Solar Ignition Water Vaporizer [20180330]

by J

Introduction

This paper addresses a growing concern for mankind: that of limited fresh water resources in the face of a growing population with growing water needs as a consequence of modernization.

A simple, elegant, and scalable solution will be offered, which when distributed at industrial scale, may be able to greatly ameliorate many of the issues being faced by clean water shortage.

But rather than focus on satisfying a modern person's water use, est. ~ 80 gallons per day, to instead focus on meeting realistic *needs* of persons without *clean* water, est. ~ 2 gallons/day.

Ideally, such a device would have a per unit cost of ~$100, and cleanly maintained last 40 years.

Thus perhaps, the more basic needs can be readily met with much simpler, less complex, and infinitely more accessible solutions than previously pursued through centralized utilities alone.

Problems

- Less than 1% of the Earth's water is fresh water in liquid form (implies that 99% of it isn't consumable or easily accessible). And given Earth's population growth and existing supply limitations, this fact would suggest humanity is headed for an eventual disaster.
- So "the world is running out of ..." clean water. In following that thought, a mind's fearful reasoning may panic because it believes or has witnessed evidence that: rivers are being polluted; aquifers and reservoirs are being drained or not replenished, or polluted by fracking and pesticide use; global warming is accelerating the melting of glaciers (2-3%) and turning fresh water into sea water; wells are now producing salt water or drying out; etc.
- The Earth's greatest resource (71%) of vast oceans, hold 97% of the Earth's water that isn't potable (safe to drink), for it contains too much salt, which leads to death by dehydration.
- "According to the World Health Organization, 80% of all diseases in the developing world are water related. By 2025, the United Nation estimates that 30% of the world's population residing in 50 countries will face water shortage." *1
- "Agriculture alone can consume 75 to 90% of a region's available freshwater. Did you know that 1 ton of grain requires 1000 tons of water? The steak you eat requires 1,232 gallons." *1

These are broad examples of the potential problems facing humanity and water consumption. At a local level, access to any supply of water (salt/dirty), may still be the major hindering factor without investment in pipelines. The issue of access, however, is beyond the scope of this paper.

From the above, one may reach a simple, preliminary conclusion that: "If only seawater could be quickly/cheaply desalinated, we could easily meet humanity's growing clean water needs."

Current Desalination Methods and Technologies
(smaller scale, from individual to regional use, from Wikipedia) *2

All of these methods have advantages and disadvantages, but this author doesn't believe (may be wrong) are truly designed for scalability (such as by multiplying units into clusters) in their current designs, as explained in Model Limitations (later).

Vacuum distillation

The traditional process used in these operations is vacuum distillation—essentially boiling it to leave impurities behind. In desalination, atmospheric pressure is reduced, thus lowering the required temperature needed. Liquids boil when the vapor pressure equals the ambient pressure and vapor pressure increases with temperature. Effectively, liquids boil at a lower temperature, when the ambient atmospheric pressure is less than usual atmospheric pressure. Thus, because of the reduced pressure, low-temperature "waste" heat from electrical power generation or industrial processes can be employed.

Multi-stage flash distillation

Water is evaporated and separated from sea water through multi-stage flash distillation, which is a series of flash evaporations. Each subsequent flash process utilizes energy released from the condensation of the water vapor from the previous step.

Multiple-effect distillation

Multiple-effect distillation (MED) works through a series of steps called "effects". Incoming water is sprayed onto pipes which are then heated to generate steam. The steam is then used to heat the next batch of incoming sea water. To increase efficiency, the steam used to heat the sea water can be taken from nearby power plants. Although this method is the most thermodynamically efficient among methods powered by heat, a few limitations exist such as a max temperature and max number of effects.

Vapor-compression distillation

Vapor-compression evaporation involves using either a mechanical compressor or a jet stream to compress the vapor present above the liquid. The compressed vapor is then used to provide the heat needed for the evaporation of the rest of the sea water. Since this system only requires power, it is more cost effective if kept at a small scale.

Reverse osmosis

The leading process for desalination in terms of installed capacity and yearly growth is reverse osmosis (RO). The RO membrane processes use semipermeable membranes and applied pressure (on the membrane feed side) to preferentially induce water permeation through the membrane while rejecting salts. Reverse osmosis plant membrane systems typically use less energy than thermal desalination processes. Desalination processes are driven by either thermal (e.g., distillation) or electrical (e.g., RO) as the primary energy types. Energy cost in desalination processes varies considerably depending on water salinity, plant size and process type. At present the cost of seawater desalination, for example, is higher than traditional water sources, but it is expected that costs will continue to decrease with technology improvements that include, but are not limited to, improved efficiency, reduction in plants footprint, improvements to plant operation and optimization, more effective feed pretreatment, and lower cost energy sources.

The Reverse Osmosis process is not maintenance free. Various factors interfere with efficiency: ionic contamination (calcium, magnesium etc.); DOC; bacteria; viruses; colloids & insoluble particulates; biofouling and scaling. In extreme cases destroying the RO membranes. To mitigate damage, various pretreatment stages are introduced. Anti-scaling inhibitors include acids and other agents like the organic polymers Polyacrylamide and Polymaleic Acid), Phosphonates and Polyphosphates. Inhibitors for fouling are biocides (as oxidants against bacteria and viruses), like chlorine, ozone, sodium or calcium hypochlorite. At regular intervals, depending on the membrane contamination; fluctuating seawater conditions; or prompted by monitoring processes the membranes need to be cleaned, known as emergency or shock-flushing. Flushing is done with inhibitors in a fresh water solution. Thus the system needs to go offline. This procedure is environmental risky, since contaminated water is rejected into the ocean without treatment. Sensitive marine habitats can be irreversibly damaged.

Freeze-thaw
Freeze-thaw desalination uses freezing to remove fresh water from frozen seawater. One method, invented by Alexander Zarchin, used freezing and vacuuming of salt from seawater.

Solar evaporation
Solar evaporation mimics the natural water cycle, in which the sun heats the sea water enough for evaporation to occur. After evaporation, the water vapor is condensed onto a cool surface.

Electrodialysis reversal
Electrodialysis utilizes electric potential to move the salts through pairs of charged membranes, which trap salt in alternating channels.

Membrane distillation
Membrane distillation uses a temperature difference across a membrane to evaporate vapor from a salty brine solution and condense pure condensate on the colder side.

Wave-powered desalination
CETO is a wave power technology that desalinates seawater using submerged buoys. Wave-powered desalination plants began operating on Garden Island in Western Australia in 2013 and in Perth in 2015.

Current "Best" Technology Desalination Solution (large-scale centralized utility use) *3

- The **Claude "Bud" Lewis Carlsbad Desalination Plant** (Carlsbad) is a desalination plant that opened on December 14, 2015 in Carlsbad, California.
- "The San Diego County Water Authority (SDCWA), the recipient of the fresh water produced by the plant, calls it 'the nation's largest, most technologically advanced and energy-efficient seawater desalination plant.' The entire desalination project cost about $1 billion for the plant, pipelines, and upgrades to existing SDCWA facilities to use the water."
- "The plant took nearly 14 years to build. The total project cost was expected to reach near $1 billion; initial cost estimates were a quarter-billion in 2004, to six hundred ninety million in 2010. The cost of construction was funded by bond sales. In late-2012, Fitch Ratings gave

the bonds the lowest investment grade rating. Upon completion, it became the largest desalination plant in the Western Hemisphere."

- "Up to 100,000,000 US gallons (380,000 m3) per day of cooling water from the Encina Power Plant is taken into the desalination plant. The water intake is filtered through gravel, sand, and other media to greatly reduce particulates before going through reverse osmosis filtration. Half of the saltwater taken into the plant is converted into pure potable water and the rest is discharged as concentrated brine. The outflow of the plant is put into the discharge from the Encina Power Plant for dilution, for a final salt concentration about 20% higher than seawater. Most desalination plants discharge water with about 50% extra salt, which can lead to dead spots in the ocean, because the super-saline brine doesn't mix well with seawater."
- "The plant is expected to produce 50 million US gallons (190,000 m3) of water per day (0.069 cubic kilometres per annum) with energy use of ~3.6 kWh for 1 m3 fresh water, or ~38 MW of average continuous power. Another estimate has the plant requiring 40 MW to operate, and a cost of $49 million to $59 million a year. It will provide about 7% of the potable water needs for the San Diego region."
- "The cost of water from the plant will be $100 to $200 more per acre-foot than recycled water, $1,000 to $1,100 more than reservoir water, but $100 to $200 less than importing water from outside the county. As of April 2015, San Diego County imports 90% of its water. A conglomerate of California-based environmentalist groups, the Desal Response Group, claims that the plant will cost San Diego County $108 million a year."

Model Limitations of the current "Best" Solution

Here an analogy may be of use, that of large and expensive, single purpose mainframe computers vs. swarms of personal computers for large scale demands of transactions processing.

In a short summary: While mainframes still maintain customers today, such as very large corporations (eg. airlines), to handle vital, never-fail, demanding, reliable, and essential workloads concentrated around servicing hubs (eg. cities)... The overwhelming trend, especially through the growth of the internet (which continues to surpass the potential for any single technology to provide its numerous needs), is to group any number of smaller sized machines, from minis to desktop and multi-processor server computers into swarms which can be located anywhere across the globe, that through millions of individual nodes, can effectively, reliably, and instantaneously provide for the needs of millions of users without location liability. IOW, rather than designing and purchasing single-use, large scale utility hardware, to meet the needs of as many users as possible using a single, centralized, and expensive platform, it's far more effective, to allow regional needs to be met as demand grows, using many smaller, easily configurable single-task computers, grouping together where required, to provide for most user's needs.

In other words, while large scale, centralized solutions may work to meet specific customer requirements, on a global scale, it is much more efficient and practical, to deploy larger numbers of smaller, standardized, and compatible units (eg. based on Intel's x86 architecture), to meet especially more localized and regional needs, independent of central authorities regulating their 'software'. For example, Google and Facebook both use thousands of bare-bones computers, to deliver instant and responsive content at speeds and efficiency unmatched by mainframe options.

In this analogy, the Carlsbad Desalination Plant would be the equivalent of mainframes: large, expensive, reliable but imposing, and limited to any adaptability beyond its immediate range.

Mainframe solutions, in contrast to reality of many people's daily water struggles, may be incomprehensibly out-of-reach to any aspiring individual or community (especially living in poverty), whereas a simple cluster of multiple units connected to well water, would suffice.

A Proposed Alternative to Existing Desalination Solutions: Solar Ignition

The concept of a Solar Ignition, is based on the idea that sufficient sunlight reflected and focused onto a point, could produce enough heat to 'instantly' vaporize water into steam.

That during peak sunlight hours, it should be possible, using a small, single device, to distill enough water for a family to provide for its immediate water needs (hydration, cooking, etc).

The theory of its design potential, is evidenced by the use of satellite dishes, converted into reflectors, which can produce sufficient heat focused on a single point to quickly melt metal.

The 'magic' of the device, is to reflect the concentrated heat source directly into the water itself, allowing it to quickly boil, and vaporize as its directly exposed without an intermediary conduit.

The simplicity of the design, should enable it to be used by single individuals in the most remote locations, be portable, simple 'for a child' to operate, and allow almost any water to be purified.

In more complex groupings, such as for neighborhood use, multiple units would be combinable (at reduced cost) to operate as a cluster, with large tanks providing scalable community needs.

By focusing on a simple, but powerful and functional unit design, able to be combined into larger clusters, even up to industry scale, overcomes the many limitations of 'mainframe centralization'.

Thus, for individuals, families, or groups or people requiring clean water daily, would provide a viable alternative and immediate solution to alleviate hardship, by providing it for one's self.

The current device concept:

- Is based on the simplest of all desalination methods, Solar evaporation, which mimics the natural water cycle of evaporation by sunlight energy, and natural distillation by the cooling vapor when it reaches lower temperatures a distance away from the heat source.
- Uses simple, affordable, and available (mass-produceable) technology to enable individuals or groups to operate small to industrial scale solutions (glass, mirrors, pipes, tanks, etc.).
- Designed to meet the daily water *needs*, not *desires* of modernization. Eg. produce more than sufficient potable, clean water daily at low cost to promote life (eg. drink/cook, not flushing).
- Make use of Earth's most natural energy source, the sun, to 'turn a carboy into a boiler', by concentrating the sun's light to produce extreme heat and boil water until it near-instantly vaporizes a small body of water to steam, or a flowing stream directly for continuous flow.

- Make use of tanks to store seawater or dirty water, to provide an evenly distributed and reliable water source throughout the day to feed the boilers, which also act as pre-heaters in sunlight for increased boiler performance, before channeling the steam into a reservoir.
- Use simple and reliable, mostly mechanical devices, to enhance the sun's light capture capacity, by auto turning the boiler's reflector toward the sun as it moves throughout the day. This can easily be achieved using small solar panels and a DC motor.
- The most optimal design for a single cell unit, would likely require custom manufactured glass and reflectors, however, these would be mass-produceable at low cost for scalability.
- A source of water, 'pumped' from the ocean, stream, lake, or deep well to supply the unit (or feed tank) would be required for continuous, higher volume operations.

Theoretical Potential

As the research and development of a functional device has yet to be conducted, the potential for such a boiler system can only be theorized at this time, based on available data of similar components to be used as the basis for the solar concentration process:

- According to a listing for a 37" reflector by Green Power Science (Florida), a 'deep dish' reflector can boil 6 oz of water in 45 secs, and reach spot temperatures up to 2250°f. *4

By textbook definition, water evaporates at 100°c or 212°f. Thus, a dish of a similar size/design, could likely produce a spot of heat in water 10x greater than required to boil it. (A 24" dish is 5x.)

So, to bring a gallon of water to boil, would take 16 minutes. What about vaporizing into steam?

Herein is the key to success of this Solar Ignition design: that the mirror used to reflect light be a custom precision shaped parabolic reflector, capable of concentrating very high temperatures by focusing the sun's light at the highest concentration ratio onto a single point, to heat the water from within itself! (The hot spot would be in the water, not heated through a container.)

So the question remains, how much vapor (clean water) could such a design produce, if exposed to for example, 2 hours of peak sunlight? If you can help answer that, please email this author.

This author's feeling is that, with sufficiently hot and sustained temperatures of concentrated solar power reflected directly into water:

- With the right design, perhaps using a smaller reflector of 24" for practicality, it may be possible to achieve distillation of < 2 gallons of clean water per unit during peak/hot sunlight in a passive configuration, and considerably more in a more advanced technology model.
- Such an amount is sufficient for drinking needs of 1-2 people on any given a day, or enough for 1 person to drink, cook a meal (eg. rice or pasta), brush their teeth, clean dishes, etc.
- Combining multiple units, would allow families/neighbors to provide for their basic, daily clean water needs, and any excess stored in tanks for later use (when the sun doesn't shine).
- More efficient design through iterations and testing evaluation, to include additional improvements in steam generation (flow preheated water), may increase the overall output.

- Auto-tracking of the sun (see *8), would also enable a Solar Ignition to boil water throughout the day, rather than passively only during peak hours, increasing output dramatically.
- The design should take into account, the variety of water sources available, and be able to 'self-clean' by continuously cycling the dirty water back to its source in the ocean/well.

Note: The evaporation temperature can be reduced through compression, and vaporization also greatly improved through factors such as airspeed over the water and pressurization of the water, heating of the water prior to boiling, and even spraying the water as mist into the unit's boiler. These factors for improvements will require further research and evaluation.

Note: In large scale desalination installations, the brine (higher slat content water) remaining may build up where its deposited, for it dissolves only with great difficulty. However, on small scale installations, such as a single home's well, this author presumes, it should prove less of an issue to cope with. Reclaimed seawater salt, when completely dried out, may be used for cooking/sold.

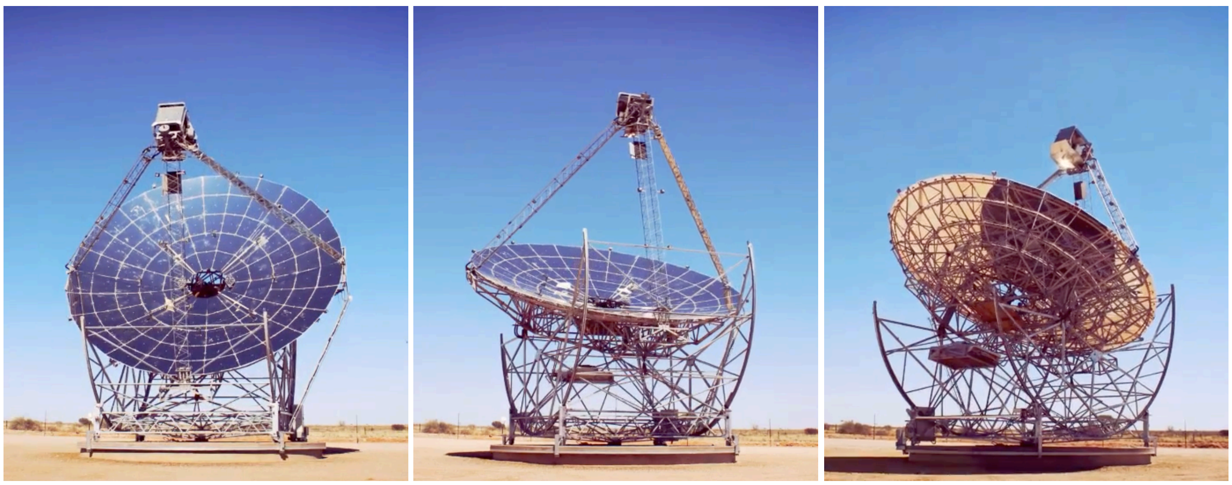
Proof of Concept

From top left to right, bottom left to right: A) Vapor streaming from the evaporated sea water. B) The reflector's hot spot focused on a singular heating point. C) Condensed water dripping into a glass. D) Drinking the desalinated and distilled sea water, which required no energy to produce.

A video *5 is posted on YouTube, entitled “Drinking water from sea water without electricity only by Sun energy,” in which its creator Rims Vaitkus, demonstrates the feasibility of pumping water using the ocean’s wave motion, and the purifying the water by vaporizing it using a large reflector, in a very similar manner to this author’s proposed concept. In the video, it can be seen that the device produces a continuous stream of steam, which when condensed, is instantly drinkable.

There are numerous improvements, this author believes, which can be made to his initial design, in order to improve flow rate, heat intensity, materials, procedure, etc. to achieve a far greater output than demonstrated in the short video, turning his proof of concept, into a viable utility. As also observed, it is also unclear how warm the temperature is, the time of day, geo location, etc.

Nevertheless, the proof is in the water, and this demonstrates its feasibility as a standalone unit.



Above: Ripasso Energy’s dish auto-tracks the sun, maximizing energy output from sunlight.

A second proof of concept that demonstrating the viability of larger scale installations, quoting: “Swedish company Ripasso Energy has created a new, state-of-the-art solar energy dish, which it believes is the most efficient in the world. One of the key elements of Ripasso’s system is an engine originally thought up nearly 200 years ago in 1816.

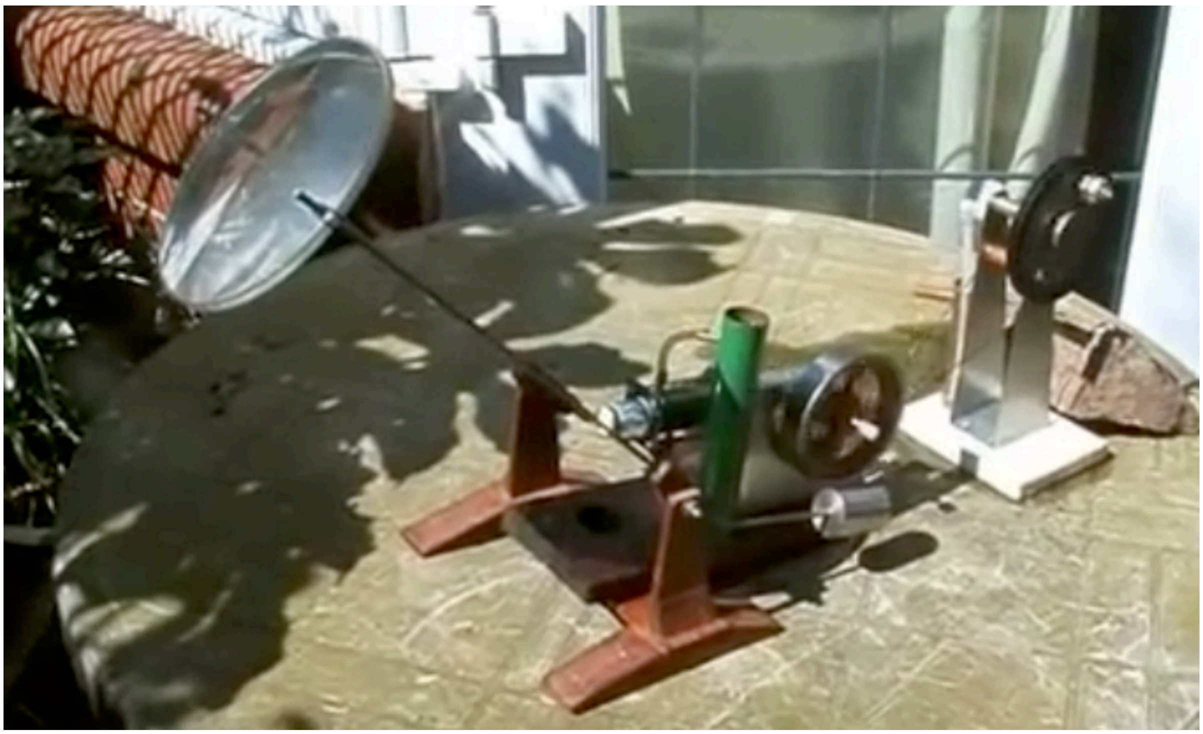
Ripasso’s CSP system works by combining a parabolic mirror with a Stirling engine. The 12 meter diameter mirror dish looks like a typical satellite dish, but its job is to focus the sun’s energy on a “tiny hot point” that then drives the Stirling engine.

Unlike other, similar systems, Ripasso’s uses no water to produce electricity. The Stirling engine is a closed-cycle regenerative heat engine that uses an enclosed gas to drive pistons and turn a flywheel. The large dish constantly turns to ensure optimal solar energy capture from the sun, the hot point powers the Stirling engine, and electricity is produced.

As for efficiency, it easily outperforms the photovoltaic panels in use today. Those panels typically convert 23% of the sun’s energy to electricity, however, making that usable on the grid means efficiency drops to just 15%. The Ripasso CSP system converts 34% of the sun’s energy to grid-ready electricity. Each dish can produce 85 megawatt hours of electricity every year, enough to power 24 homes for the same period of time.” *6

Alas, this system is designed to maximize electrical production, and doesn't use water to 'power' the Stirling engine generating electricity, in this case using gases, rather than hot air. However, the system's essential design, could probably quite easily be adapted for water purification use, greatly multiplying the volume flow of a standalone water ignition unit, if scaled to such a size.

Finally, a third proof of concept, comes from another YouTube video *7, published by Uniflow, in the self-explanatory titled "Solar powered Stirling Engine & water pump," where a miniature solar to hot-air powered Stirling engine powers a mechanical water pump. What the video proves, is that the heat alone through a Stirling engine is sufficient to drive a water pump... (Image below).



Not discussed in this paper, but worth mentioning, is the use of other related proven techniques:

- Solar panels for practical power applications, such as powering a water hose pump to carry both salt/dirty and purified/clean/fresh water over long distances, where women otherwise carry it themselves in large containers, in some cases, up to several miles every day. Such a trek is not uncommon in rural Africa, for example, where the labor of fetching water daily replaces the ability of being productive in other capacities, such as pursuing an education.
- Solar ovens, used for cooking food in a tube or metal pot, also by concentrating the sun.
- Solar water heaters, as commonly seen on rooftops of many houses in Nepal, used to heat water for showers/baths by exposing a long pipe through a light concentrating collector.

Water heating in particular, may be useful as an additional component of a Solar Ignition unit, to allow the ingesting water to be pumped automatically through heat/pressure changes, and, to pre-heat the water to a temperature requiring much less solar energy to vaporize, thus greatly increasing the potential to achieve a high-flow/maximum throughput rate through the device.

To Meet Growing Needs: A More Advanced & Future Power Proposal

To engineer a Solar Ignition+ unit, solving multiple water & energy related issues simultaneously:

- The multi-purpose device would pump water and produce both clean water and electricity.
- Pumping well, stream, or sea water by its own power (and manual 'start up' without power).
- Generate electricity by focusing the hot-spot onto a Stirling engine, or as a secondary stage by-product of water vaporization, by using pre-condensing steam power from heated water.
- Purify water by Solar Ignition, instantly vaporizing as much dirty water in a continuous burn.
- Auto-track sun throughout the day, and align in the morning, using 2-axis panels/motors.
- Store electricity produced in batteries for night, or resell to grid to offset investment costs.
- Collect production excess purified water for storage, or in water towers to supply neighbors.
- Design to be multi-environment capable, simple to manufacture, quick to install/dismantle.
- Optional: Potentially store the electrical energy produced in SaltX for later sunless heating.

See Ripasso's design as a potential template from which to integrate Solar Ignition purification.

Potential Outcome

Q: Can the theoretical output potential be calculated?

A: I don't know. The math is beyond this author's current skills to do so. Many, many factors will influence outcome, such as location, weather, temperature, time of year, water source, etc.

In simple, the ideal outcome will be to end up with a simple, mass-manufacturable device, able to function purifying water in almost any climate, but ideally suited to sunny/warmer latitudes.

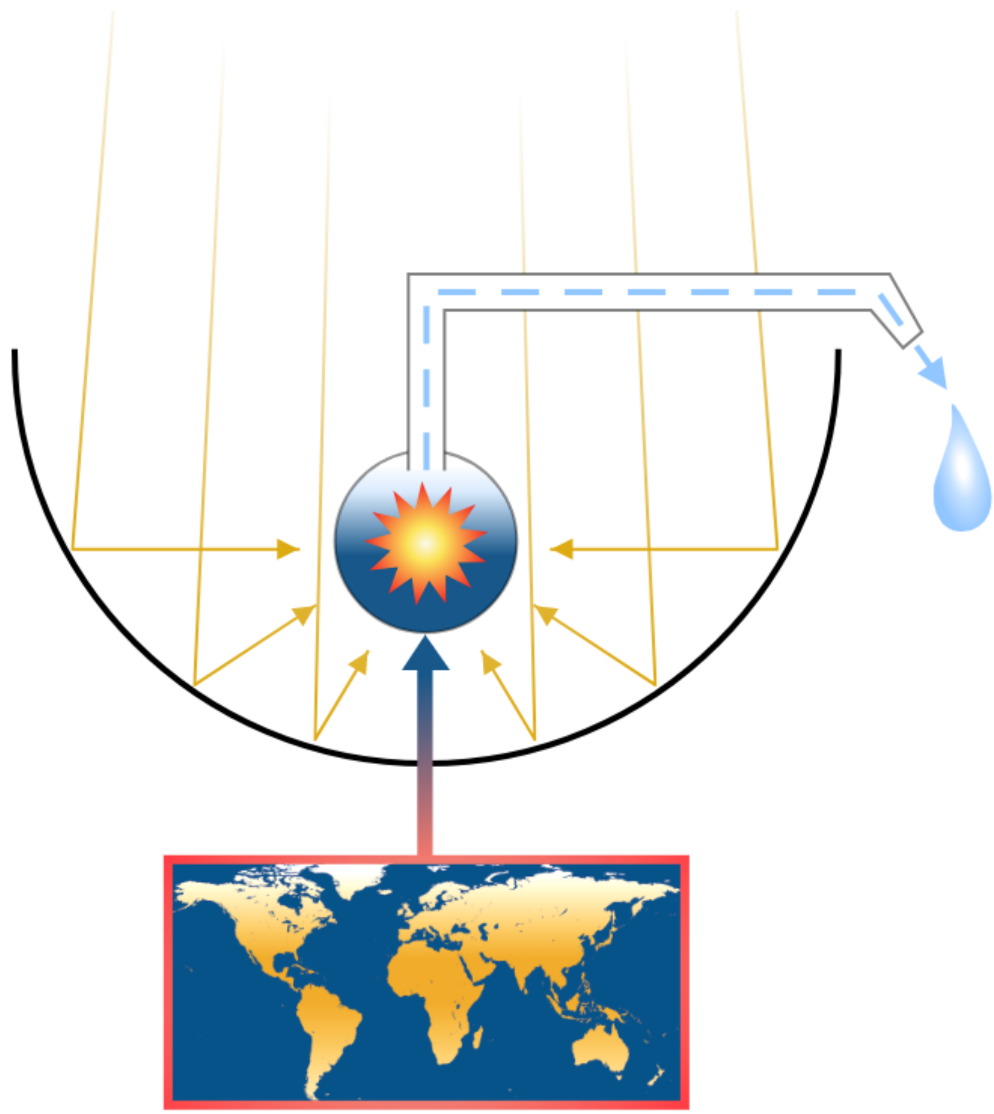
The device would be scalable in the same manner as networked computers in a cluster, easy to multiply, and infinitely scalable to meet the demands of most applications by increasing units.

From better tasting to purified water, examples of energy-free practical applications may include:

- Disaster relief — providing the means of producing clean water when services are disrupted.
- Flood water reclamation following storms, purification into reservoirs, tank trucks, or homes.
- Home/camper well or sea water filtration into tank storage for tap water faucet availability.
- In the developing world — well, river, ocean or surface water filtration for an entire village.
- Marine — portable single units for small boats, clusters on top of barges serving as tanks.
- Desert — 'greenification' through drilled wells, pumping sea water into units irrigates fields.
- Desert — utility scale, make abundant use of intense year-round sunlight for mega-clusters.
- Desert — replenishing of reservoirs (eg. Hoover Dam), using piped underground seawater.
- Remote (mountains, islands, beaches) — snow/stream/sea purification of parasites/salt.

The ‘biggest danger’ believed with such a device, is the potential to burn one’s self/arm/other if one places its body in the hot spot, or blindness if staring in the mirror too long. Both of these issues can be mitigated by placing the devices on roof tops, water towers, guarded/protected areas of a house/garden/community, vast lands empty along coastlines (pipe water back), etc.

Design Principle



In a basic ‘passive’ implementation, a large solar ‘dish’ reflector would be placed on the ground, shaped in the appropriate angle to concentrate the sun to the center of a spherical glass carboy, boiling the salted/dirty water contained within it; reaching peak vaporization in the high-noon daylight hours (~11am-2pm), to produce a useful supply of fresh water daily. As water vaporizes, the steam rises, traveling through a tube, and is collected by condensation into a separated clean tank or vessel for storage or later use. It would produce a minimum of 2 gallons of water per day, but require daily maintenance of cleaning accumulated residue salt/dirt, and manually refilling the carboy or feed water tank, by pumping/carrying from a well, surface, river, or ocean source.

In a more advanced 'active' configuration, the solar 'dish' would automatically 'wake up' at first light, using a simple 2-axis sun tracking *8 motor, orienting itself to follow the sun throughout the day, optimizing the available light for maximum fresh water production. It would require a feed tank to keep the beaker continuously refilled with a supply stream, and a larger storage tank to collect the fresh water for storage and later use. In larger installations, either using a single large dish, or a cluster of dishes mechanically bound, the supply would be automated and reliable with little human intervention or need for daily maintenance. By automating the flow using pumps and valves, and continuously cycling the residual water/brine/salt/dirt as it is produced, it should be possible to create a lasting weather-resistant installation, requiring part-time maintenance only.

Sources

*1 = http://www.theworldcounts.com/stories/average-daily-water-usage
*2 = https://en.wikipedia.org/wiki/Desalination
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*8 = https://www.youtube.com/watch?v=HkhVomoD47g

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