Solar ferry boats for passenger transport
Energy Balance

- Needed: 220 kWh
- From sun: 40 kWh (Sun)

Total: 260 kWh
Lighter Materials

Weight

35 T → 17 T
Optimum Shape

Drag

50 kW → 15 kW
Efficient Power Train

Reliability

Marine approved
Safe Battery Chemistry

Lithium Iron Phosphate (LFP)

Lithium Titanium Oxide (LTO)
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Battery</td>
<td>57 %</td>
</tr>
<tr>
<td>Speed</td>
<td>424 rpm</td>
</tr>
<tr>
<td>Service</td>
<td>28.5 V</td>
</tr>
<tr>
<td>Motor power</td>
<td>-7.2 kW</td>
</tr>
<tr>
<td>Solar Power</td>
<td>9.3 kW</td>
</tr>
<tr>
<td>Battery U</td>
<td>92.0 V</td>
</tr>
<tr>
<td>Battery I</td>
<td>33.0 A</td>
</tr>
<tr>
<td>Inverter U</td>
<td>93.3 V</td>
</tr>
<tr>
<td>Inverter I</td>
<td>-75.9 A</td>
</tr>
<tr>
<td>Solar U</td>
<td>253.0 V</td>
</tr>
<tr>
<td>Solar I</td>
<td>39.3 A</td>
</tr>
<tr>
<td>Motor T</td>
<td>99°C</td>
</tr>
<tr>
<td>Batt. In T</td>
<td>32°C</td>
</tr>
<tr>
<td>Max Cell T</td>
<td>34°C</td>
</tr>
</tbody>
</table>
History was made on 12 Jan 2017

Kerala Chief Minister, Sri. Pinarayi Vijayan

Minister of Power, Sri. Piyush Goyal
35,000 US$ savings/year
Life Cycle Cost

Conventional Diesel Ferry

2 Cr

Solar Ferry

10 Cr

3 Cr

5 Cr
Inland Ferry

- Speed:
  - >15 knots
  - 12 knots
  - 6 knots

- Distance:
  - ~0.5
  - 1~2
  - >3
  - 50 km
  - 100 km
  - >150 km

- Cargo wt./Boat wt.:
  - ~1
  - 1~2
  - >3
Optimisation

For 55 km

12 knots = 240 kW

6 knots = 20 kW

Power (kWh) vs. Speed (in knots)

Energy (kWh) vs. Speed (in knots)
India Solar Resource

Direct Normal Solar Resource

This map depicts model estimates of annual average direct normal irradiance (DNI) at 10 km resolution based on hourly estimates of radiation over 7 years (2002-2008). The inputs are visible imagery from geostationary satellites, aerosol optical depth, water vapor, and ozone.
End of Road for Diesel Boats
Awards

PM Award for Social Innovation 2017
- RINA Significant Small Ship in the World 2017
- FICCI R&D Catapult Award for Best Innovation 2017
  - AFI Silicon Valley Trek Winner 2017
  - Destination Kerala, Startup of Year 2017
  - TiE Kerala Startup Entrepreneur of Year 2017
  - Tissot Signature Award for Innovation 2017
    - Social Innovator Winner 2016
    - Global Top 5 in Transportation 2017
Solar Panel Price per watt (₹)

<table>
<thead>
<tr>
<th>Year</th>
<th>Q1</th>
<th>Q2</th>
<th>Q3</th>
<th>Q4</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>32</td>
<td>30</td>
<td>28</td>
<td>26</td>
</tr>
<tr>
<td>2016</td>
<td>29</td>
<td>27</td>
<td>25</td>
<td>23</td>
</tr>
<tr>
<td>2017</td>
<td>22</td>
<td>20</td>
<td>18</td>
<td>16</td>
</tr>
</tbody>
</table>
LITHIUM-ION EV BATTERY EXPERIENCE CURVE
COMPARSED WITH SOLAR PV EXPERIENCE CURVE

Historical price (USD/MW, USD/MWh)

Cumulative production (MW, MWh)

1976
Crystalline Si PV module
1998
1988
2004
2008
H1 2014
Li-ion EV battery pack
2010
2014

m=24.3%
m=21.6%

Note: Prices are in real (2014) USD.
Source: Bloomberg New Energy Finance, Maycock, Battery University, MIT

Michael Liebreich, New York, 14 April 2015
@MLiebreich #BNEFSSummit