2.500 Desalination and Water Purification
Spring 2009

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Water Purification for Paulette and Phaeton

9/23/2009
History

Solar distillation unit (300 m²) built in Source-Phillip near Port-au-Prince in Haiti.
Water usage

Desalination System

- 1000 ppm
- Bathing 40%
- Drinking 12%
- Cleaning 6%
- Washing 24%
- Cooking 18%
- Others 300 ppm

6920 ppm → Desalination System → 300 ppm → 1000 ppm → 3860 ppm water
# Desalination options

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Complexity</th>
<th>Appropriate for small-scale</th>
<th>Availability of Energy type</th>
<th>Energy Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>RO</td>
<td>-</td>
<td>++</td>
<td>-</td>
<td>++</td>
</tr>
<tr>
<td>EDR</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>++</td>
</tr>
<tr>
<td>MVC</td>
<td>N*</td>
<td>++</td>
<td>-</td>
<td>N</td>
</tr>
<tr>
<td>MSF</td>
<td>-</td>
<td>--</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>MEE</td>
<td>-</td>
<td>--</td>
<td>-</td>
<td>N</td>
</tr>
<tr>
<td>HDH</td>
<td>+</td>
<td>++</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Solar still</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>---</td>
</tr>
</tbody>
</table>

* N stands for neutral
## Energy options

<table>
<thead>
<tr>
<th>All values are in $/m^3</th>
<th>Generator (PPO)</th>
<th>Windmill</th>
<th>Kites</th>
<th>Solar thermal</th>
</tr>
</thead>
<tbody>
<tr>
<td>RO</td>
<td>0.20</td>
<td>0.03</td>
<td><strong>0.03</strong></td>
<td>NA</td>
</tr>
<tr>
<td>MVC</td>
<td>3.74</td>
<td>0.53</td>
<td>0.50</td>
<td>NA</td>
</tr>
<tr>
<td>HDH</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td><strong>0.96</strong></td>
</tr>
</tbody>
</table>

A cost analysis which estimates the total energy cost (the energy system cost + the fuel cost was carried out).
## Desalination cost

<table>
<thead>
<tr>
<th></th>
<th>RO with Kite power</th>
<th>Solar HDH</th>
<th>VCD with Kite power</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Equipment cost</strong>¹</td>
<td>12,460</td>
<td>273,375</td>
<td>363,000</td>
</tr>
<tr>
<td><strong>Energy system cost</strong></td>
<td>5694</td>
<td>182,250</td>
<td>94,900</td>
</tr>
<tr>
<td><strong>Total Cost (US$)</strong></td>
<td>18,154</td>
<td>455,625</td>
<td>457,900</td>
</tr>
<tr>
<td><strong>Water cost</strong>² (US$/m³)</td>
<td>0.096</td>
<td>2.4</td>
<td>2.412</td>
</tr>
<tr>
<td><strong>Cost-to-villagers</strong>³</td>
<td>0.03</td>
<td>&lt;0.96</td>
<td>0.5</td>
</tr>
<tr>
<td><strong>Level of Maintenance</strong></td>
<td>High</td>
<td>Low</td>
<td>Medium</td>
</tr>
<tr>
<td><strong>Skill required</strong></td>
<td>High</td>
<td>Low</td>
<td>Medium</td>
</tr>
</tbody>
</table>

¹Assuming membrane replacement every 2 years.
²Assuming 20 years life time.
³Assuming a benefactor pays the initial investment.
Design – RO with Kite power

Polyamide Thin-Film Composite spiral wound 8” element, 40 bar feed pressure, 34 m² active area, 99% Salt rejection.

60 GPM, 100-1000 psi, 500 rpm Frame piston pump.

Pre-filter contains a coconut shell, activated carbon filter to remove excess sediment and chlorine to extend the life of the reverse osmosis membrane.

Images removed due to copyright restrictions.
Please see
http://www.dow.com/liquidseps/images/element_family.jpg
http://www.catpumps.com/select/photos/pump/6020.jpg
Kite power

High average wind speed

Why Kites?

- High altitude wind
- More efficient

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Please see Fig. 5 in: Canale, Massimo, Lorenzo Fagiano, and Mario Milanese. "Power Kites for Wind Energy Generation." *IEEE Control Systems Magazine* 27 (December 2007): 25-38.

http://www.youtube.com/watch?v=Z1_tqnsN_Tc
Realization: Kite power

One kite (A=4m²)

Haitian Textile factory

Main Components:
- Metal Spool
- Generator (min. 2kW)
- Car Battery

KiteGen 40kW @ 15 m/s

Operation:
1 person to operate the system

Image removed due to copyright restrictions.
Please see Fig. 2 in: Canale, Massimo, Lorenzo Fagiano, and Mario Milanese. "Power Kites for Wind Energy Generation." IEEE Control Systems Magazine 27 (December 2007): 25-38.
Design –HDH

27m x 27m solar collector field

Cooling coils made from stainless steel

Plastic collection trays & cistern for storage

Packed bed made from local materials

60 GPM pump
Design – Solar FPC

Average Insolation ~4-4.9 kWh/m\(^2\)/day

Easy to manufacture using local materials
Conclusions

- **Optimized water usage**
- **RO with kite power**
  + Possible low cost option (min. capital investment)
  - Requires training of localites for skilled labor
  - Dependence on imports
- **Solar HDH**
  + Highly sustainable option (min. imports)
  - Costlier in terms of water cost (US$/m^3) and capital investment
Thank you!