Global PV market potential for small island energy systems

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Intersolar – Munich
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Overview

- Not-for-profit research institute
- 100% owned by Reiner Lemoine Stiftung (RLS)
- Based in Berlin, established in 2010
- Managing director: Dr. Claus Beneking
- 25 research assistants + students
- Member of e.g. ARE, eurosolar, BNE

Mission

Scientific research for an energy transition towards **100 % renewable energies**
## Research fields - RLI

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>- Simulation of integrated energy systems</td>
<td>- Rural electrification planning</td>
<td>- Mobility concepts with renewable energies</td>
</tr>
<tr>
<td>- Modelling of energy supply including storage options (e.g. batteries, PtG)</td>
<td>- Simulation of hybrid mini-grids</td>
<td>- Research on electrolysers and PtG</td>
</tr>
<tr>
<td>- Feasibility studies for energy supply by GIS</td>
<td>- Combination of GIS analyses and energy system simulations</td>
<td>- Implementation of hybrid mini-grids and small wind turbines</td>
</tr>
<tr>
<td>- Energy transition and social acceptance</td>
<td>- Market research and business strategies</td>
<td>- Hardware in the loop testing and measurements</td>
</tr>
</tbody>
</table>

Booth B1.470
Agenda

- Motivation
- Island detection
- Demand analysis
- PV potential
- Conclusion
Motivation

Unfavorable conditions in on-grid markets for PV increase the need for new emerging markets:
• Competitive PV projects without subsidies
• Complex systems allow technological advantages

➢ Diesel mini-grids represent an interesting new market field based on high fuel costs and technologically challenging integration of PV

Small islands (> 100,000 inhabitants) are geographically defined mini-grids:
Where are these islands?
What is their electricity demand?
What is the related PV potential?
Where are small islands?

Population

- **high**
- **0**

Island shapefile

- Population pixel excluded
- Population pixel included

707m buffer
## Global small island overview

<table>
<thead>
<tr>
<th>Region</th>
<th>Number of Islands</th>
<th>Population (av.)</th>
<th>Population (sum)</th>
<th>GDP (av.) [EUR/cap]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atl. + Arct. Oc.</td>
<td>416</td>
<td>9,985</td>
<td>4,150,000</td>
<td>18,200</td>
</tr>
<tr>
<td>Caribbean +</td>
<td>105</td>
<td>16,160</td>
<td>1,700,000</td>
<td>14,600</td>
</tr>
<tr>
<td>Indian Ocean</td>
<td>232</td>
<td>12,210</td>
<td>2,830,000</td>
<td>2,960</td>
</tr>
<tr>
<td>Mediterr. Sea</td>
<td>104</td>
<td>10,540</td>
<td>1,100,000</td>
<td>23,500</td>
</tr>
<tr>
<td>Pacific Ocean</td>
<td>1,199</td>
<td>9,690</td>
<td>11,620,000</td>
<td>8,660</td>
</tr>
<tr>
<td>Total</td>
<td>2,056</td>
<td>10,410</td>
<td>21,400,000</td>
<td>14,300</td>
</tr>
</tbody>
</table>
What is the energy demand?

- Island's GDP
- National energy consumption
- National GDP
- Annual energy consumption

GDP?
- >= 500 USD/cap
  - Island's GDP
  - National energy consumption
  - National GDP
  - Annual energy consumption
- < 500 USD/cap
  - Minimal energy consumption
  - Island's GDP

Temperature?
- < 12°C
  - Heating
  - Seasonal variation
- > mean temp
  - Cooling / tourism

Population?
- >= 50,000
  - Load profile: larger island
  - Hourly variation in a week
- < 50,000
  - Load profile: smaller island
  - Hourly load profile for one year
Island demand overview
### Island demand overview and conventional power system

<table>
<thead>
<tr>
<th>Region</th>
<th>El. cons. (sum) [GWh/year]</th>
<th>El. cons. (av.) [MWh/year]</th>
<th>El. cons. (av. per cap.) [kWh/year* cap]</th>
<th>LCOE Diesel only (av.) [EURct/kWh]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atl. + Arct. Oc.</td>
<td>18,270</td>
<td>43,920</td>
<td>4,400</td>
<td>36.6</td>
</tr>
<tr>
<td>Caribbean +</td>
<td>5,710</td>
<td>54,380</td>
<td>3,370</td>
<td>34.2</td>
</tr>
<tr>
<td>Indian Ocean</td>
<td>2,240</td>
<td>9,660</td>
<td>790</td>
<td>38.0</td>
</tr>
<tr>
<td>Mediterr. Sea</td>
<td>3,680</td>
<td>35,390</td>
<td>3,345</td>
<td>33.2</td>
</tr>
<tr>
<td>Pacific Ocean</td>
<td>22,730</td>
<td>18,970</td>
<td>1,960</td>
<td>39.3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>52,630</strong></td>
<td><strong>25,600</strong></td>
<td><strong>2,462</strong></td>
<td><strong>38.0</strong></td>
</tr>
</tbody>
</table>
PV Capex of 2,000 €/kW
PV potential on islands - map

Global Small Island Landscape
(1,000 - 100,000 inhabitants)

Potential PV Capacity (kW):
- <50
- 50 - 2,600
- 2,610 - 4,830
- 4,840 - 8,020
- 8,030 - 12,900
- 13,000 - 20,200

Oceans:
- Arctic Ocean
- Atlantic Ocean
- Caribbean Gulf of Mexico & Bahamas
- Indian Ocean
- Mediterranean Sea
- Pacific Ocean
Island demand overview

Global Small Island Landscape
(1,000 - 100,000 inhabitants)

Oceans
- Arctic Ocean
- Atlantic Ocean
- Caribbean Gulf of Mexico & Bahamas
- Indian Ocean
- Mediterranean Sea
- Pacific Ocean

Potential PV Capacity (kW)
- <50  20,300 - 33,100
- 50 - 2,600  33,200 - 55,200
- 2,610 - 4,830  55,300 - 116,000
- 4,840 - 8,020  117,000 - 190,000
- 8,030 - 12,900
- 13,000 - 20,200

GLOBAL PV MARKET POTENTIAL FOR SMALL ISLAND ENERGY SYSTEMS
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## PV potential on islands - numbers

<table>
<thead>
<tr>
<th>Region</th>
<th>Scenario</th>
<th>PV (sum) [MWp]</th>
<th>Wind (sum) [MW]</th>
<th>Storage (sum) [MWh]</th>
<th>LCOE (av.) [EURct/kWh]</th>
<th>RE share (av.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atl. + Arct. Oc.</td>
<td>Scen I</td>
<td>930</td>
<td>5,320</td>
<td>n/a</td>
<td>26.3</td>
<td>48%</td>
</tr>
<tr>
<td></td>
<td>Scen II</td>
<td>+21%</td>
<td>-1%</td>
<td>930</td>
<td>-1.9%</td>
<td>58%</td>
</tr>
<tr>
<td>Caribbean +</td>
<td>Scen I</td>
<td>910</td>
<td>1,210</td>
<td>n/a</td>
<td>24.3</td>
<td>57%</td>
</tr>
<tr>
<td></td>
<td>Scen II</td>
<td>+9%</td>
<td>-2%</td>
<td>360</td>
<td>-1.6%</td>
<td>65%</td>
</tr>
<tr>
<td>Indian Ocean</td>
<td>Scen I</td>
<td>420</td>
<td>370</td>
<td>n/a</td>
<td>29.7</td>
<td>44%</td>
</tr>
<tr>
<td></td>
<td>Scen II</td>
<td>+76%</td>
<td>-30%</td>
<td>1,240</td>
<td>-6.7%</td>
<td>65%</td>
</tr>
<tr>
<td>Mediterr. Sea</td>
<td>Scen I</td>
<td>550</td>
<td>770</td>
<td>n/a</td>
<td>25.8</td>
<td>47%</td>
</tr>
<tr>
<td></td>
<td>Scen II</td>
<td>+10%</td>
<td>-1%</td>
<td>230</td>
<td>-1.2%</td>
<td>55%</td>
</tr>
<tr>
<td>Pacific Ocean</td>
<td>Scen I</td>
<td>3,390</td>
<td>5,090</td>
<td>n/a</td>
<td>30.2</td>
<td>44%</td>
</tr>
<tr>
<td></td>
<td>Scen II</td>
<td>+19%</td>
<td>-5%</td>
<td>2,550</td>
<td>-7.0%</td>
<td>71%</td>
</tr>
<tr>
<td>Total</td>
<td>Scen I</td>
<td>6,200</td>
<td>12,760</td>
<td>n/a</td>
<td>30.2</td>
<td>46%</td>
</tr>
<tr>
<td></td>
<td>Scen II</td>
<td>+21%</td>
<td>-4%</td>
<td>5,310</td>
<td>-5.6%</td>
<td>71%</td>
</tr>
</tbody>
</table>

Scenario I w/o battery storage
Scenario II with battery storage
A huge untapped techno-economic potential exists for PV implementation on small islands.

- PV with storage outperforms diesel only systems on many tropical and subtropical islands.
- Economic and ecological advantages should accelerate the implementation of PV systems on small islands.

Remaining challenges are
- High transaction costs for single projects
- Fossil fuel subsidies
- Lack of financing opportunities
Thank you!

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