GLOBAL PV AND WIND POWER POTENTIAL OF SMALL ISLAND HYBRID MINI-GRIDS

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Motivation and Purpose

Geographical islands are very attractive for renewable energies and storage technologies:

- expensive diesel power generation
- abundant renewable resources.

To target the existing potential for PV and wind power on small islands the following aspects have to be analyzed:
the local load profile, the diesel price for power generation, and solar and wind resources.

This work uses these data as a base for simulating the techno-economic optimized renewable energy potential on each small island (1,000 to 100,000 inhabitants) worldwide to assess the local market potential for hybrid mini-grids.

Simulation Model and Input Parameters

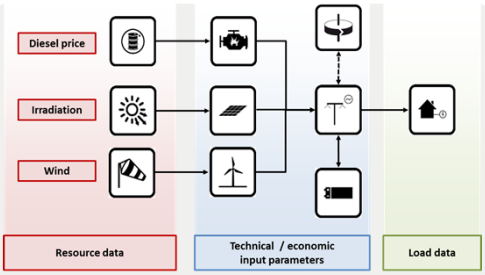


Figure 1: Simulation design and input parameter of a hybrid mini-grid.

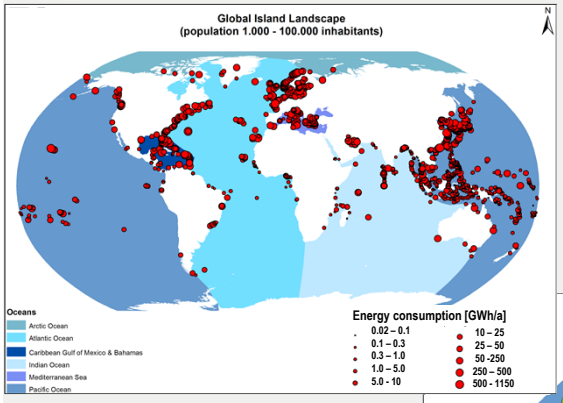
Resource data: Diesel price (0.63 EUR/l, 3 % annual increase, transportation costs by traveltime by Nelson et al.), Solar irradiation and Wind speed by DLR German Aerospace Center.

Technical: Diesel (efficiency: 25 to 35 %), Battery (round cycle efficiency: 85 %, lifetime: 10 yrs, c-rate: 1:6 kW/kWh), Flywheel (30 % of total renewable capacity, just considered in economics).

Economic: Capital expenditures - Capex (Diesel: 0 EUR/kW, PV: 2,000 EUR/kWp (high costs according to small market size and high transportation efforts), Wind: 1,250 to 1,500 EUR/kW (smaller turbine), Battery: 250 EUR/kWh, Flywheel: 1,000 EUR/kW), Operational expenditures - Opex (Diesel 0 EUR/kW*yr, PV: 2 % of Capex/yr, Wind: 2.5 % of Capex/yr, Battery: 10 EUR/kWh*yr, Flywheel: 0 EUR/kW*yr), Weighted average cost of capital – WACC (7 %), Project lifetime: 20 yrs.

Load: According to GDP, location, and tourism factor (number of overnight stays per year, derived from country level) of island.

Results: Energy Consumption of Small Islands and LCOE Reduction Potential

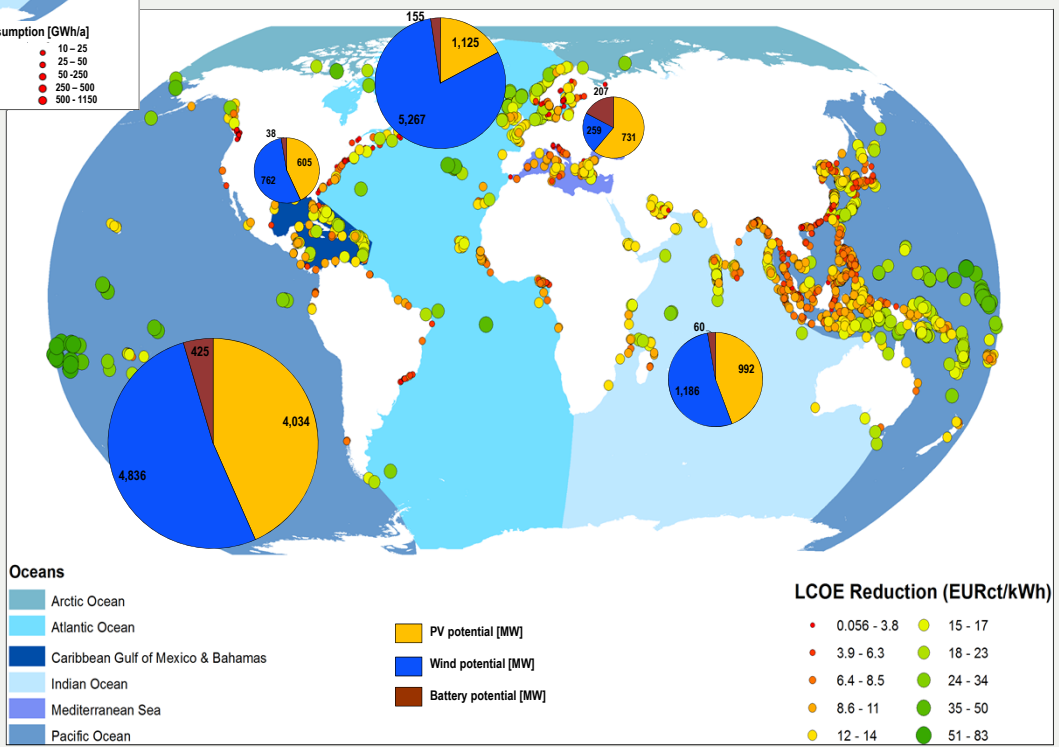


◀ **Figure 2: Energy consumption of small islands (1,000 to 100,000 inhabitants).**

Table 1: Overview on global small island landscape (1,000 to 100,000 inhabitants).
Atlantic + Arctic Ocean, Caribbean + Gulf of Mexico + Bahamas, Indian Ocean, Mediterranean Sea, Pacific Ocean.

Region	Atl. + Arct. Oc.	Car. + GM + B.	Indian Ocean	Mediterr. Sea	Pacific Ocean	Total
Number of islands	416	105	232	104	1,199	**2,056**
Population (av.)	9,985	16,160	12,210	10,540	9,690	**10,410**
Population (sum)	4,150,000	1,700,000	2,830,000	1,100,000	11,620,000	**21,400,000**

Figure 3: PV, wind and battery power potential and LCOE reduction by hybridization on small islands (1,000 to 100,000 inhabitants) ▶



PV, wind and battery power potential:

- Hybrid systems in the Arctic and Atlantic Ocean are dominated by wind power.
- The islands in the Mediterranean Sea reveal the largest potential for battery storage compared to the system size.
- The Caribbean and Indian and Pacific Ocean are dominated by tropical and sub-tropical islands. These islands show similar shares of PV, wind and battery power within their optimized hybrid systems.

LCOE reduction:
The smaller and the more remote one island is, the higher is the LCOE reduction due to high diesel costs in non-renewable systems.

- Highest LCOE reduction in the Indian and Pacific Ocean
- Lowest LCOE reduction in the Mediterranean Sea

Results: Renewable Energy Storage, PV and Wind Power Potential

Table 1: Optimized hybrid systems on small islands (1,000 to 100,000 inhabitants).
Atlantic + Arctic Ocean, Caribbean + Gulf of Mexico + Bahamas, Indian Ocean, Mediterranean Sea, Pacific Ocean.

Region	LCOE red. (av.)	LCOE Diesel only (av.)	LCOE opt. system (av.)	PV (sum)	Wind (sum)	Battery (sum)	RE share (av.)
	[EURct/kWh]	[EURct/kWh]	[EURct/kWh]	[MWp]	[MW]	[MWh]	
Atl. + Arct. Oc.	10.7	36.6	25.9	1,125	5,267	930	58 %
Caribbean +	8.7	34.2	25.5	605	762	230	55 %
Indian Ocean	14.1	38.0	23.9	992	1,186	360	65 %
Mediterr. Sea	5.5	33.2	27.7	731	259	1,240	80 %
Pacific Ocean	11.2	39.3	28.1	4,034	4,836	2,550	71 %
Total	**9.6**	**38.0**	**28.4**	**7,502**	**12,250**	**5,310**	**71 %**

Conclusion

Economically most attractive island systems are small and hard to reach which leads to difficulties in the business implementation.
Investors have to choose between highest LCOE reductions, remoteness and market size.
PV and battery distributors should focus on small remote islands within the tropical and sub-tropical regions.
Wind turbine distributors should focus on larger islands in the northern parts of the Atlantic Ocean.

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