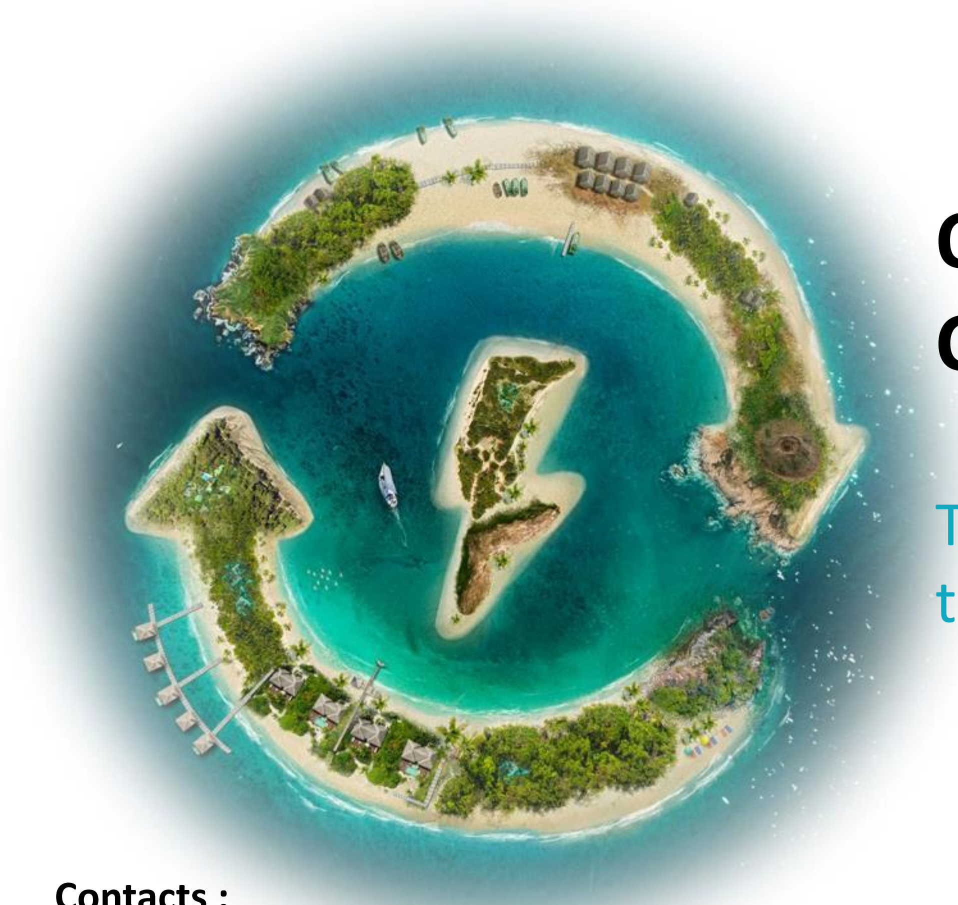

Ocean Thermal Energy Conversion

The key catalyst for energy transition

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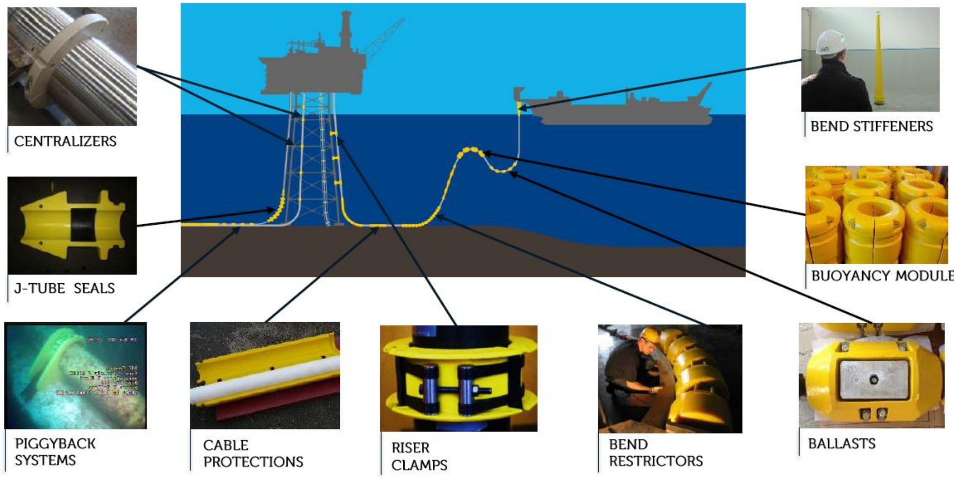
Bardot Ocean

Bardot Group has a 14 years successful track record in oil & gas offshore projects, developing subsea solutions for more than 60M€ revenues.



Bardot has invested in SWAC and OTEC technology, developing its own OTEC Lab, one of the few in the world.

In 2015 Bardot successfully delivered 6 Deep Sea Water Intake Riser to SAIPEM/TOTAL to improve KAOMBO FPSOs process.

Bardot Ocean has the experience, the skills and the will to become the leading technology provider and project developer for OTEC and SWAC.

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1. ***OTEC technology in a nutshell***
2. OTEC and renewable electricity share
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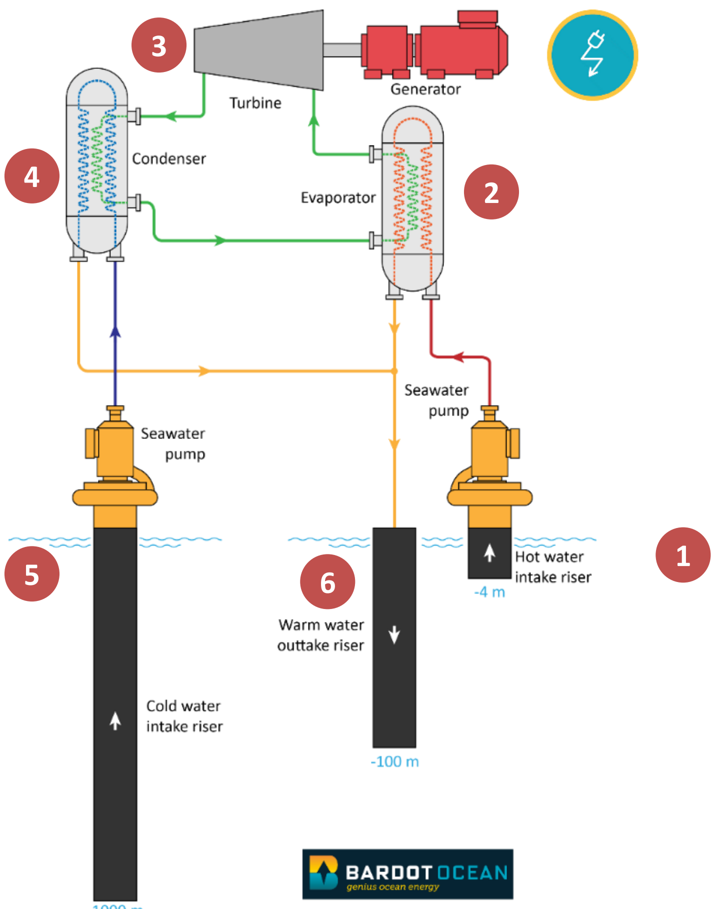
OTEC – Renewable electricity

Ocean Thermal Energy Conversion (OTEC)



USE SEA WATER TEMPERATURE DIFFERENCE TO CREATE ENERGY

1. Hot surface water (**>25°C**) is pumped to the process through a HDPE pipe.

2. Its heat content is used to vaporize a working fluid (typically NH_3, R134a or R1234yf) through evaporators.

3. The vapor is expanded in an ORC turbine to produce electricity.

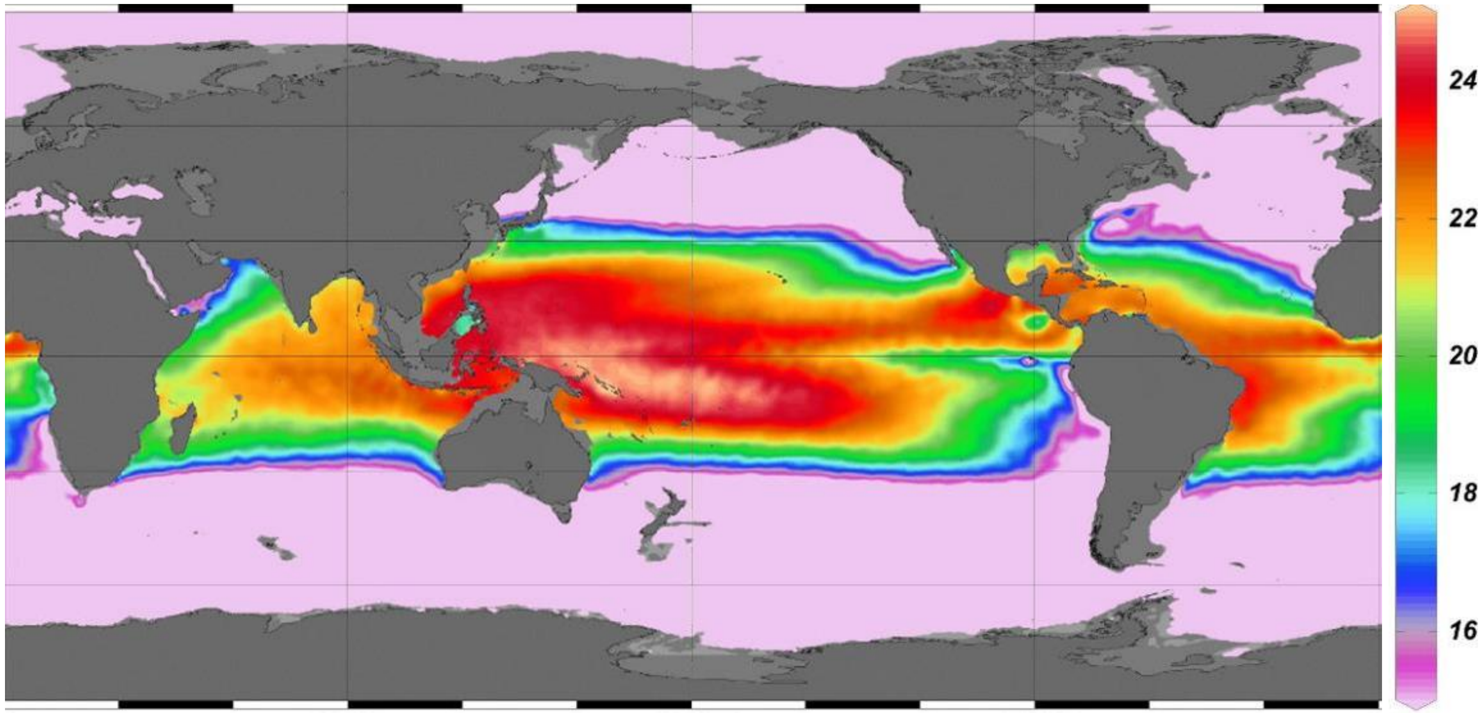
4. The low pressure vapor exhausted by the turbine is then condensed in the condensers by a flow of deep ocean cold water (5-7°C) pumped in 5.

6. Hot and cold water from the heat exchangers (evaporators and condensers) are then mixed and released back into the ocean **without any change in chemical and biological content**.

OTEC can provide the grid with baseload 24/7 predictable renewable electricity.

OTEC is highly relevant in Pacific

Worldwide average ocean temperature differences (between 20 m and 1,000 m water depths)



Source : G. Nihous, Mapping available Ocean Thermal Energy Conversion resources around the main Hawaiian Islands with state-of-the-art tools, Journal of Renewable and Sustainable Energy, 2, 043104, 1-9, 2010

The higher the temperature difference, the better the efficiency of the OTEC (and the lower the electricity cost).

OTEC is perfectly suited for Pacific islands

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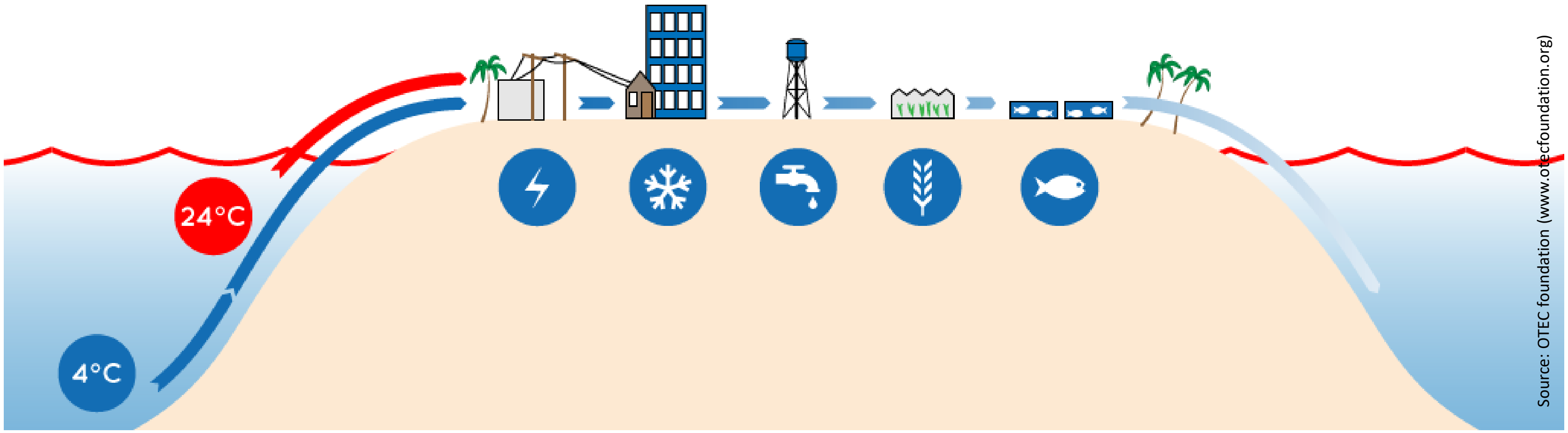
Deep ocean water can be used for other purposes



- **Drinking water**: Conventional reverse osmosis can be used to desalinate pumped back sea water
- **Bottled water**: Bottled deep-ocean water is getting more and more popular, with several brands expanding on Asian and North-American markets.
- **Aquaculture**: The absence of pathogens in deep ocean makes the water particularly well suited for the culture of sensitive and valuable species.
- **Cooling**: After the heat exchanger, ocean water is still cold and can be used to refresh buildings or to increase cooling efficiency
- **Agriculture / irrigation**: After the heat exchanger, ocean water is still cold and can be used to foster natural condensation, providing fresh water for irrigation.
- **Cosmetics**: Mineral-rich deep water can be used in cosmetics and are alleged to better moisturize skins and increase collagen production compared to regular cosmetics.

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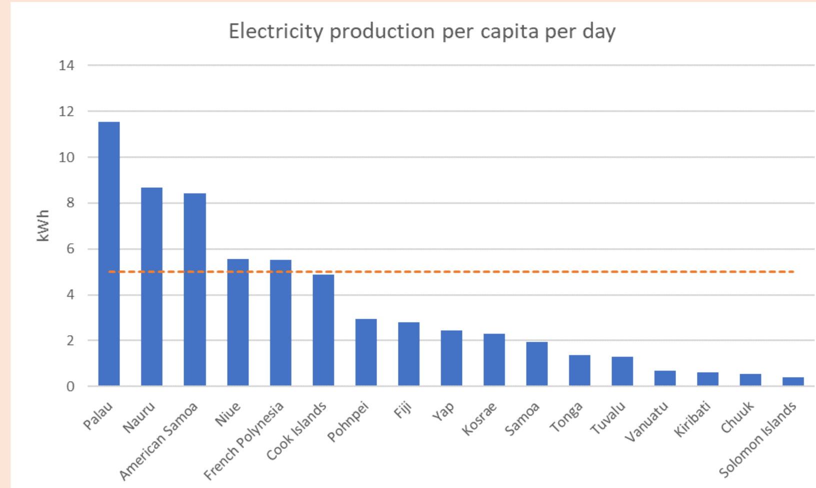
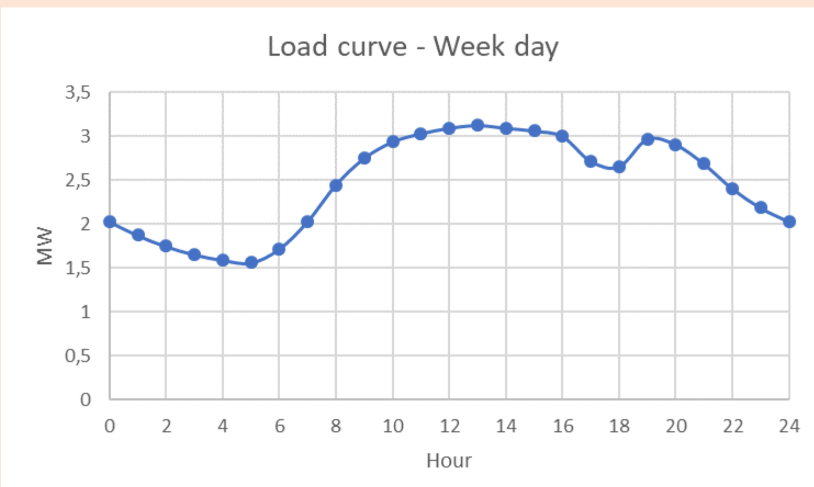
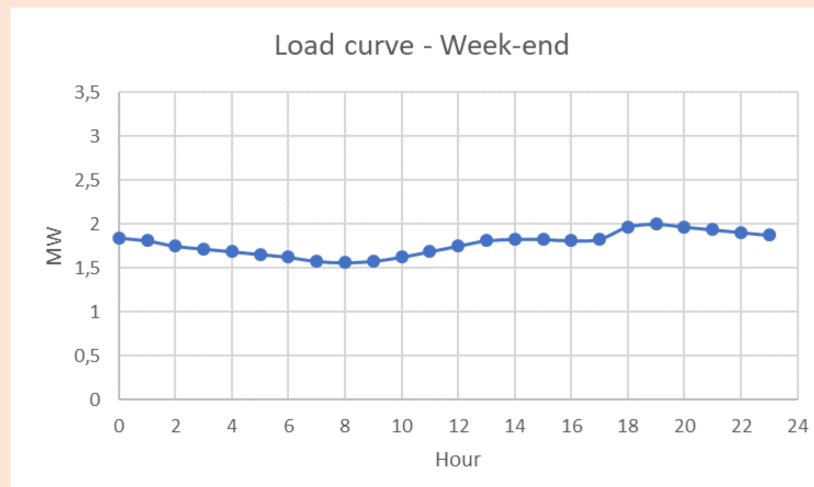
Case study briefing

- Inhabitants
  - 10,000 people

- Electricity average consumption
  - 5 kWh/capita/day
- Electricity annual peak
  - 4.2MW



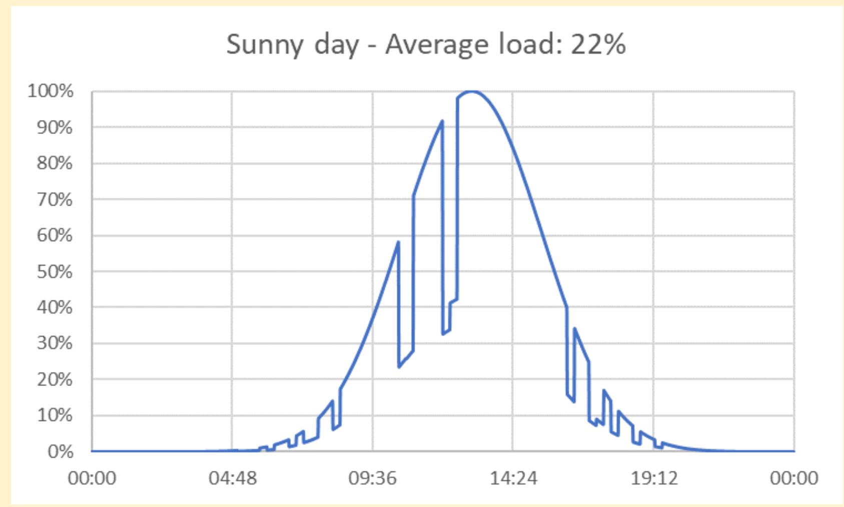


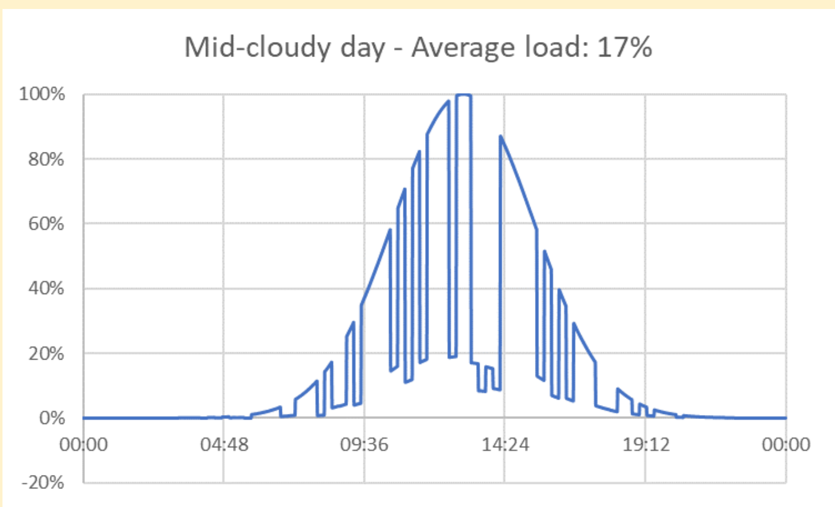


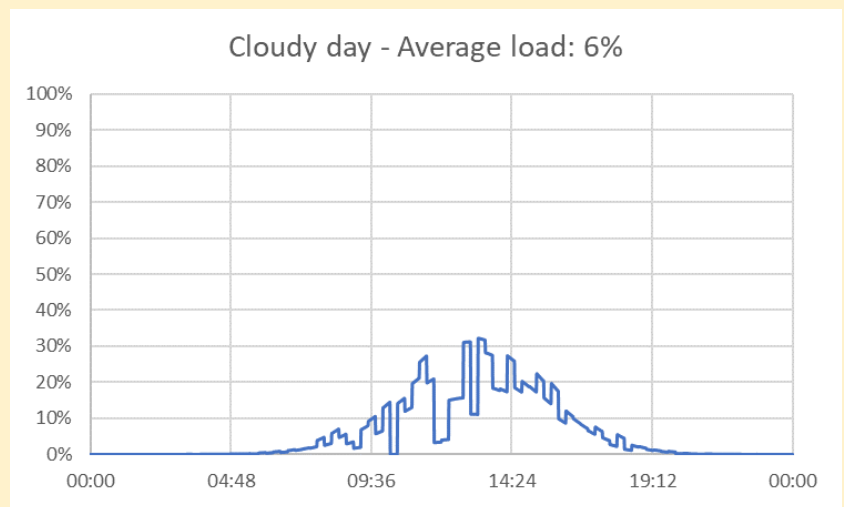
Solar electricity hypothesis

- Yearly distribution:
  - Sunny days: 56%
  - Mid cloudy day: 33%
  - Cloudy day: 11%

- Average annual load: 19%

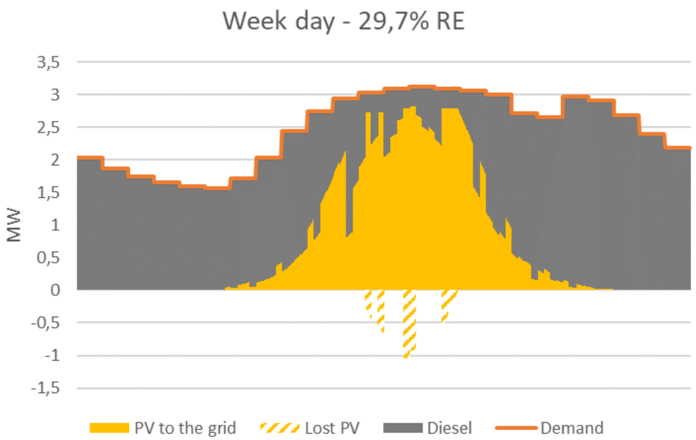


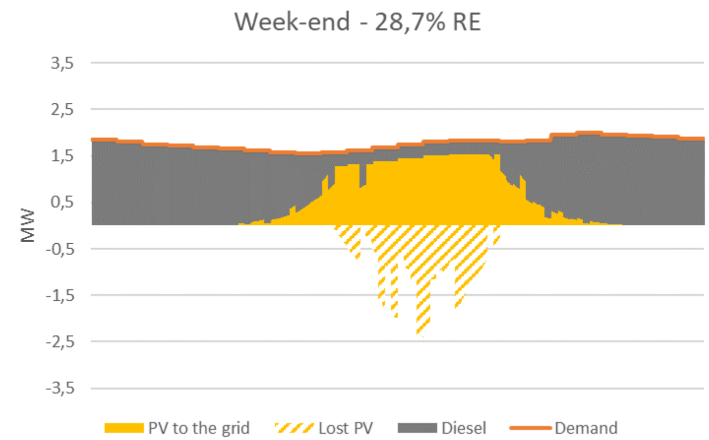




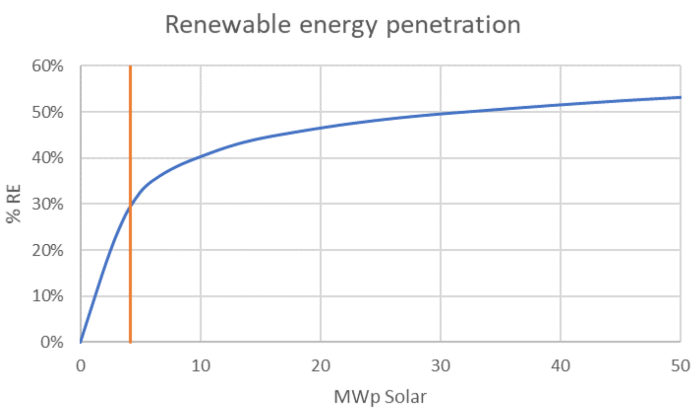
High solar capacity hardly yield high RE penetration rate

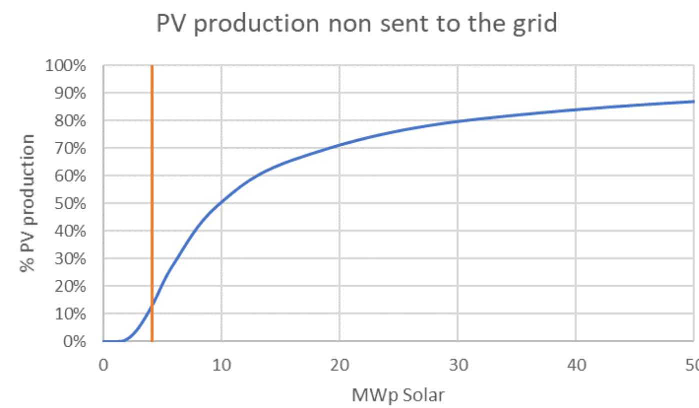
- 4.2MWp of solar capacity (i.e. annual peak load) delivers only 29% of RE over the year





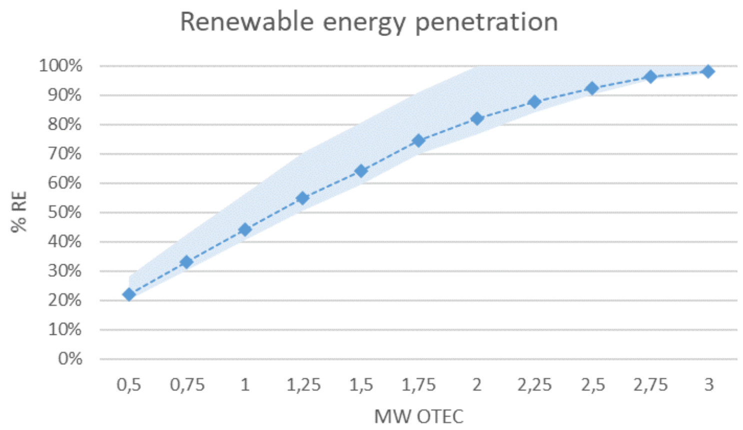
- Increasing solar capacity goes along with an increase in renewable electricity share, but with diminishing returns.

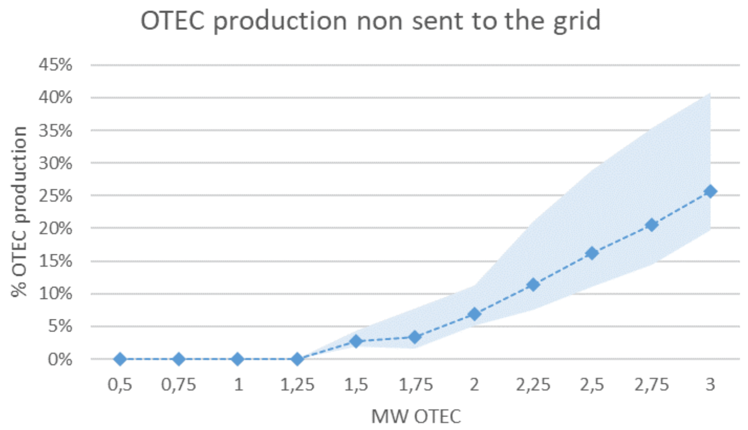




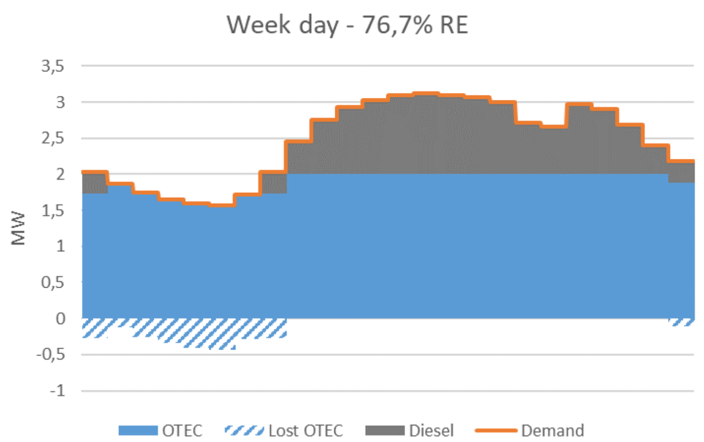
On the contrary, baseload OTEC yields high RE share at low capacity

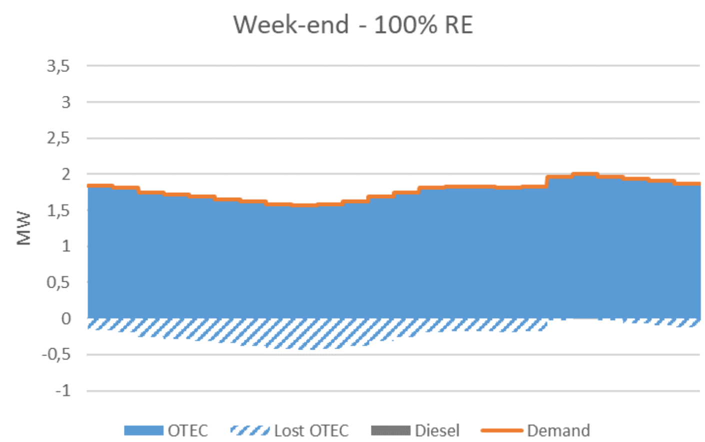
- Adding 0.25MW leads to 10% more renewable electricity in the mix





- Only 2MW OTEC will result in a 82% average renewable electricity





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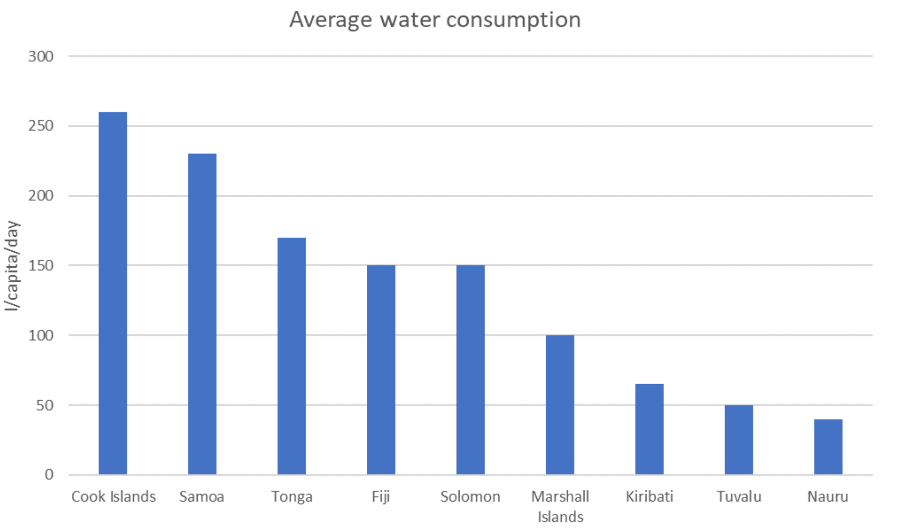
Excess electricity can be used to produce drinking water

- Pacific islands are also facing, to some extent, **water stress**, worsened by upcoming **climate change** (change of rainfall patterns, sea level rise leading to aquifer saline intrusion, etc.).
- The electricity generated by OTEC that cannot be sent to the grid can be used to **dessalinate water** and produce drinking water, hence **reducing island vulnerability**.
- A **2MW OTEC** excess electricity generation can be used to **produce drinking water in line with Pacific islands average water consumption.**
- An as we need really high sea water flows in a OTEC system to produce electricity (24,000m^3/hour for the 2MW system) far beyond islands water needs, such a system means that no additional pumping infrastructure is required. Brine will also be highly diluted in the outtake pipe, leading to very low environmental impact.

	Week days	Week-end	Average
Electricity non sent to the grid (MWh/day)	2.49	5.36	3.31
DW production (l/capita/day)	**50**	**107**	**66**
Hot sea water need (% OTEC hot water)	0.17%	0.37%	0.23%
Brine rejected (% OTEC rejected water)	0.06%	0.23%	0.08%



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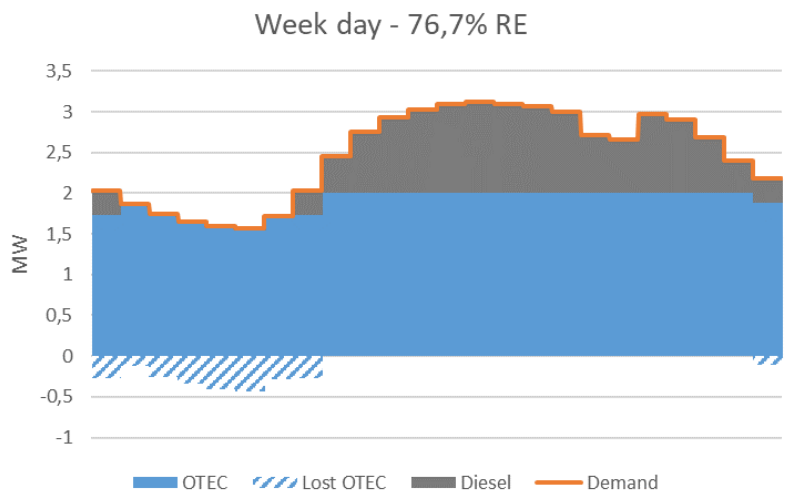
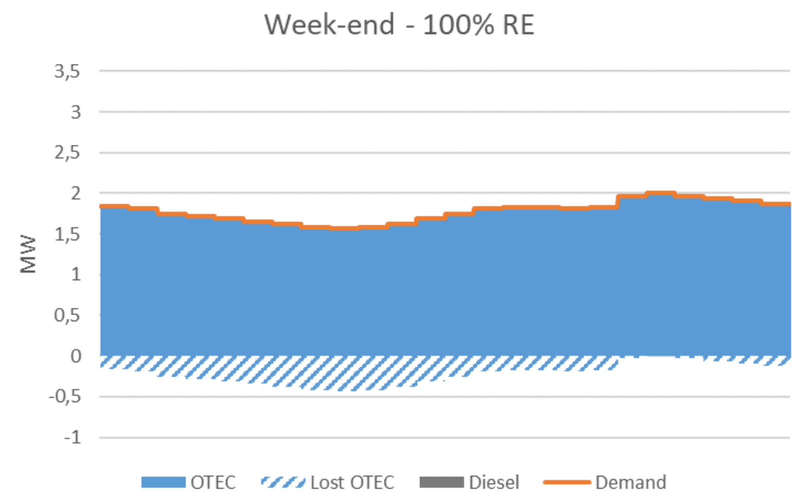
Excess electricity can also be used to charge electric vehicles batteries

- As excess renewable electricity production occurs mainly at night, when demand is low, this electricity can be used to charge electric vehicles.





- A **2MW OTEC** system will generate enough excess electricity to perform the following:

		Week days	Week-end	Average
Electricity non sent to the grid	MWh/day	2.49	5.36	**3.31**
Electric car	eq liters	891	1,914	**1,183**
	km/capita/day	1.78	3.83	**2.37**
Electric motorcycle	eq liters	1,746	3,752	**2,319**
	km/capita/day	9.70	20.84	**12.88**

- This will also reduce the island oil dependency, decreasing greenhouse gases emissions linked with mobility.

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OTEC can help islands to overcome their vulnerability factors

Vulnerability factor	How OTEC helps	Outcome
Small land size	OTEC can foster a sustainable use of the large ocean ressources	Large ocean size
Insularity and remoteness	OTEC can decrease the use of fossil fuel and foster subsistence agriculture	Energy and food autonomous
Proneness to natural disaster	OTEC (onshore and offshore) can be designed to resist to natural disaster	Resilient infrastructure
Environmental factors	OTEC has a very low footprint compared with other RE and very limited environmental impacts	Low land and environmental pressure
Financing challenges	There are many existing schemes and funds available to finance meaningful RE projects	« Green » finance

Source: Bardot Ocean analysis from Small island developing states and their economic vulnerabilities, Lino BRIGUGLIO

From Small Island Developing State to Large Ocean State

Bardot Ocean value proposition

- Bardot Ocean has been awarded its first SWAC project to provide air conditioning to a large hospital in the Indian Ocean.

- We intend to work either as a **technology provider** or as an **IPP** to transform OTEC potential into practical reality in the Pacific.

OTEC: It’s time to make it happen in the Pacific!

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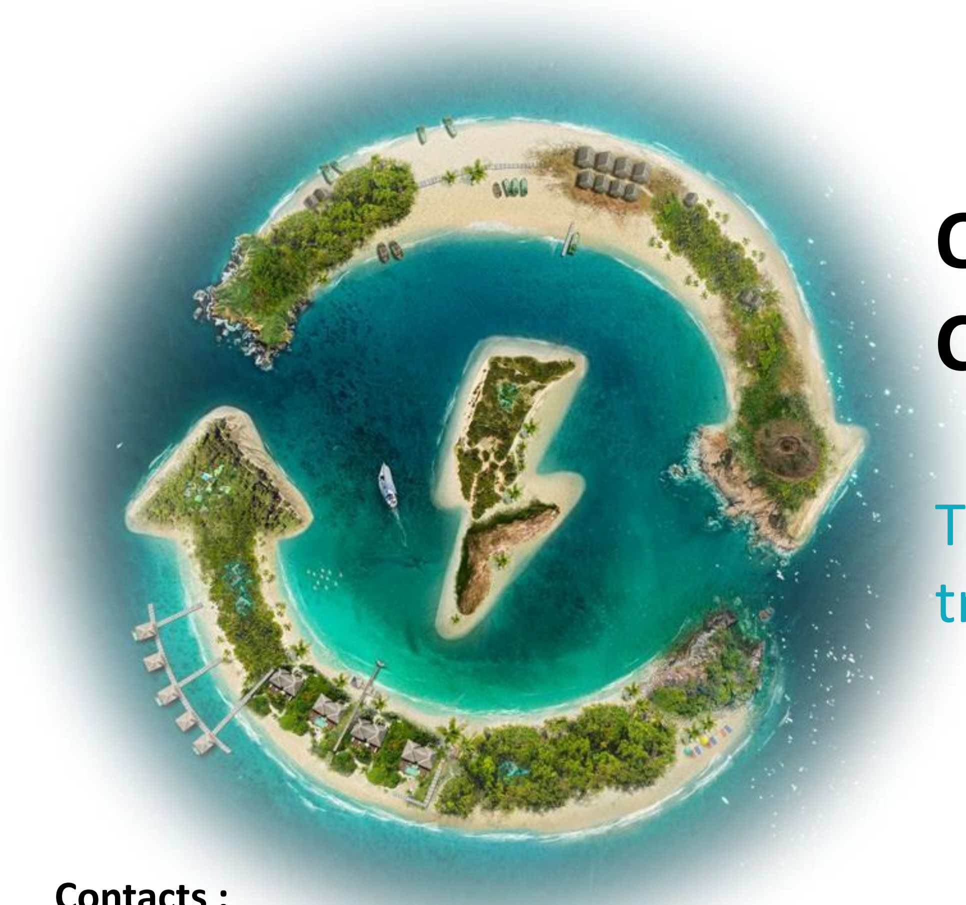

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