IRENA
International Renewable Energy Agency

A Path to Prosperity:

RENEWABLE ENERGY FOR ISLANDS

Third Edition

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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 stakeholder organisations. These examples demonstrate real-life project viability, highlight innovative solutions, and showcase successful partnerships to help advance 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 and third editions expand on the database of projects and offer a selection of tools to support SIDS in their renewable energy transition. The third edition includes case studies of power-sector transitions to renewable energy, covering in particular the planning and implementation stages, examples of enabling business models, and grid operations.

A Path to Prosperity: Renewable energy for Islands was made possible thanks to engagement and contributions from the Governments of Antigua and Barbuda, Bahamas, Cabo Verde, Fiji, France, Germany, Jamaica, Japan, New Zealand, Saint Vincent and the Grenadines, Samoa, Tokelau, Vanuatu, the United Arab Emirates, and the United States of America. Many stakeholder organisations also contributed to the initiative. These organisations include Aguas de Ponta Preta, Akuo Energy, the Asian Development Bank, the Caribbean Development Bank, the Caribbean Electric Utility Services Corporation, Comisión Nacional de los Mercados y la Competencia, the ECOWAS Commission for Renewable Energy and Energy Efficiency, Fondation Energies pour le Monde, Grenada Electricity Services Limited, Hydro Tasmania, the International Renewable Energy Agency (IRENA), the United Nations Development Programme, and the World Bank. Country information was obtained from the CIA World Factbook.

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Islands across the globe are rich in sources of renewable energy. Small Island Developing States (SIDS) can meet most, if not all, of their domestic energy needs through a combination of renewable energy technologies. Decreasing costs of such technologies offer a unique opportunity to speed the transition from fossil fuels to renewables that will decrease electricity costs, improve energy access, create jobs, and boost energy security on islands.

The International Renewable Energy Agency (IRENA) is helping islands achieve a sustainable energy future through transitioning from import-dependent systems based on fossil fuels to renewable energy technologies.

Launched at the 2014 Climate Summit, The SIDS Lighthouses Initiative provides a global framework for the energy transition on islands. By 2020, the Lighthouses Initiative aims to:

- Ensure participating SIDS develop renewable energy roadmaps
- Mobilise USD 500 million
- Deploy 120 MW of renewable energy capacity

The initiative facilitates coordinated support for islands to transition to renewable energy through partnerships with public and private sectors, NGOs, and intergovernmental organisations. Lighthouses partners in the Pacific, Atlantic, and Indian Oceans and in the Caribbean, Mediterranean, and South China Seas gain access to:

- Policy and regulatory advisory services
- Technical expertise in planning, identifying, structuring, and executing projects
- Financing for capacity building, policy and regulatory design, early-stage transactions, and project finance
- A network to share information and knowledge

CONTINUING IMPLEMENTATION

Despite recent targeted actions, many islands face barriers at different stages of project development. For example, due to increased investment, many islands experienced a project overload, where they had to focus resources on design and integration of electricity systems before they could pursue new projects. The Lighthouses initiative helps islands assess and address challenges like this to enable stronger sustainable development and smart integration of renewables.

Lighthouses works with partners to perform all operational steps and create shared knowledge of SIDS power sector, best practices, and transformation challenges.

Under the Lighthouses Initiative, A Path to Prosperity: Renewable Energy for Islands offers a portfolio of real-life renewable energy projects, that include examples of power system transformation, renewable energy transition tools, and key operational insights.

We welcome contributions to the project database.


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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**

Gorona del Viento Hydro-Wind Power Plant, **El Hierro, Spain**

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

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

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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

Technology and 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, Cape 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 was generated.
  - approximately 26.787 liters of fuel was saved.
  - about 80 tonnes of CO_2 emissions were 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.

Gorona del Viento Hydro-Wind Power Plant

El Hierro, Canary Islands, Spain
Gorona del Viento Hydro-Wind Power Plant (HWPP)
Date started: 2008
Date completed: 2014

El Hierro is the smallest of the Canary Islands with an area of 278km^2 and about 11 000 inhabitants. In the past, power on the island was generated from diesel-based thermal plants (11 MW installed) with some intermittent wind and solar PV generation. The main aim of the HWPP, which was completed in 2014, is to combine the island's high levels of wind and hydro resources with the use of battery storage to diversify the energy mix of the island and allow for the extensive penetration of renewables. This project was designed to facilitate the island's full transition to renewable sources of energy.

Main features

Technology and scale: Wind turbines: 11.5 MW
Hydro storage plant: 11.3 MW

Project budget (USD): 498,115

Public/private/multilateral: Municipality of Porto Novo (public)

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

Co-financing: Multilateral:
Local government: 60%
Endesa, S.A.: 30%
The Canary Islands Institute of Technology: 10%

- Within the project, wind power is generated for two main purposes:
- Supplying demand directly
- Pumping water to the upper reservoir
- There is an upper and a lower reservoir and pumping can only be fueled by wind energy. Thermal generation cannot be used for this purpose.
- Simultaneous operation of the turbine and pump is possible. This means reserve capacity can be provided and a more economically efficient use of the thermal plant is possible.
- The HWPP is connected to the grid through just one point and so, operation and remuneration of the pumping station and the wind generator is carried out jointly.

Impact

- The island of El Hierro is less dependent on petrol products as a result of the higher levels of renewables deployed. In July and August 2015, generation at the plant improved considerably and 55% and 49% of demand were met respectively. At certain points, 84% of demand was met.
- Pumping exclusively with wind energy has facilitated the penetration of higher levels of renewables. It has also allowed for the use of storage capacity which can meet the equivalent of two days of demand.
- Assuming that demand is constant at its 2014 level of 42 GWh and that the plant operates at optimal levels, the potential CO_2 reductions could reach 22 kt of CO_2 per year.

Project insights

- The efficiency factor of the hydro plant pumping is crucial, since it can have a significant effect on variable costs and on the hours of operation.
- For planning purposes, competitive tendering or auctions can adjust better to real costs. In such cases, demand forecasting is highly important.

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.)

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

Technology and 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

Technology and 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.

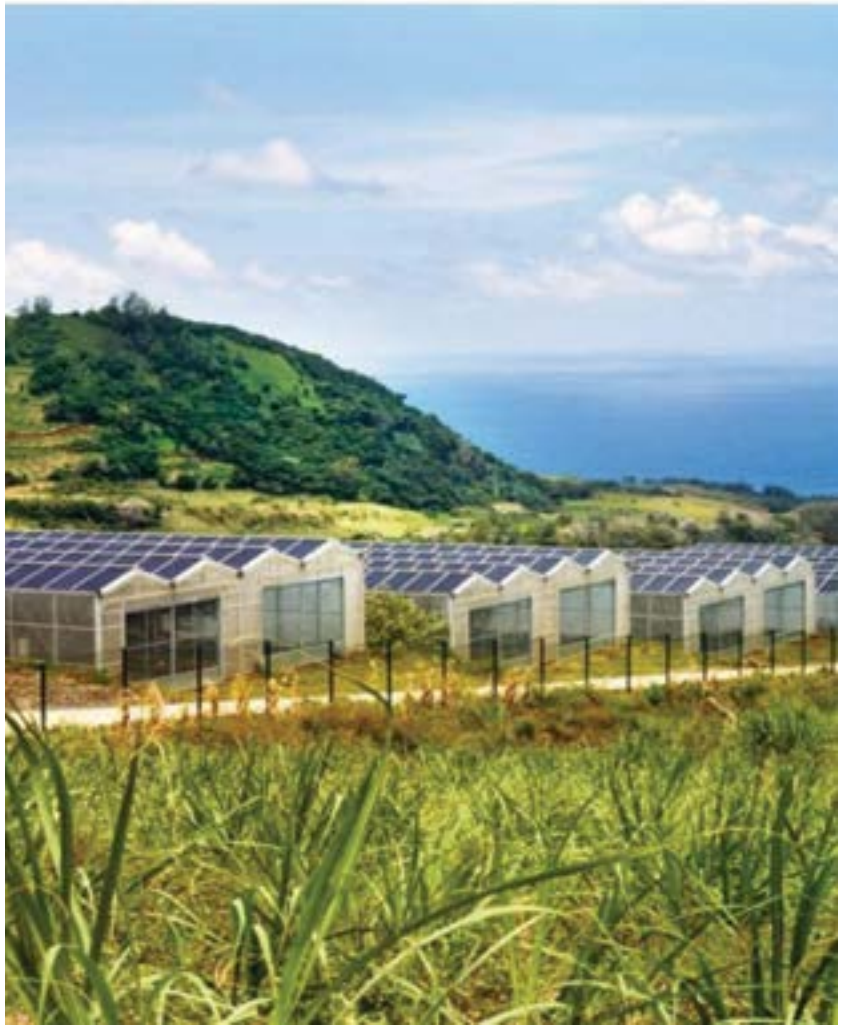
Impact

- 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.



Bardzour (Sunrise and Hope) Project

Bardazour, Le Port, La Réunion
Date started: 2010
Date completed: In operation since 2014

La Réunion has rich solar and wind energy resources. At present, more than 30% of the electricity on the island, the threshold beyond which the intermittency of renewable energy can threaten the stability of the network, is generated from renewable sources of energy. Akuo Energy has worked to increase the use of renewable energy in La Réunion, while preserving the power grid and the natural heritage of the island. This project, a solar farm with energy storage facilities located at the Le Port City detention centre, contributes to these objectives.

Main features

Renewable energy source: Solar

Technology and scale: 9MWp of solar PV
9 MWh of lithium-ion batteries

Project budget (USD): 32 million

Funding source: Private: Akuo Energy
The project is located on land belonging to the Ministry of Justice.

- Construction of the Bardzour project was carried out in 2014. It includes 27,000 photovoltaic panels (monocrystalline technology), 9 MWh lithium-ion batteries and 6000m^2 of solar greenhouses.
- The project is located on a 10 ha correctional facility, making use of an unused brownfield.
- It was developed in partnership with the Ministry of Justice and was the first solar project to be linked to a smart storage system.

- The energy stored in the batteries maintains power generation levels within the grid. A solar forecast device based on a smart control system was added, making it is possible to anticipate changes in generation levels 24 hours ahead of time and to transmit a stable signal reliant on solar and stored energy.

Impact

- Annual power generation from renewables will meet the needs of 12,000 people, a third of the Le Port City population.
- The project has also contributed the equivalent of USD 11 million to the local economy
- Akuo Energy assists in the reinsertion of the prison population through training programmes in the areas of construction, beekeeping and agriculture, making it a unique social rehabilitation programme. 37 prisoners have been trained on the project to date.
- Plans have been made to train 240 inmates over 20 years.
- 220 construction jobs were created as were 90 additional ones indirectly.

Project insights

- At the outset, the project design was too constrained, and the technology and logistics too complicated for sustainable long term plans. More reliable stakeholders and a more simplified project design were needed to make the project more sustainable.

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 impact 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

SÃO TOMÉ AND PRÍNCIPE

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.)

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 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 tonnes 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.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Caribbean

Implementation of Sustainable Solar Energy, **Bahamas**

Turtle Beach Resort Solar Water Heating Project, **Barbados**

Renewable Energy Based Rural Electrification Programme, **Dominican Republic**

Grenada Electricity Services Rooftop Photovoltaic Project, **Dominican Republic**

Désirade Electric Vehicles, **Guadeloupe**

Petite Place Wind Farm, **Guadeloupe**

Wigton Windfarm Phase I & II, **Jamaica**

Study of Martinique's Photovoltaic Performance, **Martinique**

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.

Several sustainable energy projects 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 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.

BAHAMAS

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

Technology and 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 tonnes of CO_2 emissions or about 41 tonnes 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.

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 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

Technology and scale: 23 small micro hydropower plants

Project budget (USD): 3 203 000

Funding source: Public/communities/multilateral

- 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.

Grenada Electricity Services (Grenlec) Rooftop PV Project

Dusty Highway, Grand Anse, St. George's, Grenada
Date started: September 2013
Date of completion: September 2013

In its 2008 strategic plan, Grenlec made commitments to incorporate renewable energy into its energy mix. The plan considered the development of a number of projects focused on proven technologies in addition to other options such as geothermal and waste-to-energy sources. This project is a major milestone for Grenlec in the context of its strategic objectives for renewable energy and builds on the successes of the ongoing renewable energy customer interconnection programme.

Main features

Renewable energy source: Solar

Technology and scale: PV: 148.48kW

Project budget (USD): 286,000

Funding source: Private

- The project involved the installation of solar PV panels to maximise available roof space at Grenlec's Dusty Highway facility. Panels have been installed on over 80% of the roof space of the three largest buildings at the facility.
- One of the most significant challenges during the project development phase was determining if the two older roofs were capable of supporting PV panels. Although the newest building among the group was constructed two years prior and designed specifically to accommodate PV panels, the other buildings were constructed 17 years before and were not built to withstand the additional weight

and wind loading that the installation of the PV panels would add to the roofs. Structural engineering assessments of the roofs were, therefore, made to suggest improvements needed for the facilitation of the project.

Impact

- The system is expected to generate approximately 260,000 kWh of energy each year. Generation to date is consistent with this expectation. This generation level can supply approximately 1700 Grenadian homes and results in the following benefits, estimated at:
  - Avoided diesel: 16,000 gallons per year
  - Avoided diesel costs: USD 49,000 per year
  - Avoided CO_2 emissions: 162,000 kg per year
- The project was economically feasible in the context of relatively high fossil fuel costs and declining costs of the PV system components.
- The PV technology used is also attractive because of the ease of installation and minimal maintenance requirements.
- Project investments are projected to be repaid within 7 years, taking maintenance and financing costs into consideration.
- Grenlec is about to implement a similar project of a larger scope. Approximately 1 MW of solar PV will be installed on all suitable spaces remaining at Grenlec sites, including roof tops, car ports and ground mounts. The company has also made significant progress in the development of a larger project of solar farms, with plans to supply more than 3MW of solar PV.

Project insights

- The project demonstrates the economic and technical feasibility of solar PV technology.
- The maintenance of spare inverters and adequate warranty terms is crucial. The inverters are critical since they are a common point of failure for many PV panels and they are often imported from countries far away. In this case, a spare inverter was obtained for the nine inverter installation, however, the five-year warranty only covered shipment within Germany. As a result, Grenlec had to bear the costs of the shipment of the three failed inverters and their replacements from Germany. These issues will be addressed in future projects on the island.

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 Desirade Electric Vehicles project is located on the small island of La Desirade, an ideal location for the use of electric vehicles (EVs) since it is just 6 km in length. The project involved 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

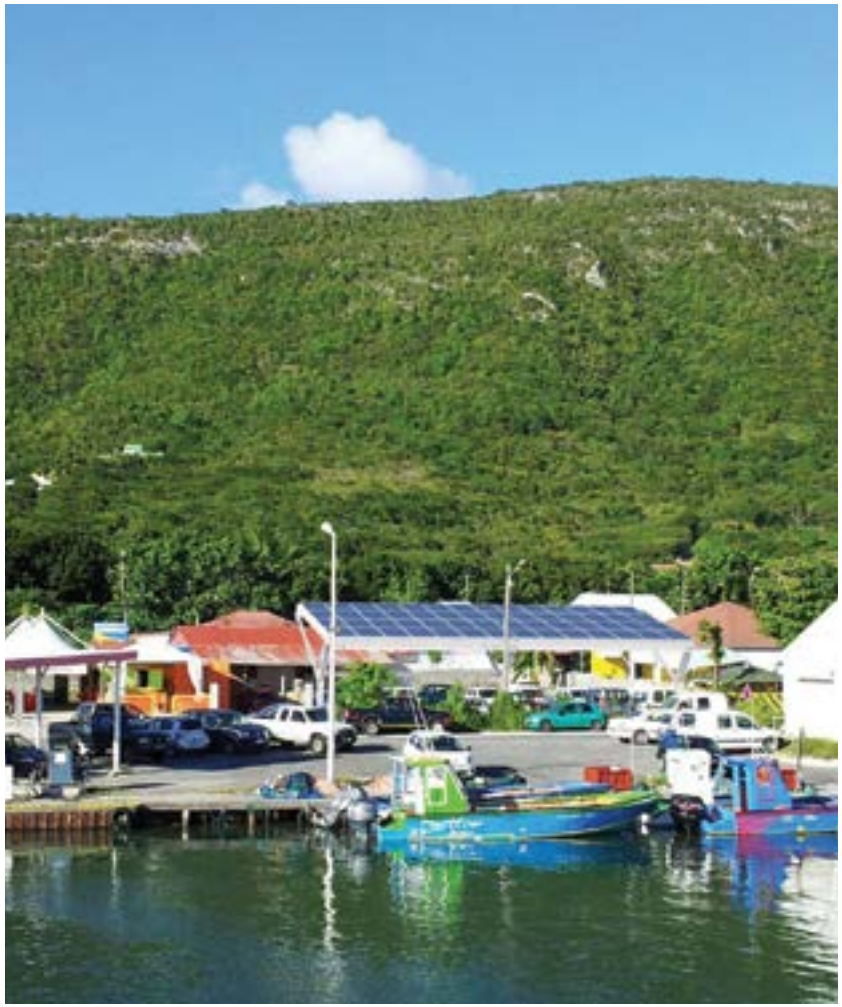
- Energy is produced by a 14 kWp solar shelter. The charging station has the capacity to refuel 6 EVs with 16 kWh each, equivalent to 100 to 150 km per day.
- The EVs are used for rental activity and charged during the night by a 50 kWh battery which stores electricity not used during the day.
- The 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 was carried out by local companies, creating local jobs.

Project insights

- This project contributes 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 are also 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 avoids 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 eastern 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 revamps a 15-year-old, 1.5 MW wind farm.
- The wind farm has nine Vergent 275 kW wind turbines, each 50 m in hub height and with a lithium-ion 500 kWh battery.
- A wind power forecast tool provides a power forecast at 30 minute intervals for the current and following day.
- A supervisory control and data acquisition (SCADA) system monitors system storage to compensate for forecast error and provides grid frequency and voltage system support.
- Turbines are able to be lowered to ground level to prevent hurricane damage and to facilitate maintenance.

- 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 produces 6 400 MWh per year over 20 years, preventing 5 085 tonnes 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 time of the project.
- Construction has been 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

Technology and 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.
- 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 and scale: 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.

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.

- In 2012, WAPA issued a Request for Proposals and negotiated offers to obtain long-term power purchase agreements from solar PV

US VIRGIN ISLANDS

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

Northern Group - "Huira Natura ke Tokerau" (Natural Light of the North) Project, **Fiji**

LaKaRo Solar Fuel Saving Project, **Fiji**

Rukua Mini-Grid Solar Project, **Fiji**

InterContentinal Bora Bora Resort & Thalasso Spa, **French Polynesia**

Pilot Project for Micro-grid System in Small Islands, **Japan**

King Island Renewable Energy Integration Project, **King Island, Australia**

Solar Water Protection Project, **Kiribati**

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**

Solar Space Creation Project

Tuvalu Photovoltaic Electricity Network Integration Project, **Tuvalu**

Talise Micro-Hydroelectric Project, **Vanuatu**

Vanuatu Solar Project, **Vanuatu**

Northern Group - "Huira Natura ke Tokerau" (Natural Light of the North) Project

Rakahanga, Manihiki, Pukapuka, Penrhyn, Nassau and Palmerston in the Cook Islands
Date started: 2014
Date of completion: 2015

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.)

The Cook Islands consist of fifteen islands, twelve of which are inhabited. 12,500 of the total population of 15,000 live on Rarotonga, the main island. The remaining 2,500 people live on ten smaller islands including six atolls that make up the Northern Group: Rakahanga, Manihiki, Pukapuka, Penrhyn, Nassau and Palmerston.

This project resulted from the commitment by New Zealand's Government at the 2013 Pacific Energy Summit to assist the Cook Islands' Government towards lowering tariffs, meeting their renewable energy targets and boosting tourism, thereby transforming the lives of the residents in the Northern Group. Different tariffs are currently applied on each island, with the average being approximately 0.5 USD per kWh.

Main features

Renewable energy source: Solar

Technology and scale: 1,126,000 kWh per year (total of 857kWp)

Project budget (USD):

- Total capital cost: 12,800,000

Funding source: Public

- The project consists of eight diesel-PV-battery mini-grid systems installed on the six atolls of the Cook Islands' Northern Group.
- It is part of the Pacific-wide Energy Access partnership between New Zealand and the European Union. The project was successfully governed by a steering group consisting of New Zealand and the Cook Islands Government officials.

- The PV systems were designed in line with the New Zealand Ministry of Foreign Affairs and Trade's Renewable Energy Mini-grid Common Design Principles. These guidelines were written to provide a consistent approach to design suited to the remote tropical marine conditions of the Pacific islands.

Impact

- Each system is designed to supply at least 95% of the islands' annual electricity demand.
- Providing reliable and affordable electricity to these remote islands has allowed more residents to increase their earnings from the fishing industry.
- Reliable electricity also improves the quality of life on remote islands like the Cooks. This may help to slow or even stop the recent trend of depopulation as young people, in particular, seek a better life on the main island or abroad.
- Total savings from the decreased diesel fuel consumption as a result of the project are currently estimated at 230,000 litres per year but there is a potential to meet a growth in demand, and for savings of up to 436,000 litres per year, if demand grows accordingly.
- The project currently prevents the equivalent of an estimated 620 tonnes of CO_2 emissions per year, but this could increase to 1,170 tonnes per year if demand grows.
- Reduced reliance on diesel means that the fragile island environment is at less of a risk of experiencing accidental fuel spills, and also that the island is less likely to run out of electricity if diesel shipments are delayed by severe weather.

Project insights

- A similar model of governance and delivery will be used within a European Union and Asian Development Bank funded project. In this project, similar PV/diesel hybrid mini-grid systems will be installed on four of the Southern Group islands in 2016.

LaKaRo Solar Fuel Saving Project

Lakeba, Kadavu and Rotuma, Fiji
Date started: September 2014
Date of completion: March 2015

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.)

The LaKaRo Solar Fuel Saving project in Fiji involved the construction of solar PV plants in three locations in Fiji (Lakeba, Kadavu and Rotuma), aiming to reduce the consumption of expensive imported diesel and increase the availability of clean power for further economic development. This project was financed by the United Arab Emirates' USD 50 million Pacific Partnership Fund, through the Abu Dhabi Fund for Development (ADFD) and was implemented by Masdar, Abu Dhabi's renewable energy company.

Main features

Renewable energy source: Solar

Technology and Scale: : 525 kW of solar PV with 500 kW of low load multi-set diesel generators and advanced control technologies

Funding source: Public grant by the Abu Dhabi Fund for Development (ADFD)

- The three new solar micro-grid projects include a 225 kW solar plant on Kadavu Island, a 150kW solar plant on Lakeba Island and a 150 kW solar plant on Rotuma Island.
- The three project installations generate a total of 820,000 kWh of solar power annually.
- This will meet up to 90% of electricity demand during daylight operating hours, or up to 50% of annual demand, with the use of low-load diesel generators with innovative control technology.
- Technical aspects of the project enable maximum solar energy penetration while maintaining grid stability.

Impact

- Electricity supply on the islands may be increased from an average of 15-18 hours to 24 hours per day.

- 260,000 litres of diesel, worth over half a million dollars (based on local 2015 diesel prices), may be saved per year.
- 720 tonnes of v emissions may be avoided annually.
- 900 additional homes will be supplied with clean energy electricity for lighting, air conditioning, home appliances and water desalination, significantly improving living conditions.

Project insights

- Transportation logistics in the Pacific are a major challenge during the construction of projects. Careful attention to this aspect of project implementation, particularly for projects in remote island locations, and the inclusion of suitable buffers into schedules, will enhance project planning and timely completion.
- The generators within the solar PV plant enable the provision of diesel-based power at low load conditions without adverse effects, thereby enabling much higher solar PV penetration into relatively small grids.
- This system configuration avoids the substantial cost of energy storage while enabling higher renewable energy shares and increasing electricity access. With three systems in operation, this configuration could serve as an excellent model for replication in remote island locations.

Kadavu Site

Lakeba Site

Rotuma Site

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 tonnes of CO_2 emissions and is projected to reduce CO_2 emissions by approximately 192 tonnes 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

Technology and scale: 450 tonnes 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 tonnes 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.

Pilot project for micro-grid system in small islands

Six islands in Kagoshima prefecture, four islands in Okinawa prefecture, Japan
Date started: 2009

In 2015, the Japanese government set a target of sourcing 22%-24% of power from renewable energy by 2030. Since islands with small-scale grid systems are more affected by fluctuations in renewable energy power supply than other areas connected to larger scale grids, grid stability is a particularly important issue when increasing the renewable energy penetration rate in these areas. This project aims to identify a strategy to improve grid stability through improved grid operations and the installation of a battery system.

Projects were developed on grids of different sizes on ten rural islands. This issue is particularly important in remote islands since they are isolated from the national grid and the grid sizes in these areas are much smaller than in others.

Main features

Renewable energy source(s): Solar and wind

Project budget (USD): 60 million

Funding source: Public: Ministry of Economy, Trade and Industry

- The project was implemented by two electric utility companies: Kyushu Electric Power Company and Okinawa Electric Power Company.
- This project aims to improve grid operations through the use of battery storage to stabilise short and long term fluctuations of solar power supply and distribution.

The table below outlines the power generation capacity installed on the ten islands:

	Max demand	Installed capacity			
		Newly installed		Existing	
		Solar	Wind	Solar	Wind
Kagoshima prefecture (6 islands)	kw	kw	kw	kw	kw
(1) Kuroshima	193	60	10	-	-
(2) Takeshima	83	7.5	-	-	-
(3) Nakanoshima	193	15	-	-	-
(4) Suwanosejima	78	10	-	-	-
(5) Kodakarajima	71	7.5	-	-	-
(6) Takarajima	125	10	-	-	-
Okinawa prefecture (4 islands)					
(7) Miyakojima	50,000	4,000	-	-	4,200
(8) Yonagunijima	2,160	150	-	-	1,200
(9) Taramajima	1,160	250	-	-	280
(10) Kitadaitojima	860	100	-	40	-

SOURCE: METI, 2010: http://www.meti.go.jp/committee/summary/0004671/007_02_01.pdf)

- In October 2010, on the southern coast of Miyakojima, 22,000 panels were installed as part of the Mega Solar Experiment Study Facility by Okinawa Electric Power Company. There are also two large wind turbines in the same area and three in the northern region of Miyakojima. These turbines can produce up to 4.2 MW of wind power. This facility has a large 4 MW battery storage system which backs up the solar- and wind-generated power when this drops, to maintain stable distribution throughout the grid.
- In Miyakojima, further introduction of PV was suspended due to installed and planned PV capacity having reached the threshold value to maintain the stable operation of the existing diesel based power system. There are plans to increase the levels of solar power generated by the project so as to reduce electrical costs on the island.

Impact

- The diversification of the energy supply is improving energy security within the relatively expensive diesel-based system.
- Wind and solar power generated at a super market in central Miyakojima meet 12% of its electricity demand. There are also facilities for free high-speed electric vehicle charging at this location.
- On Kurimajima, a small island southwest of Miyakojima, with about 90 households and about 200 people, a pilot project for 100% reliance on renewable energy has been deployed. The island's peak power demand is about 200 kW. Two units of a 176kWh battery were installed for the grid. Based on this pilot project, the solar power generated and stored in the battery system can meet half of the island's annual demand.

Project insights

- Knowledge on the subjects of battery management and grid stability maintenance were improved after the integration of renewable energy into the local grid system.

King Island Renewable Energy Integration Project

King Island, Australia
Date started: 1998

King Island is the world's first hybrid system to achieve 100% renewable energy penetration at a mega-watt scale. It is located in Bass Strait, about halfway between mainland Australia and Tasmania, Australia's southernmost island state. The island is approximately 65km long and 30km wide and has fewer than 2,000 residents. King Island's economy is based mainly on agriculture, in particular, the dairy, beef and fishing sectors. The cost of power supply on the island was high due to a reliance on diesel. The King Island Renewable Energy Integration Project aims to address this by contributing to the Australian national mandated target for renewable energy generation of 20% by 2020.

Main features

Renewable energy source(s): Wind: 2.45MW
Solar PV: 0.39MW

Total generation capacity installed on island: 8.84 MW

Total renewable energy capacity installed on island: 2.84MW

Renewable energy source(s): Wind: 2.45MW
Solar PV: 0.39MW

Annual energy demand of island: 12 GWh

Annual energy demand met by renewables: 7.8 GWh

Total investment in renewable energy equipment (USD): 22 million

Funding source: Australian Government funding: Hydro Tasmania (state-owned utility) and Australian Renewable Energy Agency (ARENA).

KING ISLAND, AUSTRALIA

- Some significant activities and milestones of the process:
  - 1998 – the first wind farm was constructed with 3 250kW Nordex turbines
  - 2003 – the second wind farm was constructed with 2 850kW Vestas turbines
  - 2014 – a 3MW / 1.5 MWh battery was installed
- Key enabling circumstances for the project included:
  - An availability of government grants to support technology demonstration and to assist commercialisation.
  - The strong support from the government and the utility to show leadership in renewable energy technologies.
  - The strong internal technical capabilities within Hydro Tasmania.
- This was the first time many of the technologies had been developed or deployed, so there were several technical challenges. Many technical issues were avoided through significant preparatory work involving a process of sequential reviews and risk assessments as the design process progressed. Detailed equipment specification for intended use also mitigated technical risk, as did detailed planning prior to site installation, commissioning and testing activities. Access to the right, highly-skilled personnel on site was also essential.
- Important enabling business models and institutional frameworks were also present. The project proponent was the utility operating the power system and responsible for generation, distribution and retail of electricity to customers. This was critical to the success of the project. It allowed for a holistic design approach at a system level and reduced the level of interfacing between organisational elements, allowing for easier coordination of activities.

Impact

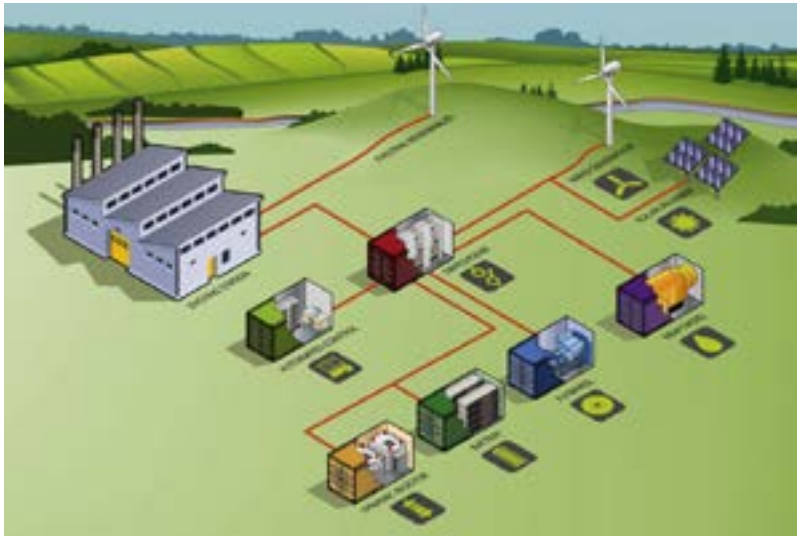
- The King Island project has addressed energy security issues by diversifying energy supply and reducing grid wide outages by close to 100%. It has also reduced disruptions associated with fuel supply logistics by approximately 50%.
- The system has operated solely on renewable energy for over 3,500 hours, including several continuous periods over 24 hours. The longest period of continuous 100% renewables penetration is now 61 hours. No blackouts occurred between 2014 and 2016.
- So far, the project has resulted in a reduction of over 21 million litres of diesel for power generation purposes, representing savings of more than USD 21.7 million. Direct savings related to the project are approximately USD 1.8 million per year in diesel, operation and maintenance costs.
- A number of local businesses were hired during the construction phases. These were mainly associated with civil works and electrical services.
- So far, the system has resulted in the prevention of the equivalent of over 55,000 tonnes of greenhouse gas emissions.

King Island Renewable Energy Integration Project (cont'd)

- Hydro Tasmania is currently implementing another 100% renewables island hybrid system on neighbouring Flinders Island, where designs developed for King Island are being refined into scalable modular systems to allow for lower cost deployment.
- Hydro Tasmania has been engaged by the operator of a 3.5MW peak load power system in Coober Pedy, South Australia to support the facilitation of the enabling environment needed for a 70% reduction in diesel use there.
- King Island has attracted the attention of a number of utilities across the globe and in particular, within the Asia Pacific region. It has hosted many delegations with an interest in replicating its success.

Project insights

- It is important to undertake detailed long-term planning in the form of a roadmap before the power system transition. This should adequately investigate options for renewable energy deployment and the associated enabling systems. This needs to be carried out holistically, rather than in a piecemeal fashion, and should include an understanding of the power dynamics of the system.
- Islands are very different from large-scale systems and adequate due diligence of technologies and suppliers is essential to ensure that equipment will operate as intended.

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Solar Water Protection Project

Tarawa, Kiribati
Date started: November 2014
Date of completion: December 2015

Tarawa atoll is home to most of Kiribati's population. Rising sea levels and a high population density have reduced access to clean water here. This water is accessed mainly from freshwater lens aquifers. A solar PV plant was built in Tarawa on the premises of the only underground water source on the island. The area was fenced in to protect the aquifer from human activity and pollution. This project was financed by the United Arab Emirates' USD 50 million Pacific Partnership Fund, through the Abu Dhabi Fund for Development (ADFD) and developed by Masdar, Abu Dhabi's renewable energy company.

Main features

Technology and scale: 500 kWp solar PV plant with a control system within a 33,000 m2 fenced area

Funding source: Public grant by the Abu Dhabi Fund for Development (ADFD)

- Advanced technologies were used to control the output of the plant to ensure grid stability, taking into consideration solar capacity elsewhere on the island.
- Monitoring of demand and generation capacity is done to control the output of the plant and to ensure minimal grid impact.
- The project includes 7 km of fibre optic cables connecting the PV plant to the Bikenibeu power station.

Impact

- 855,000 kWh of power is generated annually, enough clean power for more than 860 homes.
- The project is expected to save over 227,000 litres of diesel per year, which should result in annual savings of about USD 341,000 (based on local diesel prices in 2015).
- 708 tonnes of CO_2 emissions may be avoided per year.

Project insights

- Ideally, all solar PV plants on a common grid should be monitored and controlled by the same system to ensure optimum operations and solar PV penetration. This requires stakeholders, for example, project developers, donors and systems suppliers, working very closely together and effective project coordination from the outset. This project involved regular coordination meetings and workshops for key stakeholders throughout the project development stage.
- The reliability of existing diesel generation can drastically impact the level of solar energy able to penetrate the grid while maintaining grid stability. Such issues should be carefully studied in the project feasibility stage.
- There are often significant benefits associated with planning energy projects in parallel with other infrastructure projects. For example, this project benefited from essential fibre-optic conduits being installed at a major road construction project undertaken around the same time.
- The project has helped raise awareness of the need for further development in the field of water resource management.

Prony I, II, III and Mont Mau

New Caledonia
Date started: 2004
Date of completion: 2004, 2005, 2006 and 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 Vergent wind turbines enabled easier construction of the wind farms - particularly in hard to reach locations.
- Sixty-six wind turbines were constructed (of nominal power from 220kw to 275kw).
- 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 (second city of New Caledonia in terms of inhabitants).
- 5 470 tonnes of diesel are saved per year.
- 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, Samoa, 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 thanks to their special design.

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

Technology and 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 has been extended via underground cable to the wind project substation.

- The project was enabled by strong government commitment, including multiple community consultation sessions.
- The wind farm also features the Hybrid WizardTM real-time controller developed by Vergnet, which ensures a smooth integration of wind power on the electrical grid, in real time.
- 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 tonnes 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) often have a greater impact on project feasibility than the wind resource has itself. Similarly, elevated locations may have better wind resources, but will often not be economically feasible given infrastructure costs is 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

- 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.

- 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.

Solar Space Creation Project

Pre-construction (diesel power station site)

Solar Space Creation Project
Date started: September 2014
Date of completion: November 2015

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

The Tuvalu Solar Space Creation Project was financed by the United Arab Emirates' USD 50 million Pacific Partnership Fund through the Abu Dhabi Fund for Development (ADFD) and developed by Masdar, Abu Dhabi's renewable energy company. The project tackles a challenge the majority of small island developing states face during renewable energy project development: limited space. With a total land area of just 26 km2, this issue is particularly pertinent in Tuvalu

Main features

Technology and scale: 500 kW solar PV plant with control systems

Funding source: Public grant by the Abu Dhabi Fund for Development (ADFD)

- The project is located within the premises of the local utility at a new workshop, storage and office facility with 540m2 of floor space.
- Solar panels were constructed on the roof of the building and on canopies, creating shaded space in an area of land not previously used effectively.
- In addition, PV panels capable of generating 150 kW of solar energy were installed on the roofs of buildings at the local port and hospital.
- The project, with the help of advanced control technology to ensure grid stability, generates 755,000 kWh/year.

Impact

- The project meets up to 30% of Tuvalu's annual energy demand and supplies more than 800 homes with clean energy.
- The use of over 248,000 litres of diesel, worth over USD298,000 (based on 2015 local diesel prices), could be prevented annually.
- 631 tonnes of CO_2 emissions could be avoided annually.
- The project demonstrates an innovative approach to space utilization. The new workshop, storage, office and recreational spaces created total 2,380m2.

Project insights

- The project faced some port and equipment logistics challenges due to the number of other projects under way in Tuvalu at the time. Proactive planning is necessary to ensure port capacity can adequately meet the expected demands associated with such projects.
- Many brownfield sites, such as this project site, have been previously contaminated by substances such as waste oil and asbestos, and so require very careful management.
- This project involved two existing solar PV plants which were refurbished and connected to the central control system. This refurbishment highlights the importance of careful material selection to ensure longevity of the installed system in some highly corrosive island environments.

Completed structures with solar PV panels on roofs

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

Technology and 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 tonnes 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 kWpW

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.
- 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.

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

VANUATU

- 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.

Vanuatu Solar Project

Completed Parliament Buildings: car park and ground-monted solar PV plants

Port Vila, Vanuatu
Date started: November 2014
Date of completion: December 2015

The Vanuatu Solar Project was financed by the United Arab Emirates' USD 50 million Pacific Partnership Fund, through the Abu Dhabi Fund for Development (ADFD) and developed by Masdar, Abu Dhabi's renewable energy company. Located at the Ministry of Land and Natural Resources and Parliament Buildings, the project is one of the first solar energy systems in Port Vila and the largest one in Vanuatu. It is considered a testament to the commitment of Vanuatu's government to sustainable development.

Main features

Technology and scale: Solar PV System: 767 kW

Funding source: Public grant by the Abu Dhabi Fund for Development (ADFD)

- The project consists of ground-mounted solar PV arrays and panels on car parking stalls at the Parliament buildings.
- In addition, a ground-mounted solar PV array was built on the premises of the Ministry of Lands and Natural Resources.
- The project contributes 1,240,000 KWh/year to the Port Vila grid.

Impact

- The projects generated enough electricity to power more than 1,500 homes.

- The Vanuatu Solar Project will help to save 452,000 liters of fuel per year, an equivalent of approximately USD 543,000 (based on local 2015 diesel prices).
- The project prevents 1020 tonnes of CO_2 emissions annually.
- Substantial local employment and economic activity were generated at a time of high unemployment.
- Significant capacity building and training related to the solar PV project development was provided to local officials, maintenance personnel and industry representatives. Such local capacity is essential for long-term operation and maintenance of the project.
- 112 shaded car parking spaces were created in the process. These will serve the Parliament buildings and the newly built conference and exhibition center.

Project insights

- Large-scale solar PV systems offer an economically viable alternative to diesel since they provide electricity at a lower cost. In addition, such projects stimulate local business activity and employment.
- Ground-mounted solar arrays are more suitable than rooftop systems for large-scale PV deployment in cyclone prone areas, particularly if the underlying buildings are not strong enough to withstand high winds.
- Land availability on small islands can be a barrier to solar PV development. The use of car park canopies for this purpose can be a solution.


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IRENA Tools

Lighthouses Initiative Quickscans

Renewables Readiness Assessments

Island Roadmaps

Project Navigator

Sustainable Energy Marketplace

Grid Integration Assessments

Lighthouses Initiative Quickscans

The Lighthouses Initiative Quickscan is a tool to provide a high-level snapshot of the existing conditions, enabling deployment of renewable energy in small island developing states (SIDS) with a particular focus on the SIDS-specific challenges. This IRENA-designed programme serves as a first step in evaluating the readiness of SIDS to deploy renewable energy and allows partner organisations to identify and address SIDS-specific barriers.

The Quickscan is based on a questionnaire that covers seven areas critical for successful deployment of renewable energy. The key needs identified by the Quickscan allow governments and development partners to prioritise the areas of support that will have the largest impact on accelerating renewable energy deployment. Through a series of interviews with a designated government point of contact, IRENA provides information on the following:

1. Institutional framework

- The level of political support within the country for the deployment of renewables
- The effectiveness of governmental plans and targets to support deployment of renewable energy

2. Knowledge base

- The availability and quality of national assessments of renewable energy sources
- The availability and quality of energy balances and other data on the current performance of off-grid and in-grid assets
- The availability of regularly updated demand growth forecasts
- The level of engagement and information exchange between important stakeholders and agencies in the renewable energy sector
- The availability of local experience in design, installation and procurement of renewable energy technologies

3. Planning

- The readiness of infrastructure and organisations to support the planning process for deployment of renewable energy projects on a large scale
- The availability of assessments to support integration of variable levels of 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 the renewables

5. Deployment

- The availability 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 of the projects

6. Capacity building

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

7. Co-operation

- 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 co-ordination

Quickscan progress

20 SIDS in the Pacific, Atlantic, and Indian Oceans and the Caribbean, Mediterranean, and South China Seas have taken part in the Quickscans programme. The resulting analysis is available on the IRENA website at http://irena.org/quickscan/

In partnership with IRENA, the Association of the Overseas Countries and Territories of the European Union (OCTA) has applied the Quickscan methodology to 19 OCTA members.

If you wish to take part in the Quickscan initiative, please contact:

islands@irena.org

Renewables Readiness Assessments

The Renewables Readiness Assessment (RRA) is a country-initiated, country-led, multi-stakeholder process that identifies the actions needed to address the factors hindering an accelerated deployment of renewables.

The RRA consists of four main phases:

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

The process engages various stakeholders to compile relevant information, establish networks, and strengthen the enabling environment for renewable energy deployment. This multi-stakeholder consultation process brings together key actors to discuss common challenges and jointly devise actions to address them with resources from the international community.

Impact and insights

Since 2011, RRAs have improved cooperation at the national and regional levels in 30 countries. Islands that have engaged in the RRA process include Antigua and Barbuda, Fiji, Grenada, Kiribati, the Republic of the Marshall Islands (RMI), and Vanuatu. Drawing upon the expertise within these countries and IRENA, the RRAs develop a portfolio of short- and medium-term recommendations.

RRAs have made an immediate impact in islands. These include:

- Fiji adopted a new method for the calculation of tariffs for independent power producers (IPPs) making the tariff more attractive to investors
- The Utilities Regulatory Authority of Vanuatu decided to develop regulatory guidelines for Independent Power Producers and Power Purchase Agreements
- The Republic of Marshall Islands developed an action plan for grid-connected renewables and a plan to use solar photovoltaic systems as an alternative to diesel for mini-grids

An RRA report analyses the national energy context, legal and regulatory framework, and the institutional and administrative structures of subject countries. This information constitutes a valuable insight for potential investors willing to develop renewable energy projects.

If you would like to take part in an RRA, please contact:
regions@irena.org

Island Roadmaps

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 process of carrying out an energy roadmap benefits from completion of Quickscan and a Renewables Readiness Assessment as the roadmap provides quantitative insights and techno-economic solutions for the barriers identified in these two initiatives.

A roadmap analysis covers cost-effective renewable energy options and supporting technologies. It outlines key milestones and provides recommendations on policies to support the transition to renewable energy taking into consideration the national targets, energy security issues, pollution limits, and other country-specific objectives. The government selects stakeholders to be included in the process. Typically, they include representatives from utility service providers and the ministry covering renewable energy.

IRENA has delivered renewable energy roadmaps for the Republic of Cyprus, the Republic of Nauru, the Republic of Mauritius, the Republic of Maldives, the Republic of Kiribati and Barbados. Roadmaps for the Republic of Palau and for the Federated States of Micronesia are next to come. An Ocean energy roadmap has been developed for Mauritius. Support was also provided to GIZ on a joint project for the implementation of roadmaps in Cabo Verde and Vanuatu.

Energy Roadmap for Barbados

The Barbados roadmap is rooted in an in-depth technical analysis of least-cost deployment mechanisms of solar photovoltaics (PV), wind, local biomass generation, and supporting technologies through 2030. The roadmap simulates operations of the power system in country-specific environment in 2030. The results show that renewables are already the most cost-effective energy option in Barbados and that following the least-cost deployment pathway could lead to a less volatile and cheaper power system. This system could support up to 76% renewables-based power generation annually with improved reliability. The roadmap analysis also assessed feasibility of 100% renewables-based power generation.

The Barbados roadmap includes a detailed software model of the Barbados energy system for future energy planning. It can act as a national energy accounting framework and inform the development of the energy component of the Nationally Determined Contributions. The roadmap analysis also covers deployment and charging options for electric vehicles (EVs) and their impact on electricity generation, showing that EVs could greatly reduce gasoline imports for transportation. The transportation sector analysis concluded that the use of locally produced sugar cane ethanol also has the potential to reduce gasoline imports.

The Barbados roadmap was officially presented to local stakeholders at a meeting of the National Energy Taskforce in October 2016.

Kiribati Integrated Energy Roadmap (KIER)

The KIER was jointly developed by IRENA, the Pacific Power Association (PPA), and the Pacific Community (SPC). This roadmap provides a comprehensive strategy covering the future development of the entire Kiribati energy sector. IRENA provided technical, economic, policy, and regulatory analyses to develop a clear plan for the deployment of significant shares of renewable energy across Kiribati.

The KIER also draws on complementary analysis from two associated studies. One of these is a detailed report covering the options for renewable energy-powered desalination. The KIER also uses the analysis from a grid stability study completed by the PPA, with support from IRENA, to offer further insights into the options to deploy high shares of renewable energy without affecting the reliability of South Tarawa's power system operation.

The KIER was delivered for endorsement by the Government of Kiribati in July 2016.

Renewable Energy Roadmap for the Maldives

The renewable energy roadmap for the Maldives focuses on identifying and overcoming the barriers that have prevented a broader uptake of renewable energy. It also includes a technical analysis of potentially replicable renewable energy deployment strategies for smaller islands in the Maldives. The final roadmap document and the materials were discussed during a roadmap launch event in September 2015.

Renewable Energy Roadmap for the Republic of Cyprus

The Republic of Cyprus roadmap is based on an in-depth analysis of several scenarios for renewable energy deployment. It provides an insight into the impact of key energy policy decisions and outlines the least-cost pathway for the evolution of the power generation mix in Cyprus from 2015 to 2030.

The Government of Cyprus used the results of the roadmap analysis for the development of a new National Renewable Energy Action Plan. In addition, the Government of Cyprus, with support from the European Commission, has used the roadmap as a baseline for a detailed grid stability study to identify actions needed to support the integration of solar and wind energy technologies.

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:

islands@irena.org

Project Navigator

Despite the increasing levels of installed renewable energy 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 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 consists of three main sections:

- **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 photovoltaic (PV) projects. However, guidelines on other renewable energy technologies will follow, including residential PV and off-/mini-grid applications for islands; as well as, small hydro, geothermal energy and bioenergy.
- **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.
- **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 on 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.

The deployment of the Project Navigator on islands is already under way, and among other activities, IRENA is looking to assist project developers directly by providing support in drafting project proposals with the Project Navigator.

To access the IRENA Project Navigator, please visit:
www.irena.org/navigator

For additional information on the IRENA Project Navigator, please contact: **navigator@irena.org**

Sustainable Energy Marketplace

Key challenges for governments and power sector entities include the identification of available financing options, the preparation of bankable proposals and the mobilisation of financing to meet renewable energy investment requirements. IRENA's Sustainable Energy Marketplace, at www.irena.org/marketplace, offers an interactive online platform to enhance the visibility of renewable energy projects and to connect project developers, host governments, financiers, and service and technology providers in several regions.

The Marketplace aims to actively facilitate project initiation and development, and to bring bankable renewable energy projects to financial closure. Renewable energy project opportunities can be screened by investors by using efficient search criteria. Project developers can also efficiently identify funding and advisory services according to their specific needs. Information on markets, regulations and incentives can also be accessed. The Marketplace will also provide the users with regularly updated information on country-level policies and regulations through the joint IEA(International Energy Agency)/IRENA Policies and Measures database, as well as information on existing capacities and generation costs of renewable energy technologies.

The Marketplace is expected to attract private sector investors to the renewable energy investment market in developing countries. It offers a platform for governments seeking to promote investment frameworks, initiatives and project pipelines in their countries in order to attract investors. In this way, it reduces asymmetric information and increases the transparency and liquidity of the renewable energy project market. Several projects being developed in the Caribbean region with support from SIDS Lighthouses Initiative partners, the Clinton Climate Initiative and the Rocky Mountain Institute-Carbon War Room, have recently been included in the Marketplace, representing a financing opportunity of more than US$ 600 million. At COP21 in December 2015, the Marketplace was officially launched to cover Africa, Latin America and the Caribbean.

For questions regarding the
Sustainable Energy Marketplace, please contact:
marketplace.administrator@irena.org

Grid Integration Studies

The integration of variable renewable energy resources into existing electrical networks often requires the implementation of additional enabling technologies to ensure the secure and economical operation of the grid and therefore, the reliable delivery of electricity to its final users. The ability of the grid to sustain particular 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 levels of renewable energy are accommodated. Grid studies allow for these assessments.

IRENA's grid integration studies are undertaken in close cooperation with local stakeholders to assist policy makers, energy authorities and power system operators in 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. Grid studies identify 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 study 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 studies. 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 grid expansion and operational measures to integrate them can be evaluated more accurately based on the information gained from these grid studies. This could also allow the integration of higher shares of renewable energy beyond previously identified limits.

At present, IRENA has completed grid studies in Antigua and Barbuda, the Cook Islands, Palau and Samoa. The methodological guidelines derived from these studies are scheduled to be published in early 2017. They will provide step by step guidance on planning, expansion and operation measures needed to host the target shares of variable renewable energy and will 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 study completed 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 studies 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 technical visit from IRENA staff. The technical visit also included live demonstrations of the conducted studies, 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. A follow-up study, investigating the state of operations expected by 2022 has been completed.

If you wish to engage in the grid integration assessment process, please contact:
islands@irena.org

IRENA
International Renewable Energy Agency

IRENA Headquarters
Masdar City
P.O. Box 236, Abu Dhabi
United Arab Emirates

IRENA Innovation and Technology Centre
Robert-Schuman-Platz 3
53175 Bonn
Germany

www.irena.org

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