IRENA
International Renewable Energy Agency

A Path to Prosperity:

RENEWABLE ENERGY FOR ISLANDS

Prepared on the occasion of the Renewable Energy Forum

About IRENA

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

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A PATH TO PROSPERITY: RENEWABLE ENERGY FOR ISLANDS

A Path to Prosperity: Renewable energy for islands was developed in support of the Renewable Energy Forum, a one day forum preceding the Third International Conference on Small Island Developing States (SIDS) held in Apia, Samoa on 1-4 September 2014. The brochure is a collection of case studies submitted by SIDS and development partners to complement Forum discussions. This compilation of real-life projects illustrates innovative solutions and partnerships used to advance renewable energy deployment in SIDS.

A Path to Prosperity: Renewable energy for islands was made possible because of the engagement and contributions of Antigua & Barbuda, Bahamas, Cabo Verde, Fiji, France, Germany, Jamaica, New Zealand, Samoa, Tokelau, Vanuatu, United Arab Emirates, United States of America, the Asian Development Bank, the Caribbean Development Bank, the International Renewable Energy Agency, the United Nations Development Programme, and the World Bank. Country information was obtained from the CIA World Factbook.

"Bringing together SIDS leaders, development partners, and stakeholders from around the world, the Renewable Energy Forum offers a unique opportunity for SIDS and their partners to identify the elements needed to transform island energy sectors and discuss how renewable energy is helping other SIDS achieve sustainable economic development.

Forum objectives are to:

- *Highlight the economic, social and climate change mitigation benefits of renewable energy.*
- *Identify and showcase policies, practices and experiences that could help increase renewable energy use in SIDS.*
- *Catalyse new and innovative partnerships for the deployment of renewable energy in SIDS."*

NEW ZEALAND

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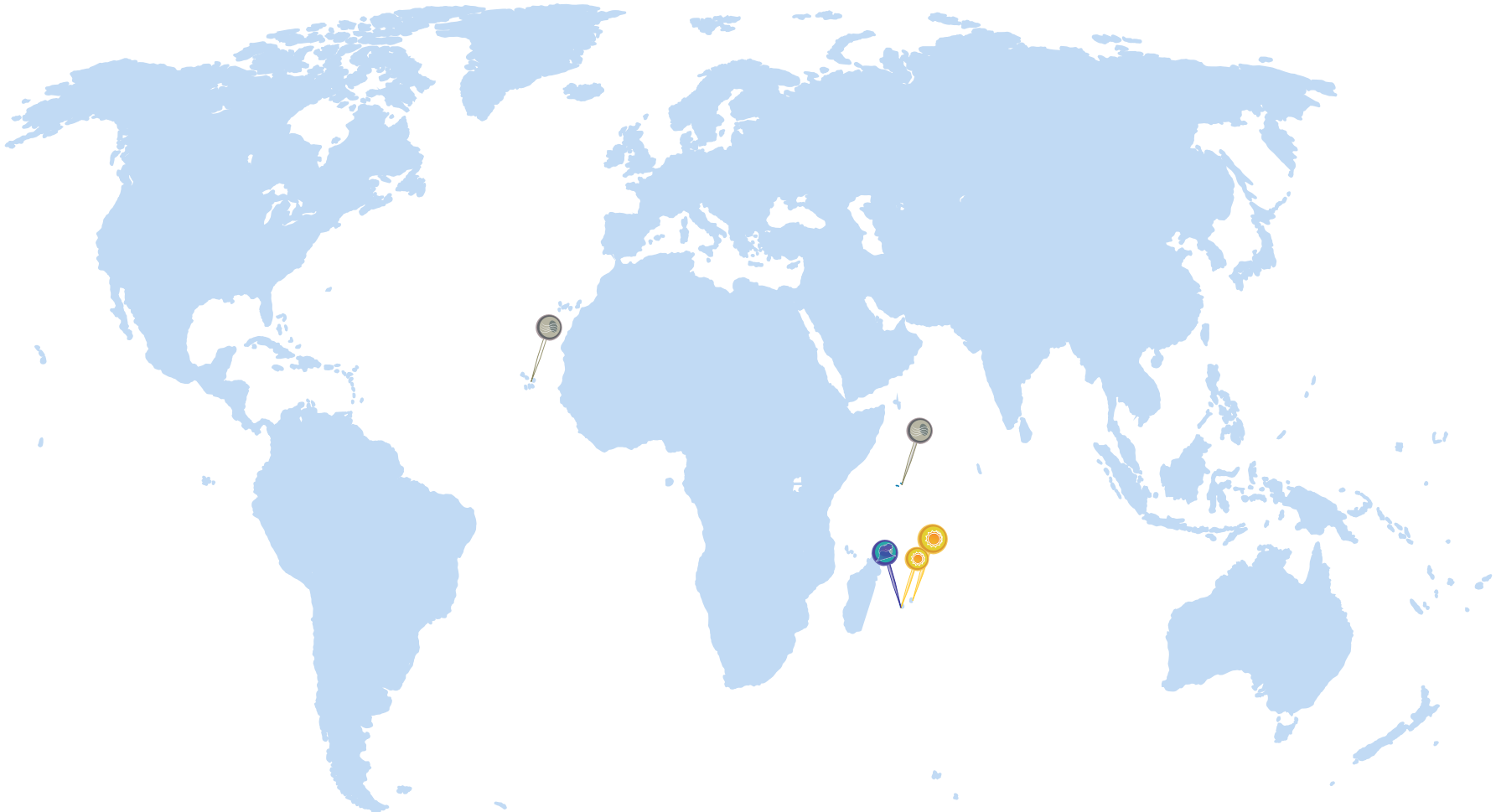

1 Africa, Indian Ocean, Mediterranean and South China Sea

Cabeolica Wind Project, **Cabo Verde**

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Cabeolica Wind Project

Cabo Verde archipelago
Date started: 2006
Date completed: 2011

Republic of Cabo Verde
Total Area: 4 033 sq km
Coastline: 965 km
Population: 538 535 (July 2014 est.)
GDP: USD 2.222 billion (2013 est.)

CABO VERDE

The Cabo Verde archipelago is one of the best sites for the generation of wind power 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 (RE) 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

Public/private/multilateral: 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.

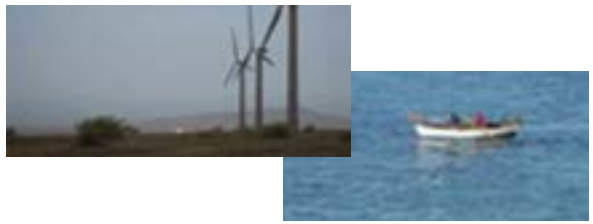
Impact

- 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.



Renewable Energy and Energy Efficiency in Buildings and Industry

Mauritius
Date started: 2008
Date completed: 2014

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

MAURITIUS

The cost of importing fossil fuels for energy generation in Mauritius is significant. Renewable energy (RE) 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 RE and energy efficiency (EE) 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 EE in residential and commercial buildings. A similar approach is being pursued within the country's industrial sector. This project aims to sustainably transform and decarbonize Mauritius' energy future via a suite of policies and incentives in the areas of RE and EE.

Main features

Scale: 3.8 MW installed capacity & cost saving in industry sector of USD 3 million/annum

Project budget (USD):

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

Public/private/multilateral: Public/Multilateral

The project aims to:

- Build institutional and human resource capacity at the policy level and to promote RE and EE 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 EE.
- 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 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.

- The project has supported the development and formal enactment of the 2012 Energy Efficiency Act which created a functional EE 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.

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. The annual cost savings potential from EE measures in industrial sectors is expected to total USD 3 million.

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

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

Public/private/multilateral: 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 also 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 (installed and running) to current day (operating)

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

RÉUNION

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 (RE) deployment. Since 2009, the Réunion Island University, the Réunion Island Local Authorities and the DCNS have worked towards the deployment 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.

Public/private/multilateral: Public & 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.

- 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 four years (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. It also 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 desalinization, 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.

Port Victoria Wind Farm

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

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

SEYCHELLES

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 (RE) target of 15% by 2030. As part of the close cooperation between the Seychelles and 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 RE.

Main features

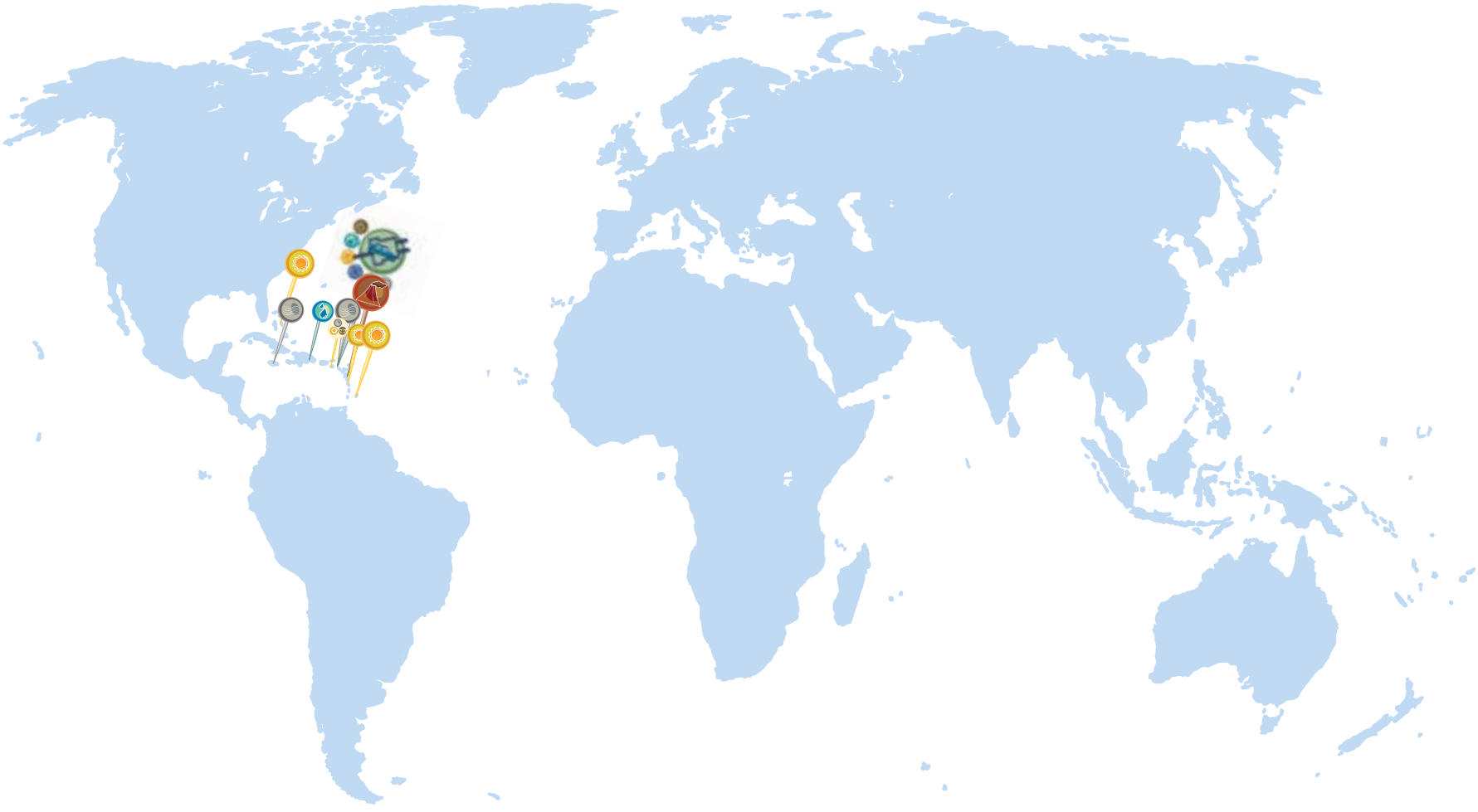
- The project was enabled by strong government support for implementation and land acquisition, matched with grant-funding from the UAE.
- The project's large size meant that careful study of grid stability was necessary, given the implications for project design.
- 8 x 750 kW wind turbines were built 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.



2 Caribbean

Implementation of Sustainable Solar Energy, **Bahamas**
Turtle Beach Resort Solar Water Heating Project, **Barbados**
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Implementation of Sustainable Solar Energy

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

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

BAHAMAS

Electricity generation in the Bahamas is based almost entirely 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 (RE) and energy efficiency programs into national plans.

In 2012, the government, with the assistance of the Inter-American Development Bank (IDB) and the Global Environment Facility (GEF), implemented a pilot project. The project was designed to ultimately remove barriers to RE 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.

Main features

Technology and Scale: Solar PV: 2 kWp, and solar water heaters: 60 – 80 gallons

Project budget (USD): 1 million

Public/private/multilateral: 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 RE is being introduced into the building code.
- Existing acts and regulations are being created and amended to regulate the RE industry in the future.
- A net billing/net metering system will be utilised.

Project insights

- Laws and policies should be amended prior to the deployment of RE 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 RE 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
Total Area: 430 sq km
Coastline: 97 km
Population: 289 680 (July 2014 est.)
GDP: USD 7.004 billion (2013 est.)

BARBADOS

Prior to 1997, hot 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 (FCA) 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 minimize 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

Public/private/multilateral: 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

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 neighboring islands.

Main features

Scale: 10-15 MW

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

Public/private/multilateral: 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

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

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 (RE) 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 RE 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

Public/private/multilateral: Public/communities/multilateral

- The Rural Electrification Programme promotes access to RE 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 recognize 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)

GUADELOUPE

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 through 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

Public/private/multilateral: 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 from 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.
- The charging station will be operational in January 2015.

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 other than 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)

GUADELOUPE

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 (RE) 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

Public/private/multilateral: 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.
- The plant will be in operation in March 2015.

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 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, thus creating local jobs.

Project insights

- With current technology, energy storage has an impact on price, however, it offers valuable opportunities for improving the insertion of RE 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: Studies - 1996, Construction Wigton I – September 2003, Wigton II – March 2010
Date completed: Wigton I – April 2004
Wigton II – December 2010

JAMAICA

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 (RE) 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 and Wigton II: 38 MW

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

Capital Cost Wigton II: 47.5 Million

Public/private/multilateral: 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.
- The electricity sector's generation market was liberalized 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 utilized, 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 RE 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 an RE 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 pressurized water pumping system. The neighboring 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 RE uptake. For example, for the 2012 call for 115 MW of RE proposals which stipulated technology specific rate caps, there were over 800 MW of RE 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)

MARTINIQUE

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 (RE) 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 PV systems under realistic conditions and through this, contribute to increased RE 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

Public/private/multilateral: Public

Partners: The Martinique Energy Agency (AME), 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 and voltage analysers, 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 RE 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 can be 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 RE legislation.

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

Public/private/multilateral: A government led initiative that resulted in

US VIRGIN ISLANDS

both public and private sector investments.

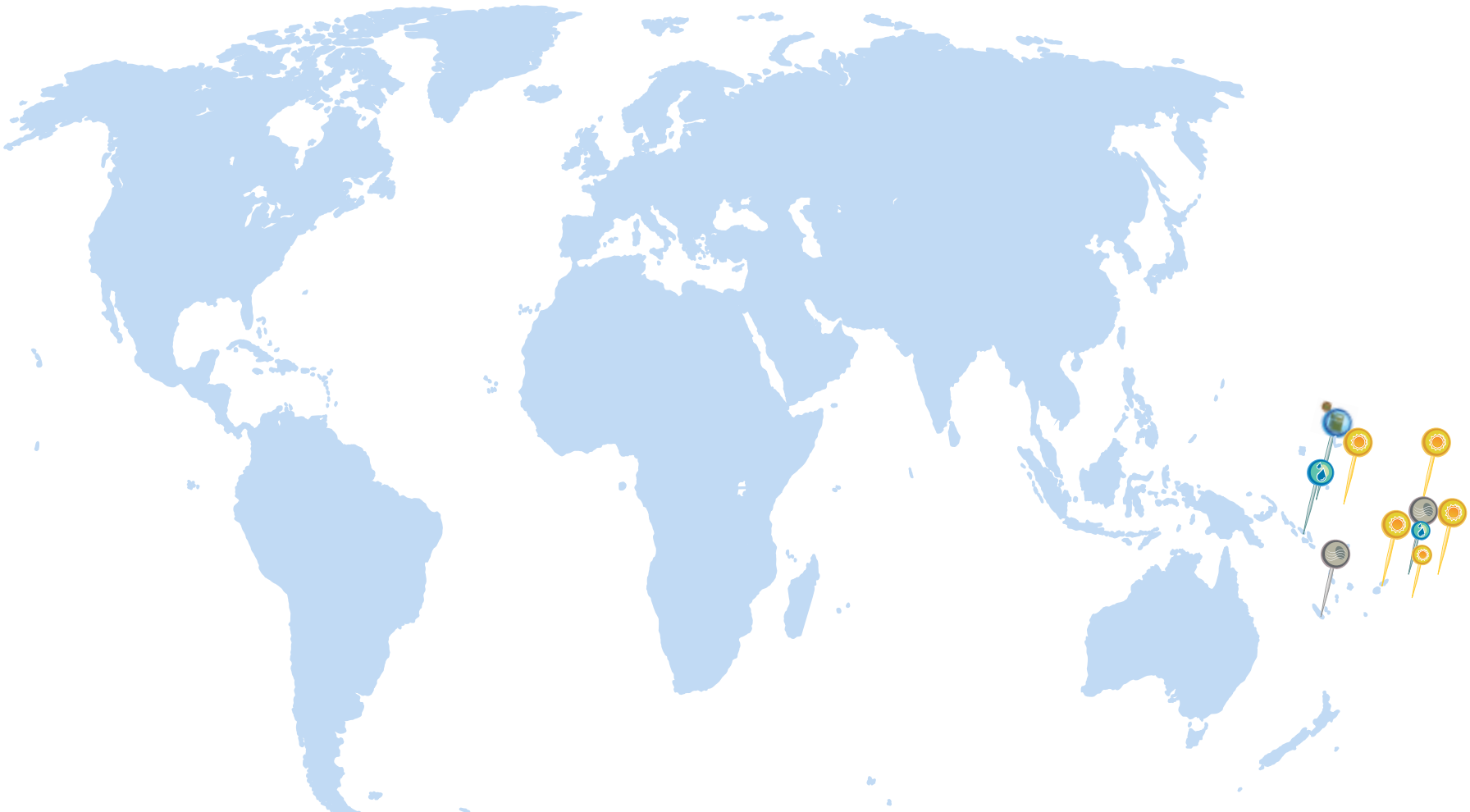
- In 2012, WAPA issued a Request for Proposals and negotiated offers to obtain long-term power purchase agreements from solar PV facilities that would account for approximately 15% of peak load at an average cost of USD 0.15 — USD 0.17/kWh. Two projects totaling 9 MW capacity are under construction, 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 is saving the Port Authority nearly USD 1 000 a day.
- Solar water heater requirements improve energy use in new buildings and maximize 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.



3 Pacific

Rukua Mini-Grid Solar Project, **Fiji**
InterContentinal Bora Bora Resort & Thalasso Spa, **French Polynesia**
Prony I, II, III & 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.)

FIJI

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 (Amortized): 4 000

Public/private/multilateral: 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 & 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.)

FRENCH POLYNESIA

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, it was decided to install a seawater air conditioning system (in place of conventional air conditioning systems).

Main features

Scale: 450 tons or 1.6 MW of air conditioning

Project budget (USD): Capital investment: 7.9 million

Public/private/multilateral: 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.
- 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 & Mont Mau

NEW CALEDONIA

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 New Caledonia'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 (RE) 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

Public/private/multilateral: 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 & 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 RE 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.)

SAMOA

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 (RE) deployment in Pacific islands.

Main features

Scale: 1 619 MWh per annum (550 kWp)

Public/private/multilateral: 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 RE, particularly PV and hydro, while improving the control of the grid to cope with the variability of some RE 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 a new technology is 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.)

SAMOA

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

Public/private/multilateral: 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.

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


Ethan Daniels

SOLOMON ISLANDS

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.)

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. Utilizing 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

Public/private/multilateral: 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 such as 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.)

TOKELAU

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 centralized 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: Fakaofo 365 kWp, Nukunonu 265 kWp, Atafu 300 kWp, Total 930 kWp.

Project budget (USD): 6.93 million

Public/Private/multilateral: 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.)

TONGA

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 (RE) generation projects in Pacific island countries.

Main features

Scale: 866 MWh per annum (512 kWp)

Public/private/multilateral: 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 minimizing 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 RE technology in Tonga. In recent years, the maximum RE accepted level of instantaneous penetration averaged only 20-30%. This reinforces the business case for further RE deployment and reduces 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.)

TUVALU

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/18hrs 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 (RE) 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

Public/private/multilateral: 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 24hrs 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.
- Since the commissioning of the project in 2009, 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% RE by 2020.

Talise Micro-Hydroelectric Project

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

VANUATU

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 (RE) resources to improve the rate of rural electrification while using environmentally friendly methods. As part of this, 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

Public/private/multilateral: 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 between its source and the location of the power station location. 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 sound materials and local skills and knowledge, where possible.
- The project promotes small rural business operations to enable revenue generation for the communities, 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.
- 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 also benefit from electricity and, as a result of better conditions and resources, education standards will be improved.
- Comfort and 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 as well as the maintenance and probable extension of the grid to neighboring areas.

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