Solar Thermal Desalination for Rural Applications

A few current views upon an old technology and its possible new role in the global Water Crisis

By Stefan Thiesen, on behalf of Zonnewater
The Solar Still - a simple copy of Nature

- Around since the late 19-hundreds
- Wide spread application and production until the 1960s
- Simple technology using evaporation/distillation in single chamber
- Displaced by large volume centralized fossil energy operated systems
Global Water Situation beyond 2000

- Increased population densities
- Increased industry & agriculture
- Exponential global economic growth (impossible goal?)
- Increased pressure on and degradation of water – and most other – resources
- Fossil fuel scarcity (peak oil, ever rising energy costs)
- Diverse impacts of climate change
A few considerations

• Western Nations use 3 to 5% of GDP for central water treatment and freshwater infrastructure (barely enough)
• For Western EU: ca. € 800 to € 2000 per capita, up to € 8000 per household
• No foreseeable fully centralized option for most developing countries!
Is Privatization a solution?

- Large scale Privatization will not benefit the poor due to „market driven“ prices
- Small scale privatization is interesting option (e.g. the Solco water business model)
- Single household solutions are privatization, too!
- Access to drinking water is **absolute human right!**
- But: price incentives can also help to establish a culture of conservation
Technical Solutions

• Wide spread application of renewable energy for Water treatment is a mid term must
• Different technologies on different scales must be applied parallel (e.g. affordable filters, sand filtration, nano filtration, simple PV UV sterilizers etc.)
• For desalination: various types of large and small scale RO systems with energy recovery (Wind, PV powered), various solar thermal systems
Simple solar distillation: A dead technology?

- Single chamber still
- To date in various forms in occasional use for emergency purposes and in rural settings e.g. in India
- 2 sqm deliver ca. 10 litres in (sub) tropics
- Drinking water for small family
A few Classic Solar Still Pros:

- Low initial investment
- Relatively simple operation & maintenance
- No high tech exchange parts like batteries, filters or membranes
- Simple production (often locally)
- Independent drinking water supply for individual families
A few Classic Solar Still Cons:

- Low yield (limited amount of drinking water only) because of two conflicting processes (evaporation and condensation) combined in one chamber.
- Yield very sensitive to solar irradiation variations.
- Prone to microbial contamination during low temperature operation.
- Requires a certain operational discipline by individual operator.
- Sensitive (transportation, operation: glass).
- Continuously decreasing effectiveness (white scaling = backscattering).
Jan de Koning’s (Zonnewater’s) Aqua Solaris

- Separation of evaporation and condensation
- Increased collector aperture and evaporation surface
- Mikro controlled, PV powered airflow (feedback)
- High operation Temp.
Aqua Solaris Diagramm:

- Operation always above 70 °C
- Heat & humidity recovery
- Product water collection in both „chambers“
- Optimized utilization of temp. gradient
The Bonaire test facility:

- Ambient Temp. Average 30 °C
- Production measured to be 40l/day with pre-heated water & trade winds (cooling)
- Regular Operation at above 80 °C, mostly around 85 °C (near sterile)
Sketch of Bonaire Setup
Tests in New Delhi, August 2005:

- To determine sensitivity to irradiation and other variables
- Result: too sensitive to radiation variations
- Op. Temp only max. 60 °C @ ambient T 40 °C
- Yield far below Bonair measurements
Steps towards market readiness:

- Better heat trapping (modern selective absorbers and transparent insulation)
- Continuous operation temperature above 70 °C must be assured
- $\Delta T > 30$ K is required for optimal condensation
- Considerations to economically increase temperature gradient by other simple means (cooling)
- Jan de Koning’s goal remains: 40l/day below 1000 € investment and a 20 year lifetime
Why so high? The Temperature

- Nonlinear increase of saturation amount with temperature
- Partly explains yield limitation of classic still (operation T generally under or around 60 °C)
- Increased T gives more yield than increased classic collector area
- And: Water safety / sterilization!
Economics of Solar Distillation

• Regionally very diverse and wildly scattered market
• Makes sense where water supply is expensive (bottled water on islands; in arid settings with brackish ground water and degraded wells)
• Individual solutions have price damping effect in crisis and in regions with corporate control over water (Ebaye example)
• Suggested indicator for technologies: Investment per litre normalized yield
A few solar still comparisons

<table>
<thead>
<tr>
<th>Solar Still Company</th>
<th>Location</th>
<th>Description</th>
<th>Price Information</th>
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<tbody>
<tr>
<td>RSD Solar, Germany</td>
<td>(patented, commercial, high tech, up to 12 litres per sqm)</td>
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<tr>
<td>Water Cone, Germany</td>
<td>(patented, commercial)</td>
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<td>Solaqua Rainmaker, USA</td>
<td>(patented, commercial)</td>
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<tr>
<td>Solaqua solar still “do it-yourself” Kit</td>
<td>(non profit, public domain, USA)</td>
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<tr>
<td>UNIDO Study</td>
<td>(Non-profit, assuming local labor and material in Sudan); System not built</td>
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<tr>
<td>Aqua Solaris</td>
<td>at € 975, Netherlands, price for glass system as tested on Bonair,</td>
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<tr>
<td></td>
<td>(patented, commercial)</td>
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<td>at € 800</td>
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<td>€ 70</td>
<td>€ 170</td>
<td>€ 63</td>
<td>€ 22</td>
<td>€ 10.5</td>
<td>€ 24.40</td>
<td>€ 20</td>
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In India classic low yield (< 5 l / 1 sqm collector) and low temperature stills are available at less than 8 Euro investment / litre output, but with the known problems.
The Zonnewater Target

- Provide safe, independent and affordable drinking water supply with one system for a large family, including storage capacity for low yield periods, potential extra yield for selling/trading water.
Conclusion

- Solar distillation has a future as a complementary intermediate technology
- Modern approaches (simulations during development, mikro controlling of operation, optimized heat bridges, transparent insulation etc.) increase effectiveness of the classic still process, have downsides
- High- and lowtech systems both will have their market niches
Weij – Ji: Danger and Chance?

- Free market alone is no solution: it leads to more money, not to more water.
- Crisis offers potential for new thinking (non-commercial community solutions complementing commercial ones?)
- Best solution will be renewable energy based multi level approach with many existing technologies & organisations
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