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Latent Power, Solar Desalination Plant

Patent application Nos. 0511946.6, 0608208.5

1 Basic solar desalination system theory

Basic, traditional solar powered desalination plants are ideal for small scale domestic use in sunny climates because solar power free and the distilled water produced has a high degree of purity.

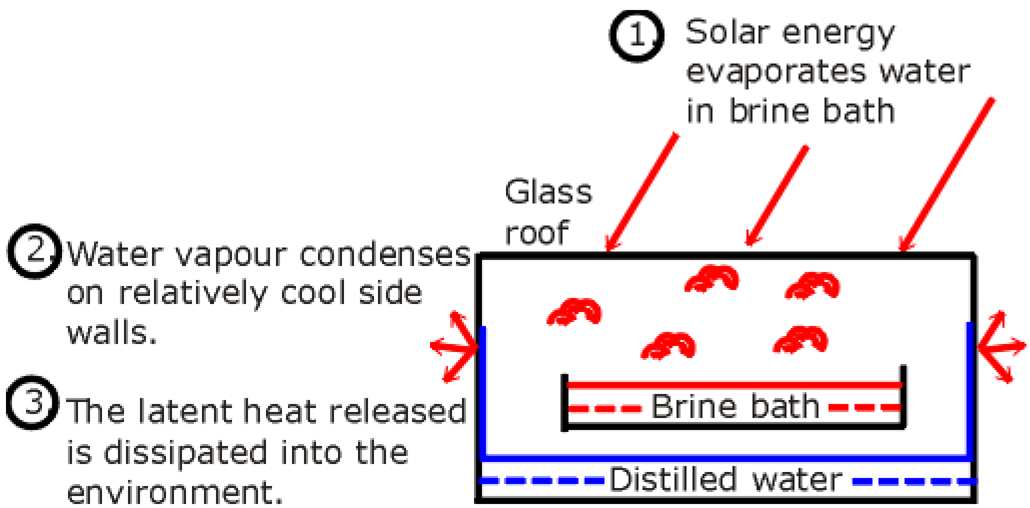

Figure 1. The simplest form of solar desalination unit.

The principle weaknesses of the design are:

(i) The system is inherently inefficient because a large amount of heat (latent heat of vaporisation) is required to evaporate the water.

(ii) It is difficult to dissipate this low temperature waste heat into the environment.

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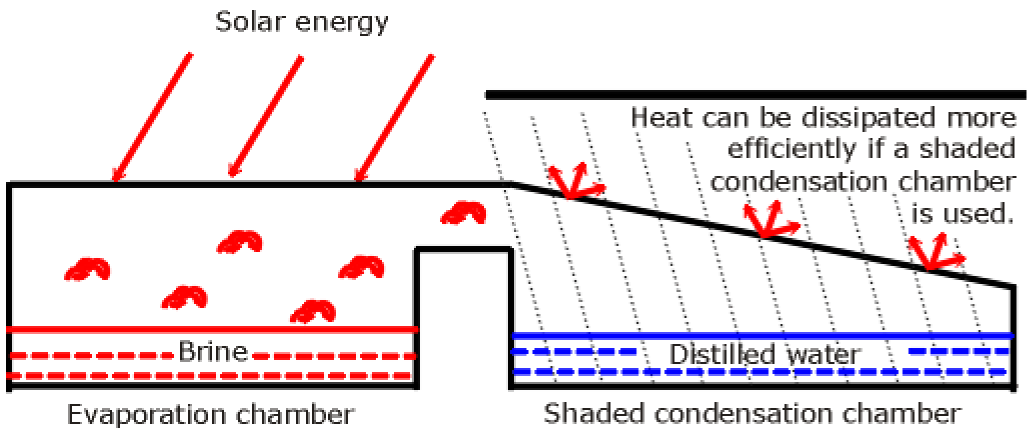

Figure 2. The heat dissipation problem can be reduced by allowing the condensation to take place in a chamber that is shaded from the direct heat of the sun.

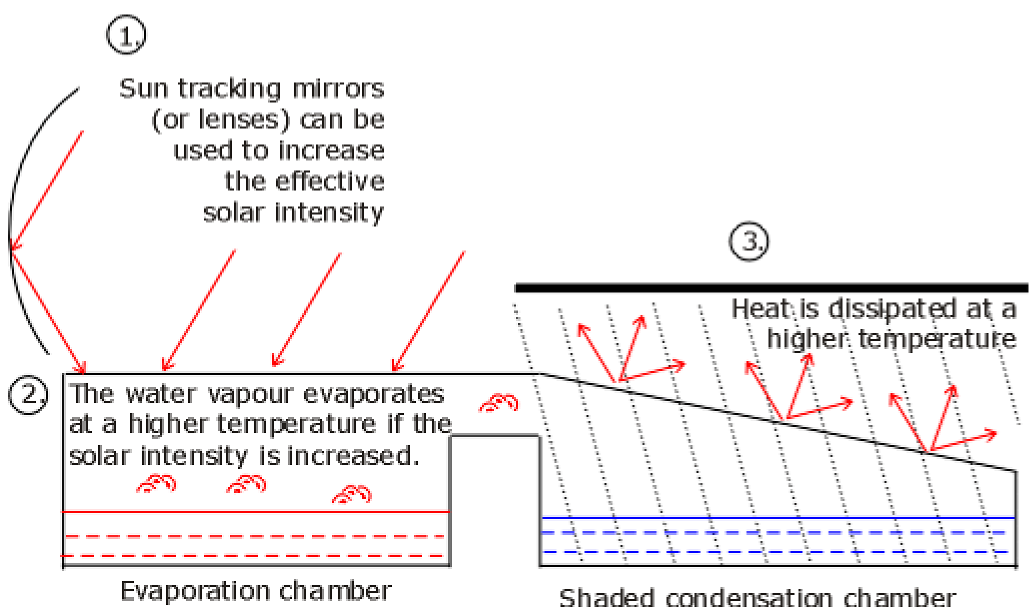

Figure 3. The heat dissipation problem can be further reduced by using an optical system to concentrate the solar energy and raise the temperature of the system. The position of the optical system (lenses or mirrors) has to change throughout the day as the position of the sun changes.

These improvements can reduce the heat dissipation issues, but traditional solar desalination plants are commercially uncompetitive because of the latent heat problem.

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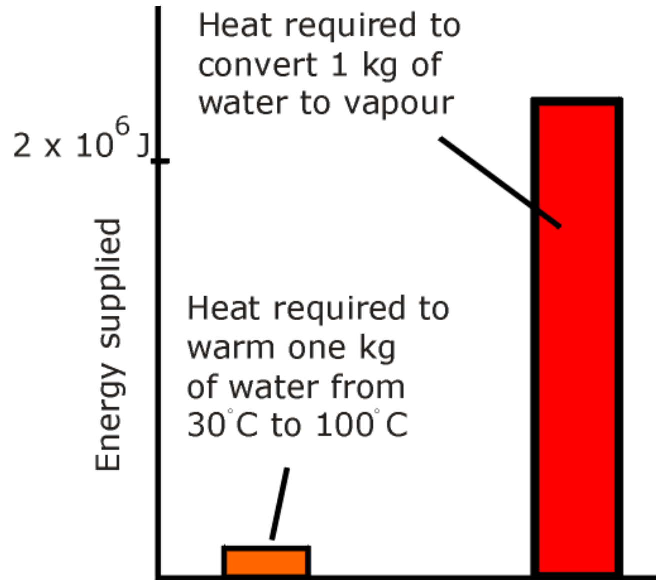

Figure 4. Even if the water is raised to boiling point using concentrated solar energy, the latent heat problem remains.

2 Latent Power Solar Desalination

Key design considerations:

- Simplify the solar tracking system by keeping the optical system stationary and moving the location of the water being heated.
- Use lenses instead of mirrors, but keep the weight of glass down by using Fresnel lenses, similar to those used in flat credit card sized magnifying glasses.
- Instead of wasting the latent heat released when vapour condenses, use it to warm up and evaporate water in shaded troughs.

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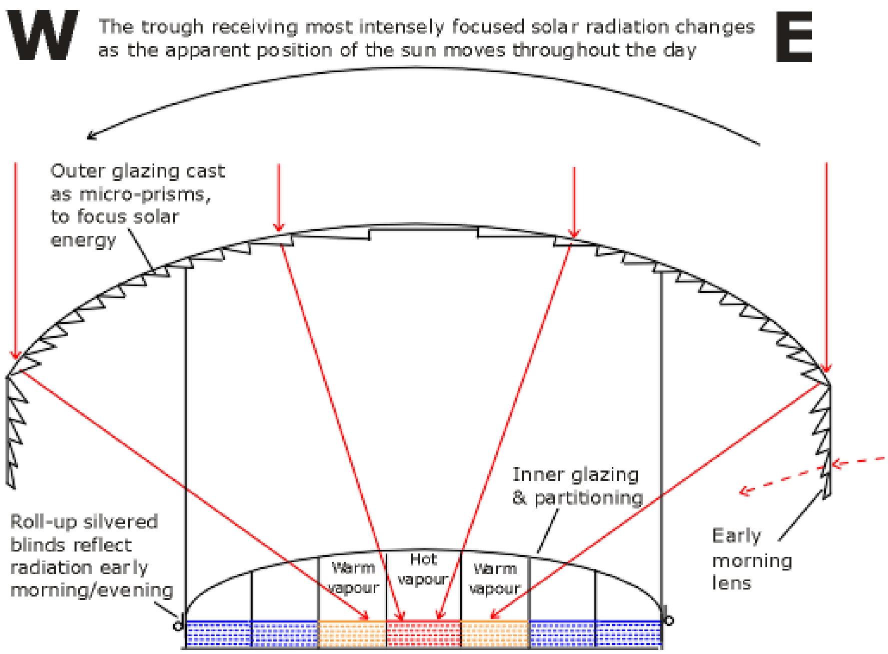

Figure 5. By using a canopy made up of cylindrical Fresnel thin lenses (i.e., micro prisms) the sun can be tracked throughout the day without the complexity of the moving mirrors commonly associated with large solar power units.

The troughs take the form of long (100 metes plus) channels running from North to South. This simplifies the Fresnel lens design because the lens only needs to focus solar radiation in the East to West plain. The design does not require the optical sharpness of a reading glass, so relatively course Fresnel lenses can be used. Manufacturing costs per square metre should be similar to bathroom glazing glass.

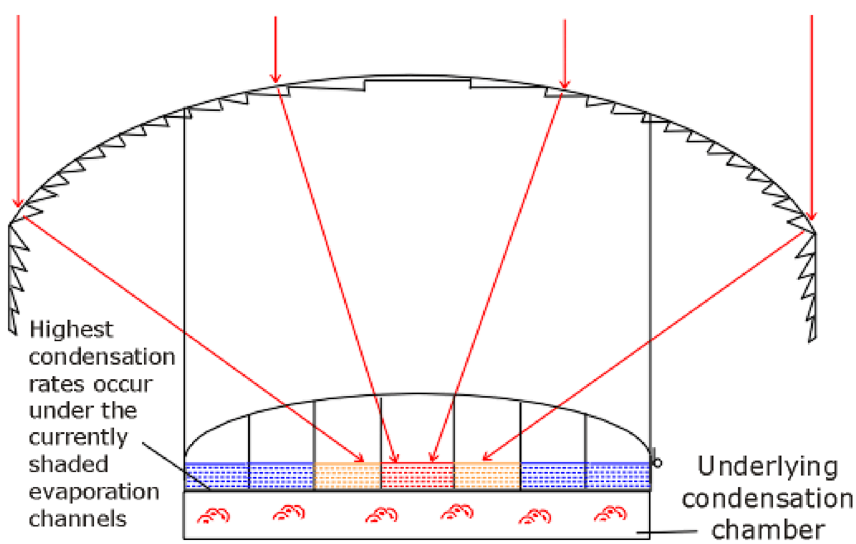

Figure 6. The condensation chamber is built under the channels. At any given time, most of the channels are relatively cool because they are in the optical shade.

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The design produces two categories of vapour:

(i) Hot (100°C) water vapour in the channel currently under illumination.

(ii) Warm vapour when the water in the shaded channels evaporates.

In order to maximise thermal feedback, the hot and warm vapours need to condense out in different condensation chambers.

This design feature is best understood by examining two North-South profiles; one for the illuminated channel and one for a channel in the shade.

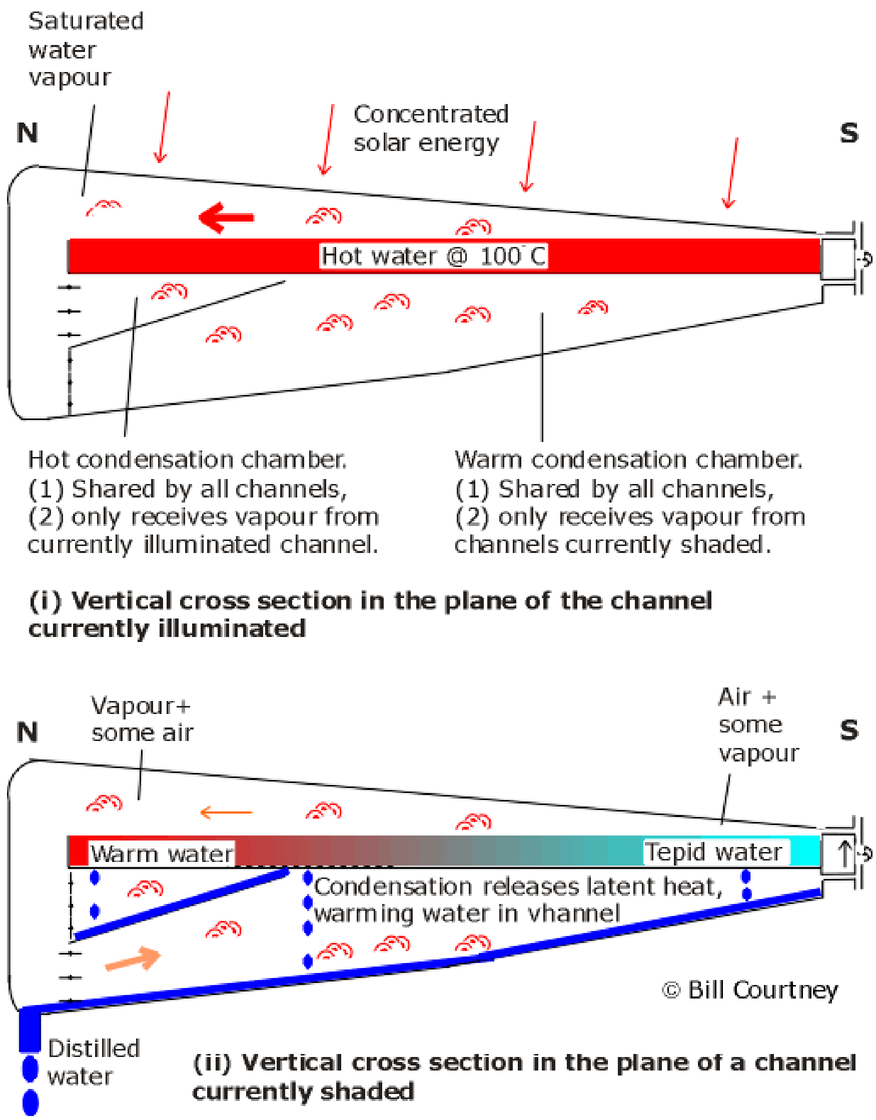

Figure 7. Thermal feedback allows the design to recycle solar energy. This cannot be done indefinitely because some heat leaks out of the system into the environment. In order to determine the efficiency of the feedback system, proof of concept experiments will need to be carried out and the results fed into computer models.

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For the time being, we are assuming that the heat can be used five times, before it is lost to the environment.

The evaporation chambers will operate at approximately atmospheric pressure, but a small pressure gradient will be required to ensure circulation of the vapour. At the beginning of the day's operations, the chambers will be filled with air. This will need to be vented off as the system warms and the volume of water vapour increases. Air will have to be drawn back into the system when its temperature drops.

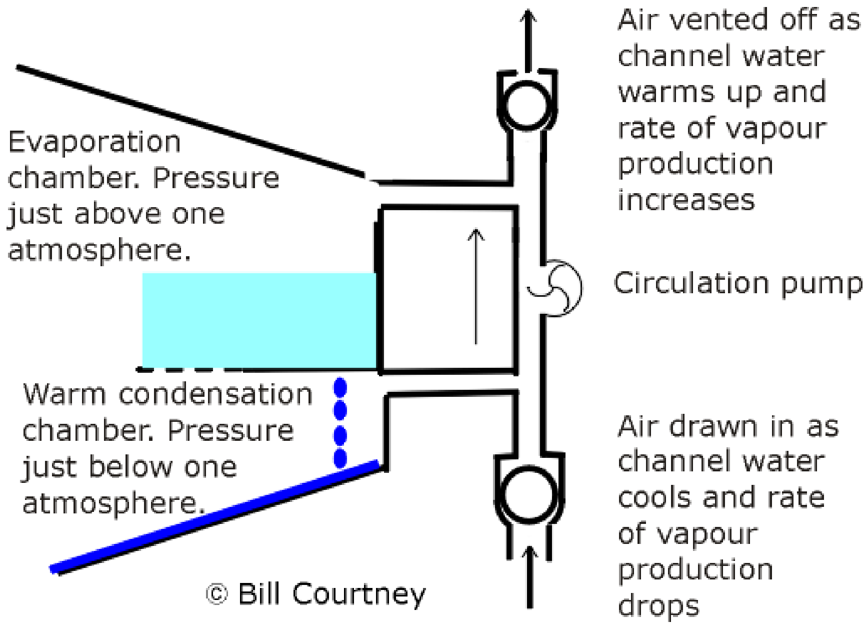

Figure 8. Each channel will be supplied with its own circulation pump and air vent. The vented air will be slightly moister than dry desert air. During the early hours of daylight, it can be fed into the horticultural areas (see below), to avoid wasting the moisture.

3 Maximising the commercial potential of the design

The Fresnel lens roof will have a larger surface area than the evaporation channels. The spare space under the roof could be used as a working area or for growing crops.

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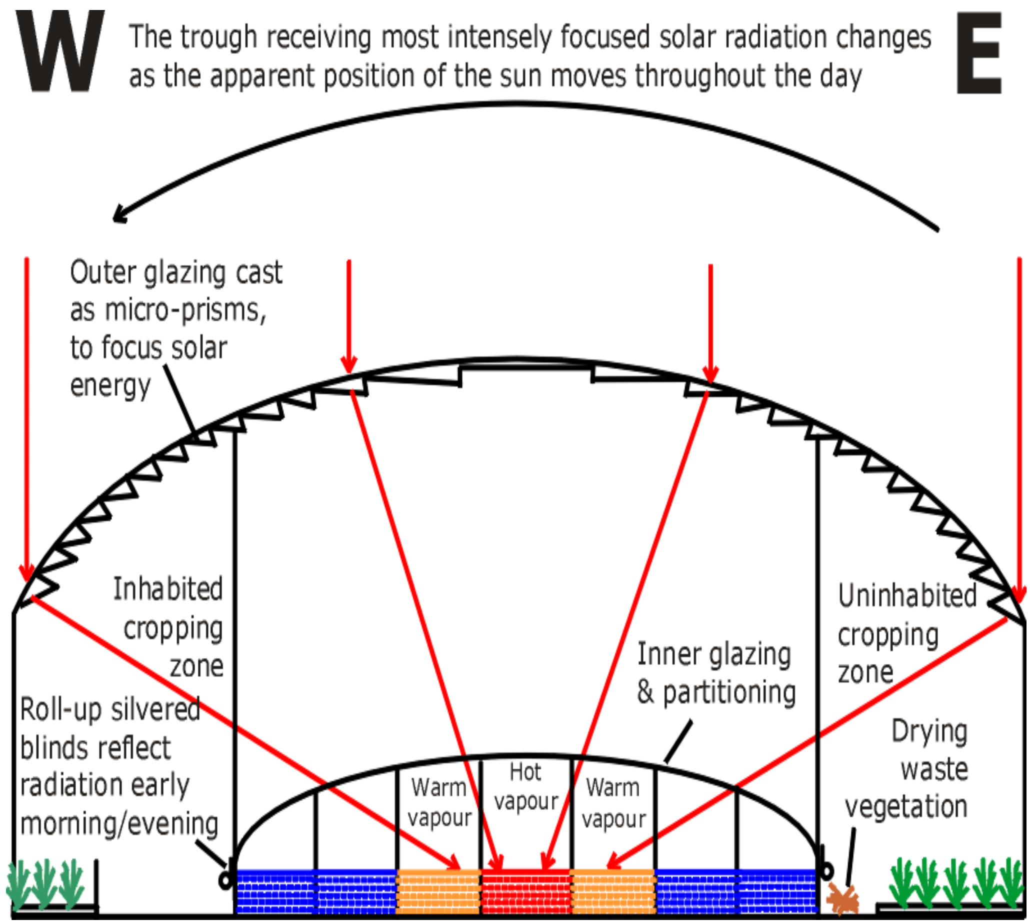

Figure 9. Pleasantly humid working and cropping zones can be created by adding external glass walls.

Larger cropping zones and more intense focusing of solar radiation can be achieved by employing a higher Fresnel lens canopy.

The cropping zones are only illuminated by scattered sunlight from the sky. In effect, the inner glazed zone, occupied by the troughs, acts like a giant heat pump, shunting heat away from the cropping zones.

Plants can provide natural air cooling: (i) Photosynthesis will convert about 10% of the solar energy falling on to the leaves in to chemical energy inside the plants. (ii) Evaporation of water from the leaves of the plants provides further cooling. This system will allow people to work comfortably in hot regions, with minimal need for air conditioning.

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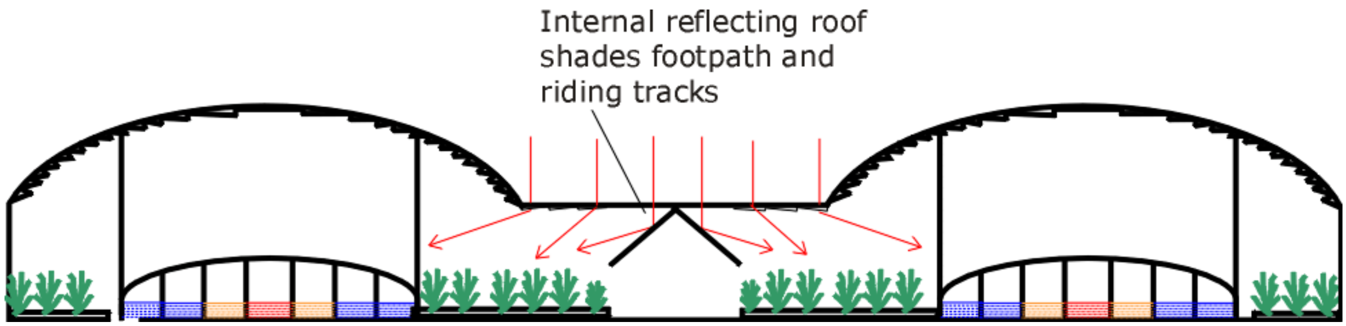

Figure. 10. Parallel solar desalination units may be grouped under a common Fresnel lens canopy. Additional internal shading can be provided for inhabited zones.

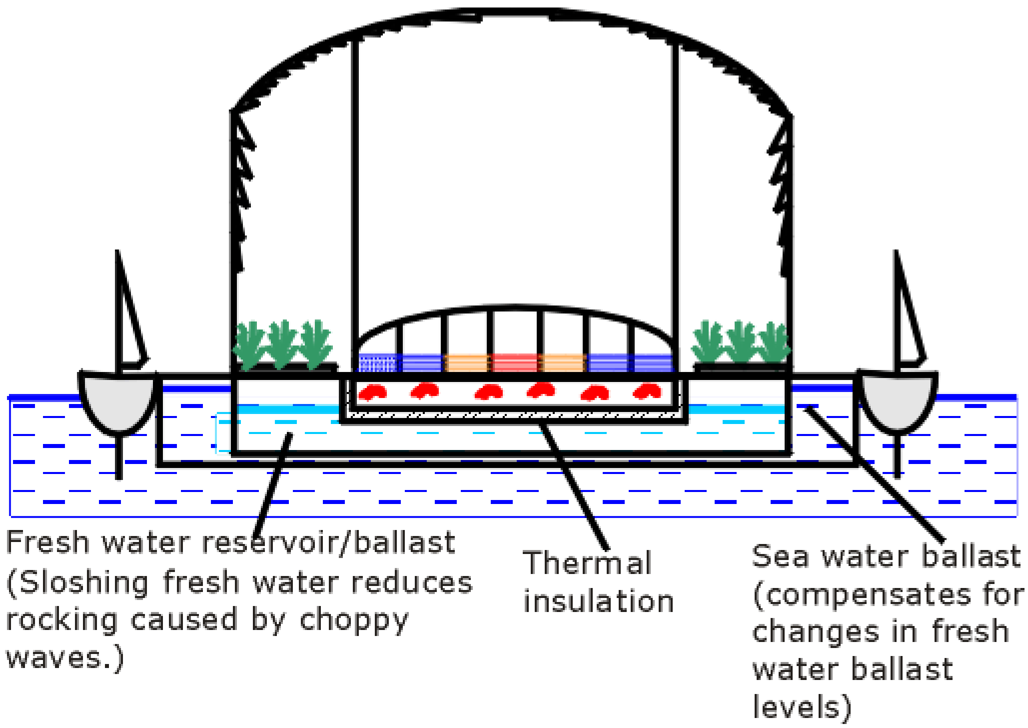

Figure. 11. If land space is scarce, consider building a pontoon system.

4 Taking the design concept forward

Before building a prototype system, proof of principle experiments will need to be carried out in the laboratory. These could use electric heating elements to mimic solar radiation. In order to minimise construction costs, the water would be heated directly, instead of using Fresnel lenses.

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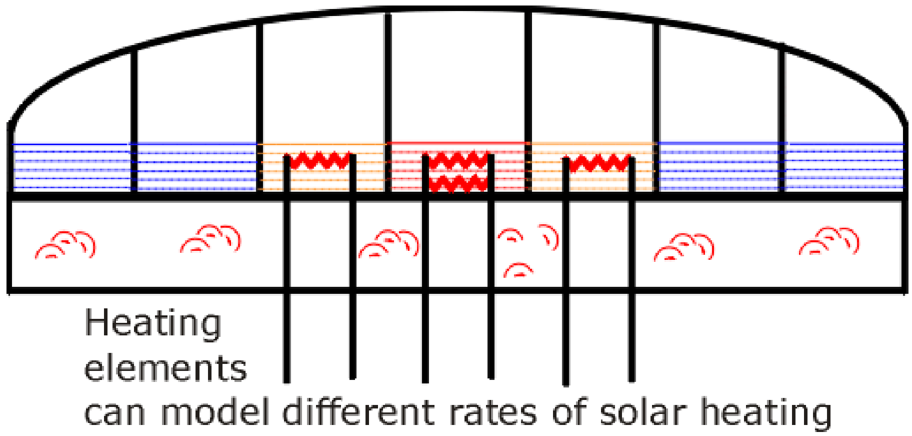

Figure. 12. The first round of experiments can be done indoors using heating elements to model the input of solar energy.

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