseline report has also been completed for Pacific SIDS and an island roadmap blueprint workshop is being planned for 2015.

If you wish to know more about IRENA's work on island transition planning, or would like to request support for the development of an island roadmap, please contact
Mr. Emanuele Taibi: ETaibi@irena.org

Project Navigator

Despite the increasing levels of renewable energy installed capacity worldwide, deployment is still hindered by the fact that a large number of renewable energy projects do not come to fruition due to a failure to secure the required financing. The main reason for this is the lack of a project proposal capable of convincing banks of the potential profitability of the project. A lack of reliable data for an adequate investment analysis and weak project development skills often lead to such situations.

IRENA's Project Navigator is a comprehensive platform that provides developers with the means to create a comprehensive and bankable project proposal which can facilitate the securing of funds by guiding developers through each step of the project development process. Renewable energy project developers, financing institutions and academia on islands will benefit greatly from the use of Project Navigator.

Through different sets of guidelines, the Navigator provides information on general and technology-specific levels. It also provides more transparency in the project development process and thereby enables better decision-making. This information is needed to turn the idea of a project into reality.

The Project Navigator is composed of three main parts:

- **Learning Section**: this presents general, environmental, legal, administrative, commercial, financial and organisational recommendations to be taken into consideration during the project development stages. Technical guidelines currently cover onshore wind and utility scale solar photovoltaics and will cover residential solar, small hydro, off-grid and mini/micro-grid applications and bioenergy in the near future.
- **Start a Project:** this is an interactive workspace for developers to create their own projects and keep track of progress. In this way, it assists project developers in identifying gaps in their proposals.
- **The Financial Navigator**: this is a database comprised of different types of renewable energy funds, which helps developers identify funding opportunities for their projects by providing detailed data on each fund.

Case studies and best practices are also available to assist in the successful creation of bankable project proposals. Workshops are conducted in member countries to train project developers in the use of the platform.

The first Project Navigator workshop was conducted in Cabo Verde in September 2014. It focused on identifying the needs and challenges met when developing renewable energy projects and securing financing on islands. Policy makers, funding institutions and project developers from across the globe discussed issues related to renewable energy project development in Cabo Verde, common challenges met in this environment, important success factors of such projects and insights gained from these experiences. Feedback on the tool was received from participants in order to further strengthen its capacity on the national and regional levels.

To find out more about the IRENA Project Navigator, please visit www.irena.org/navigator

If you wish to use the Project Navigator tool, please contact Mr. Roland Roesch: RRoesch@irena.org

Grid Integration Assessments

The integration of variable renewable energy resources into existing electrical networks often requires the implementation of additional technologies to ensure the safe, reliable and economical operation of the grid. The readiness of the grid to sustain the targets for renewable energy deployment therefore needs to be assessed. Since grids on islands are often small and inflexible, these assessments are vital as higher shares of variable renewable energy are accommodated.

Grid integration assessments are undertaken in close cooperation with local stakeholders to assist policy makers and energy authorities on islands. These studies involve the following:

- After the deployment of renewables, physical changes to the grid and the conditions under which it is operated often occur. The grid assessment identifies actions needed to deal with these changes.
- Certain actions are proposed to local stakeholders to tackle problems identified and to ensure the secure and reliable operation of the grid. When the process of integrating variable renewable energy resources into the grid is done gradually, this often requires more than one step, since the technical feasibility of the process needs to be assessed along the way. Therefore, more than one grid integration assessment may be needed to make the deployment process more successful for local stakeholders.
- To make the grid integration process sustainable, in parallel, local capacity is built through expert meetings and workshops to provide public utilities and energy planning offices with training and online access to the specialised software tools used during grid assessments. Workshop and expert meetings have involved training for the use of the PowerFactory tool which can be used to create simulation models and analyse the grid integration process from the technical point of view.

Impact and insights

Short- and long-term renewable energy deployment targets as well as expansion and operational steps can be evaluated more accurately based on the information gained from these assessments. This could also allow the integration of higher shares of renewable energy beyond previously identified limits.

The pilot grid integration study was completed in Palau in 2013. At present, grid assessments are in progress in Antigua and Barbuda, the Cook Islands and Samoa. They are scheduled for completion in 2015, with additional studies being planned.

The first section of the methodological guidelines derived from IRENA's grid integration studies will be published in 2015. These technical guidelines include insights from completed studies. As a result, a better understanding and deeper knowledge of the technical challenges found will be provided to local stakeholders and the international community.

The example of the grid integration assessment to support the transformation of the power system in Samoa is below.

The grid integration study completed for Upolu, Samoa's main island, was requested by the government to support the Electric Power Corporation (EPC)'s generation expansion plan for the period 2015 to 2017. The plan is in alignment with the government's target to generate 100% of the island's electricity supply from renewable energy by 2017, with a focus on high shares of PV and hydro power generation. The study assessed the adequacy of the EPC's existing infrastructure and operational practices to guarantee a reliable supply of power from the planned shares of renewables. It identified the technical issues that constrain generation from renewable energy sources and threaten the reliability of the power supply.

The study found that despite ambitious plans for a transition to 100% renewables by 2017, a high dependence on diesel will remain (at about 40 % of the annual electricity demand) in 2016 and 2017 if no extensions are made to the current infrastructure. However, if the study's recommendations, including those made to install battery energy storage and voltage control systems are followed, in 2017, renewables have the potential to supply up to 96% of the island's electricity demand. Since hydro power is the main potential source, the final share of renewables will depend on the availability of water resources. Contributions from solar PV and wind generation could meet around 18% of the total electricity demand in 2017. Battery storage devices will contribute to these efforts by improving system stability and decreasing the levels of reserves required by diesel generators in operation.

A simulation model of the island's power system, based on the study's assessments, was developed using the PowerFactory software. The model was given to the EPC along with access to the simulation software, allowing for use in future assessments of the feasibility and impact of further expansion plans and changes within the power system. The results of the study and the methodology followed were presented to and discussed with EPC engineers during a one week technical visit from IRENA staff. The technical visit also included live demonstrations of the conducted assessments and sessions guiding EPC engineers on the use of the simulation model.

Due to the incorporation of new projects into the utility's expansion plans, changes to the recommendations made within the conducted studies will be required. The second phase of the process, building upon the conducted activities, is under way.

If you wish to engage in the grid integration assessment process, please contact Mr. Francisco Gafaro: FGafaro@irena.org

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